30- and 90-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
  + Hospital Characteristics:
    - Hospital bed size (Small, Medium, Large)
    - Location of hospital (Urbanization)
    - 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:

### Baseline Characteristics

| **Characteristic** | **Overall** N = 19,603*1* | **Without Readmission** N = 19,075*1* | **With 30-day readmission** N = 527*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) |  |  |  | <0.001 |
| <5 | 1,144 (5.8%) | 1,142 (6.0%) | 2 (0.4%) |  |
| 5–11 | 5,386 (27%) | 5,337 (28%) | 50 (9.5%) |  |
| 12–18 | 13,072 (67%) | 12,596 (66%) | 476 (90%) |  |
| Sex |  |  |  | 0.014 |
| Male | 9,520 (49%) | 9,316 (49%) | 203 (39%) |  |
| Female | 10,083 (51%) | 9,759 (51%) | 324 (61%) |  |
| Median Income Quartile |  |  |  | 0.044 |
| 0-25th percentile | 6,201 (32%) | 5,976 (32%) | 225 (43%) |  |
| 26th to 50th percentile | 5,372 (28%) | 5,248 (28%) | 124 (24%) |  |
| 51st to 75th percentile | 4,846 (25%) | 4,721 (25%) | 125 (24%) |  |
| 76th to 100th percentile | 2,990 (15%) | 2,938 (16%) | 52 (9.8%) |  |
| Hospital Bed Size |  |  |  | 0.8 |
| Small | 2,505 (13%) | 2,433 (13%) | 72 (14%) |  |
| Large | 13,233 (68%) | 12,892 (68%) | 340 (65%) |  |
| Medium | 3,865 (20%) | 3,750 (20%) | 115 (22%) |  |
| Hospital Urbanization |  |  |  | 0.2 |
| Large metropolitan ≥1 million | 10,998 (56%) | 10,711 (56%) | 287 (54%) |  |
| Micropolitan | 639 (3.3%) | 615 (3.2%) | 24 (4.6%) |  |
| Non-urban | 199 (1.0%) | 185 (1.0%) | 14 (2.7%) |  |
| Small metropolitan <1 million | 7,766 (40%) | 7,564 (40%) | 202 (38%) |  |
| Hospital Teaching Status |  |  |  | <0.001 |
| Metropolitan, non-teaching | 1,618 (8.3%) | 1,533 (8.0%) | 86 (16%) |  |
| Metropolitan, teaching | 17,146 (87%) | 16,742 (88%) | 403 (76%) |  |
| Non-metropolitan | 839 (4.3%) | 800 (4.2%) | 38 (7.3%) |  |
| Insurance |  |  |  | <0.001 |
| Private | 7,797 (40%) | 7,680 (40%) | 117 (22%) |  |
| Medicaid | 10,569 (54%) | 10,214 (54%) | 355 (67%) |  |
| Medicare | 20 (0.1%) | 20 (0.1%) | 0 (0%) |  |
| Other | 1,198 (6.1%) | 1,142 (6.0%) | 56 (11%) |  |
| No. of comorbidities |  |  |  | 0.014 |
| One comorbidity | 16,946 (86%) | 16,525 (87%) | 421 (80%) |  |
| Two or more comorbidities | 2,657 (14%) | 2,551 (13%) | 106 (20%) |  |
| *1*n (%) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment | | | | |

### Outcomes of Index Hospitalizations

| **Characteristic** | **Overall** N = 19,603*1* | **Without Readmission** N = 19,075*1* | **With 30-day readmission** N = 527*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| In-Hospital Mortality | 24 (0.1%) | 24 (0.1%) | 0 (0%) | 0.7 |
| Length of Stay (days) | 2.00 (1.00, 3.00) | 2.00 (1.00, 3.00) | 2.00 (1.00, 3.00) | 0.3 |
| Inflation-Adjusted Total Charges ($) | 15,172 (9,671, 23,569) | 15,182 (9,675, 23,603) | 14,518 (9,486, 23,220) | 0.7 |
| Discharged to Non-Home Setting | 363 (1.9%) | 344 (1.8%) | 19 (3.6%) | 0.2 |
| *1*n (%); Median (Q1, Q3) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

## Readmission Hospitalization Characteristics

### In-Hospital Mortality Among Readmitted Patients

Readmission hospitalizations resulted in:

1. Deaths (n): 1
2. Death Rate (%): 0.27%
3. Death Rate (95% CI): -0.27% to 0.82%

### Resource Utilization During Readmission

Readmission hospitalizations resulted in:

1. Median Length of Stay (IQR), days: 2 (IQR: 1–3)
2. Median Total Charges (IQR): $17,086 (IQR: $11,688–$26,354)

## Multivariable Analyses

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) |  |  |  |
| <5 | — | — |  |
| 5–11 | 5.38 | 0.68, 42.3 | 0.11 |
| 12–18 | 19.3 | 2.65, 141 | 0.004 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.55 | 1.10, 2.17 | 0.011 |
| Insurance |  |  |  |
| Private | — | — |  |
| Medicaid | 1.94 | 1.26, 2.97 | 0.003 |
| Medicare | 0.00 | 0.00, 0.00 | <0.001 |
| Other | 2.75 | 1.43, 5.27 | 0.002 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.69 | 0.45, 1.05 | 0.086 |
| 51st to 75th percentile | 0.87 | 0.56, 1.35 | 0.5 |
| 76th to 100th percentile | 0.70 | 0.36, 1.35 | 0.3 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.97 | 0.56, 1.67 | >0.9 |
| Medium | 1.01 | 0.54, 1.90 | >0.9 |
| Hospital Urbanization |  |  |  |
| Large metropolitan ≥1 million | — | — |  |
| Micropolitan | 0.65 | 0.29, 1.47 | 0.3 |
| Non-urban | 1.11 | 0.34, 3.62 | 0.9 |
| Small metropolitan <1 million | 0.93 | 0.64, 1.34 | 0.7 |
| Hospital Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.50 | 0.33, 0.77 | 0.001 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 1.57 | 0.58, 4.27 | 0.4 |
| No. of comorbidities |  |  |  |
| One comorbidity | — | — |  |
| Two or more comorbidities | 1.49 | 0.99, 2.25 | 0.056 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |