30-Day Readmissions in Pediatric Patients with Type 1 Diabetes

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## Preamble:

* **Reference Studies:**
  + [Bhatt et al., 2020](https://pubmed.ncbi.nlm.nih.gov/32469429/)
* **Study Objective:**
* To identify patient- and hospital-level predictors of 30-day all-cause hospital readmission among adults hospitalized with type 1 diabetes mellitus 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 type 1 diabetes mellitus using ICD code E50
  + 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 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 (categorized: <5, 5–11, 12–18)
    - Sex (FEMALE; ref = Male)
    - 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 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:

Index hospitalizations resulted in:

1. Readmission (n): 4051
2. Readmission Rate (%): 6.83%
3. Readmission Rate (95% CI): 6.17% to 7.49%

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 39
2. Death Rate (%): 0.07%
3. Death Rate (95% CI): 0.03% to 0.11%

Readmission hospitalizations resulted in:

1. Deaths (n): 6
2. Death Rate (%): 0.17%
3. Death Rate (95% CI): -0.1% to 0.43%

### LOS and Cost by Readmission Status:

Index hospitalizations resulted in:

1. Mean Length of Stay (days): 2.26
2. Mean Length of Stay (95% CI): 2.19 to 2.34
3. Mean Charge ($): 20093
4. Mean Charge (95% CI): 18817 to 21369

Readmission hospitalizations resulted in:

1. Mean Length of Stay (days): 2.75
2. Mean Length of Stay (95% CI): 2.55 to 2.94
3. Mean Charge ($): 23136
4. Mean Charge (95% CI): 21351 to 24922

## Baseline Characteristics

| **Characteristic** | **Overall** N = 59,312*1* | **Without Readmission** N = 55,261*1* | **With 30-day readmission** N = 4,051*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) |  |  |  | <0.001 |
| 0–6 | 5,896 (9.9%) | 5,795 (10%) | 101 (2.5%) |  |
| 13–18 | 35,144 (59%) | 31,826 (58%) | 3,318 (82%) |  |
| 7–12 | 18,273 (31%) | 17,640 (32%) | 633 (16%) |  |
| Sex |  |  |  | <0.001 |
| Male | 28,658 (48%) | 27,110 (49%) | 1,548 (38%) |  |
| Female | 30,654 (52%) | 28,151 (51%) | 2,503 (62%) |  |
| Median Income Quartile |  |  |  | <0.001 |
| 0-25th percentile | 19,198 (33%) | 17,481 (32%) | 1,718 (43%) |  |
| 26th to 50th percentile | 16,460 (28%) | 15,354 (28%) | 1,107 (28%) |  |
| 51st to 75th percentile | 14,087 (24%) | 13,334 (24%) | 752 (19%) |  |
| 76th to 100th percentile | 8,974 (15%) | 8,531 (16%) | 443 (11%) |  |
| Patient Residence |  |  |  | 0.2 |
| Central metro ≥1 million | 12,967 (22%) | 11,990 (22%) | 977 (24%) |  |
| Fringe metro ≥1 million | 14,195 (24%) | 13,309 (24%) | 886 (22%) |  |
| Metro 250,000-999,999 | 14,154 (24%) | 13,219 (24%) | 935 (23%) |  |
| Metro 50,000-249,999 | 7,084 (12%) | 6,617 (12%) | 468 (12%) |  |
| Micropolitan | 5,917 (10.0%) | 5,557 (10%) | 361 (8.9%) |  |
| Other | 4,916 (8.3%) | 4,495 (8.1%) | 421 (10%) |  |
| AWEEKEND |  |  |  | 0.025 |
| Monday-Friday | 44,956 (76%) | 41,996 (76%) | 2,960 (73%) |  |
| Saturday-Sunday | 14,356 (24%) | 13,265 (24%) | 1,091 (27%) |  |
| Hospital Bed Size |  |  |  | 0.6 |
| Small | 7,454 (13%) | 6,897 (12%) | 557 (14%) |  |
| Large | 39,462 (67%) | 36,845 (67%) | 2,617 (65%) |  |
| Medium | 12,396 (21%) | 11,519 (21%) | 877 (22%) |  |
| Hospital Teaching Status |  |  |  | <0.001 |
| Metropolitan, non-teaching | 5,135 (8.7%) | 4,626 (8.4%) | 509 (13%) |  |
| Metropolitan, teaching | 51,648 (87%) | 48,401 (88%) | 3,247 (80%) |  |
| Non-metropolitan | 2,529 (4.3%) | 2,234 (4.0%) | 295 (7.3%) |  |
| Insurance |  |  |  | <0.001 |
| Medicaid | 31,907 (54%) | 29,121 (53%) | 2,786 (69%) |  |
| Other | 3,626 (6.1%) | 3,297 (6.0%) | 329 (8.1%) |  |
| Private | 23,713 (40%) | 22,779 (41%) | 934 (23%) |  |
| Discharged to Non-Home Setting | 996 (1.7%) | 831 (1.5%) | 165 (4.1%) | <0.001 |
| No. of comorbidities |  |  |  | <0.001 |
| One comorbidity | 51,328 (87%) | 48,104 (87%) | 3,224 (80%) |  |
| Two or more comorbidities | 7,984 (13%) | 7,157 (13%) | 828 (20%) |  |
| Length of stay |  |  |  | 0.074 |
| ≤4 | 56,002 (94%) | 52,227 (95%) | 3,775 (93%) |  |
| >4 | 3,310 (5.6%) | 3,034 (5.5%) | 276 (6.8%) |  |
| *1*n (%) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment | | | | |

## Multivariable Regression

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) |  |  |  |
| 0–6 | — | — |  |
| 13–18 | 4.40 | 3.04, 6.37 | <0.001 |
| 7–12 | 1.81 | 1.23, 2.67 | 0.003 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.50 | 1.29, 1.75 | <0.001 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.81 | 0.68, 0.98 | 0.030 |
| 51st to 75th percentile | 0.71 | 0.59, 0.86 | <0.001 |
| 76th to 100th percentile | 0.78 | 0.60, 1.00 | 0.053 |
| Patient Residence |  |  |  |
| Central metro ≥1 million | — | — |  |
| Fringe metro ≥1 million | 0.88 | 0.70, 1.12 | 0.3 |
| Metro 250,000-999,999 | 0.87 | 0.71, 1.08 | 0.2 |
| Metro 50,000-249,999 | 0.87 | 0.66, 1.14 | 0.3 |
| Micropolitan | 0.67 | 0.49, 0.91 | 0.011 |
| Other | 0.93 | 0.65, 1.31 | 0.7 |
| AWEEKEND |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.14 | 0.99, 1.31 | 0.070 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.93 | 0.74, 1.15 | 0.5 |
| Medium | 0.94 | 0.73, 1.19 | 0.6 |
| Hospital Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.71 | 0.57, 0.88 | 0.002 |
| Non-metropolitan | 1.25 | 0.85, 1.84 | 0.3 |
| Insurance |  |  |  |
| Medicaid | — | — |  |
| Other | 1.07 | 0.77, 1.47 | 0.7 |
| Private | 0.53 | 0.44, 0.64 | <0.001 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 1.88 | 1.36, 2.59 | <0.001 |
| No. of comorbidities |  |  |  |
| One comorbidity | — | — |  |
| Two or more comorbidities | 1.16 | 0.97, 1.40 | 0.11 |
| Elixhauser comorbidity index | 1.27 | 1.18, 1.35 | <0.001 |
| Length of stay |  |  |  |
| ≤4 | — | — |  |
| >4 | 0.95 | 0.73, 1.25 | 0.7 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |