90-Day Readmissions in Pediatric Patients with Type 1 Diabetes

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Eliza Aisha

Adarsh Raja

## Preamble:

* **Reference Studies:**
  + [Bhatt et al., 2020](https://pubmed.ncbi.nlm.nih.gov/32469429/)
* **Study Objective:**
* To identify patient- and hospital-level predictors of 90-day all-cause hospital readmission among patients 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:
  + Non-elective admission
  + Index discharge by the end of November to allow for a complete 90-day follow-up period
  + Complete data on LOS and NRD\_DAYSTOEVENT, required to compute discharge dates
* **Outcomes of Interest:**
  + Primary Outcome:
    - Binary indicator of 90-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 injury-related returns unrelated to diabetes care.
  + 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
* **Covariates:**
  + Demographic & Socioeconomic Factors:
    - Age
    - Sex
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - ZIP-based median income quartile
  + Clinical Characteristics:
    - Number of comorbidities
    - Elixhauser comorbidity index
  + Hospital Characteristics:
    - Hospital bed size (Small, Medium, Large)
    - Patient’s residence
    - 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 90-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 90-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 90-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:

Index hospitalizations resulted in:

1. Readmission (n): 7777
2. Readmission Rate (%): 16.07%
3. Readmission Rate (95% CI): 14.85% to 17.28%

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 32
2. Death Rate (%): 0.07%
3. Death Rate (95% CI): 0.02% to 0.12%

Readmission hospitalizations resulted in:

1. Deaths (n): 10
2. Death Rate (%): 0.14%
3. Death Rate (95% CI): -0.03% to 0.32%

### LOS and Cost by Readmission Status:

Index hospitalizations resulted in:

1. Mean Length of Stay (days): 2.27
2. Mean Length of Stay (95% CI): 2.19 to 2.34
3. Mean Charge ($): 19924
4. Mean Charge (95% CI): 18585 to 21262

Readmission hospitalizations resulted in:

1. Mean Length of Stay (days): 2.54
2. Mean Length of Stay (95% CI): 2.4 to 2.68
3. Mean Charge ($): 22526
4. Mean Charge (95% CI): 20864 to 24187

## Baseline Characteristics

| **Characteristic** | **Overall** N = 48,404*1* | **Without Readmission** N = 40,627*1* | **With 90-day readmission** N = 7,778*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) |  |  |  | <0.001 |
| 0–6 | 4,825 (10.0%) | 4,647 (11%) | 178 (2.3%) |  |
| 13–18 | 28,477 (59%) | 22,117 (54%) | 6,360 (82%) |  |
| 7–12 | 15,102 (31%) | 13,862 (34%) | 1,240 (16%) |  |
| Sex |  |  |  | <0.001 |
| Male | 23,418 (48%) | 20,341 (50%) | 3,077 (40%) |  |
| Female | 24,986 (52%) | 20,286 (50%) | 4,701 (60%) |  |
| Median Income Quartile |  |  |  | <0.001 |
| 0-25th percentile | 15,683 (33%) | 12,373 (31%) | 3,310 (43%) |  |
| 26th to 50th percentile | 13,382 (28%) | 11,323 (28%) | 2,060 (27%) |  |
| 51st to 75th percentile | 11,441 (24%) | 9,936 (25%) | 1,505 (20%) |  |
| 76th to 100th percentile | 7,392 (15%) | 6,558 (16%) | 834 (11%) |  |
| Patient Residence |  |  |  | 0.10 |
| Central metro ≥1 million | 10,738 (22%) | 9,036 (22%) | 1,702 (22%) |  |
| Fringe metro ≥1 million | 11,681 (24%) | 9,944 (25%) | 1,737 (22%) |  |
| Metro 250,000-999,999 | 11,479 (24%) | 9,673 (24%) | 1,805 (23%) |  |
| Metro 50,000-249,999 | 5,746 (12%) | 4,678 (12%) | 1,068 (14%) |  |
| Micropolitan | 4,649 (9.6%) | 3,955 (9.7%) | 695 (8.9%) |  |
| Other | 4,050 (8.4%) | 3,287 (8.1%) | 763 (9.8%) |  |
| AWEEKEND |  |  |  | 0.057 |
| Monday-Friday | 36,870 (76%) | 31,075 (76%) | 5,795 (75%) |  |
| Saturday-Sunday | 11,534 (24%) | 9,551 (24%) | 1,983 (25%) |  |
| Hospital Bed Size |  |  |  | 0.031 |
| Small | 6,064 (13%) | 4,942 (12%) | 1,122 (14%) |  |
| Large | 32,152 (66%) | 27,349 (67%) | 4,804 (62%) |  |
| Medium | 10,188 (21%) | 8,336 (21%) | 1,852 (24%) |  |
| Hospital Teaching Status |  |  |  | <0.001 |
| Metropolitan, non-teaching | 4,114 (8.5%) | 3,140 (7.7%) | 974 (13%) |  |
| Metropolitan, teaching | 42,249 (87%) | 36,017 (89%) | 6,232 (80%) |  |
| Non-metropolitan | 2,041 (4.2%) | 1,470 (3.6%) | 571 (7.3%) |  |
| Insurance |  |  |  | <0.001 |
| Medicaid | 26,121 (54%) | 20,842 (51%) | 5,279 (68%) |  |
| Other | 2,951 (6.1%) | 2,381 (5.9%) | 570 (7.3%) |  |
| Private | 19,283 (40%) | 17,359 (43%) | 1,924 (25%) |  |
| Discharged to Non-Home Setting | 856 (1.8%) | 573 (1.4%) | 283 (3.6%) | <0.001 |
| No. of comorbidities |  |  |  | <0.001 |
| One comorbidity | 41,938 (87%) | 35,594 (88%) | 6,344 (82%) |  |
| Two or more comorbidities | 6,466 (13%) | 5,033 (12%) | 1,433 (18%) |  |
| Length of stay |  |  |  | 0.5 |
| ≤4 | 45,724 (94%) | 38,402 (95%) | 7,322 (94%) |  |
| >4 | 2,680 (5.5%) | 2,225 (5.5%) | 456 (5.9%) |  |
| *1*n (%) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment | | | | |

## Multivariable Regression

### 90-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) |  |  |  |
| 0–6 | — | — |  |
| 13–18 | 5.70 | 4.24, 7.67 | <0.001 |
| 7–12 | 2.09 | 1.54, 2.85 | <0.001 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.51 | 1.36, 1.69 | <0.001 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.74 | 0.64, 0.85 | <0.001 |
| 51st to 75th percentile | 0.67 | 0.57, 0.79 | <0.001 |
| 76th to 100th percentile | 0.69 | 0.55, 0.87 | 0.001 |
| Patient Residence |  |  |  |
| Central metro ≥1 million | — | — |  |
| Fringe metro ≥1 million | 1.01 | 0.82, 1.24 | >0.9 |
| Metro 250,000-999,999 | 1.02 | 0.85, 1.21 | 0.9 |
| Metro 50,000-249,999 | 1.22 | 0.98, 1.53 | 0.080 |
| Micropolitan | 0.73 | 0.56, 0.94 | 0.016 |
| Other | 0.95 | 0.73, 1.23 | 0.7 |
| AWEEKEND |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.08 | 0.97, 1.21 | 0.2 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.83 | 0.68, 1.01 | 0.058 |
| Medium | 0.99 | 0.79, 1.25 | >0.9 |
| Hospital Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.66 | 0.55, 0.79 | <0.001 |
| Non-metropolitan | 1.33 | 0.97, 1.81 | 0.077 |
| Insurance |  |  |  |
| Medicaid | — | — |  |
| Other | 0.95 | 0.70, 1.30 | 0.8 |
| Private | 0.53 | 0.46, 0.61 | <0.001 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 1.83 | 1.35, 2.48 | <0.001 |
| No. of comorbidities |  |  |  |
| One comorbidity | — | — |  |
| Two or more comorbidities | 1.12 | 0.95, 1.31 | 0.2 |
| Elixhauser comorbidity index | 1.25 | 1.18, 1.32 | <0.001 |
| Length of stay |  |  |  |
| ≤4 | — | — |  |
| >4 | 0.86 | 0.70, 1.06 | 0.15 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |