Predictors and Outcomes of 30-Day Readmission in Patients Hospitalized for Sepsis with Comorbid Diabetes Mellitus

RCOP NRD Analysis Template

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## Preamble:

* **Reference Studies:**
  + [Zahid et al., 2022](https://www.ahajournals.org/doi/10.1161/JAHA.121.024890)
* **Study Objective:**
* To identify patient- and hospital-level predictors of 30-day all-cause hospital readmission among adults hospitalized with sepsis and comorbid 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 sepsis, identified using ICD-10-CM codes for septicemia and systemic infection (isSepsis pattern, including A40*, A41*, R65.2\*, etc.)
  + Evidence of comorbid diabetes mellitus (Type 1, Type 2, or other), derived from secondary diagnosis fields using ICD-10-CM patterns E08–E13
  + 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 and required a minimum one-day separation from the index discharge.
    - Trauma-related hospitalizations were excluded only from the readmission pool to avoid planned or injury-related returns unrelated to sepsis care.
  + Mortality:
    - In-hospital death recorded during index or readmission (DIED = 1)
  + LOS:
    - Reported in days; modeled as count outcome
  + Cost:
    - Derived from HCUP’s TOTCHG variable and adjusted to 2017 dollars using Consumer Price Index (CPI) data
* **Covariates and Variable Construction:**
  + Demographic & Socioeconomic Factors:
    - Age (categorized: 18–49, 50–64, 65–79, 80+)
    - Sex (FEMALE; ref = Male)
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - ZIP-based median income quartile (ZIPINC\_QRTL)
    - Weekend admission (AWEEKEND)
  + Clinical Characteristics:
    - Diabetes subtype (T1DM, T2DM, Other), derived from ICD-10 patterns
    - Comorbidities based on Elixhauser Comorbidity Index, using binary indicators:
    - Congestive heart failure
    - Chronic pulmonary disease
    - Renal failure
    - Liver disease
    - Obesity
    - Hypertension (composite of 2 Elixhauser variables)
    - Coagulopathy
    - Cancer (Lymphoma, Metastatic, Solid Tumor without metastasis)
    - Acute complications identified via ICD-10 code matching:
    - Acute Kidney Injury (AKI)
    - Acute Respiratory Failure (ARF)
    - Mechanical ventilation
    - Vasopressor use
  + 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 incorporated NRD’s complex sampling design using discharge weights (DISCWT), strata (NRD\_STRATUM), and clustering (HOSP\_NRD) 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 design-based statistical tests (Rao–Scott adjusted chi-square for categorical variables; design-based 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.
    - Reference levels were explicitly set (e.g., Male, T1DM, LOS ≤4 days).
    - 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).

## Baseline table:

| **Characteristic** | **Without Readmission** N = 1,081,458*1* | **With 30-day readmission** N = 164,892*1* | **p-value***2* | **Overall** N = 1,246,351*1* |
| --- | --- | --- | --- | --- |
| Age (years) | 68 (14) | 67 (14) | <0.001 | 67 (14) |
| Age Category |  |  | <0.001 |  |
| 18–49 | 123,149 (11%) | 19,166 (12%) |  | 142,315 (11%) |
| 50–64 | 294,528 (27%) | 47,121 (29%) |  | 341,649 (27%) |
| 65–79 | 419,339 (39%) | 65,035 (39%) |  | 484,374 (39%) |
| 80+ | 244,443 (23%) | 33,570 (20%) |  | 278,013 (22%) |
| Sex |  |  | 0.026 |  |
| Male | 553,444 (51%) | 83,582 (51%) |  | 637,026 (51%) |
| Female | 528,014 (49%) | 81,311 (49%) |  | 609,325 (49%) |
| Primary Expected Payer |  |  | <0.001 |  |
| Private | 156,456 (14%) | 18,548 (11%) |  | 175,003 (14%) |
| Medicaid | 123,758 (11%) | 22,341 (14%) |  | 146,099 (12%) |
| Medicare | 749,885 (69%) | 118,019 (72%) |  | 867,904 (70%) |
| Other | 50,132 (4.6%) | 5,853 (3.6%) |  | 55,984 (4.5%) |
| Median Income Quartile |  |  | <0.001 |  |
| 0-25th percentile | 342,808 (32%) | 55,577 (34%) |  | 398,385 (32%) |
| 26th to 50th percentile | 291,329 (27%) | 44,303 (27%) |  | 335,633 (27%) |
| 51st to 75th percentile | 253,421 (24%) | 36,853 (23%) |  | 290,274 (24%) |
| 76th to 100th percentile | 178,982 (17%) | 26,073 (16%) |  | 205,055 (17%) |
| Admission Day |  |  | 0.024 |  |
| Monday-Friday | 793,233 (73%) | 121,590 (74%) |  | 914,823 (73%) |
| Saturday-Sunday | 288,225 (27%) | 43,303 (26%) |  | 331,528 (27%) |
| Hospital Bed Size |  |  | 0.003 |  |
| Small | 186,850 (17%) | 27,150 (16%) |  | 214,000 (17%) |
| Large | 576,295 (53%) | 88,744 (54%) |  | 665,039 (53%) |
| Medium | 318,314 (29%) | 48,998 (30%) |  | 367,312 (29%) |
| Hospital Location and Teaching Status |  |  | <0.001 |  |
| Metropolitan, non-teaching | 297,117 (27%) | 46,428 (28%) |  | 343,544 (28%) |
| Metropolitan, teaching | 679,374 (63%) | 103,764 (63%) |  | 783,138 (63%) |
| Non-metropolitan | 104,968 (9.7%) | 14,701 (8.9%) |  | 119,669 (9.6%) |
| Type of Diabetes |  |  | <0.001 |  |
| T1DM | 36,185 (3.3%) | 7,537 (4.6%) |  | 43,722 (3.5%) |
| T2DM | 1,022,755 (95%) | 154,304 (94%) |  | 1,177,059 (94%) |
| Other | 22,518 (2.1%) | 3,052 (1.9%) |  | 25,570 (2.1%) |
| Congestive Heart Failure | 333,999 (31%) | 61,607 (37%) | <0.001 | 395,607 (32%) |
| Chronic Pulmonary Disease | 321,477 (30%) | 56,024 (34%) | <0.001 | 377,502 (30%) |
| Chronic Kidney Disease | 394,117 (36%) | 69,910 (42%) | <0.001 | 464,026 (37%) |
| Liver Disease | 93,286 (8.6%) | 15,005 (9.1%) | <0.001 | 108,291 (8.7%) |
| Obesity | 272,387 (25%) | 38,997 (24%) | <0.001 | 311,385 (25%) |
| Coagulopathy | 138,666 (13%) | 20,920 (13%) | 0.3 | 159,586 (13%) |
| Lymphoma | 14,247 (1.3%) | 2,662 (1.6%) | <0.001 | 16,909 (1.4%) |
| Metastatic Cancer | 38,016 (3.5%) | 6,321 (3.8%) | <0.001 | 44,337 (3.6%) |
| Solid Tumor (No Metastasis) | 66,128 (6.1%) | 11,612 (7.0%) | <0.001 | 77,740 (6.2%) |
| Hypertension | 859,227 (79%) | 132,802 (81%) | <0.001 | 992,030 (80%) |
| Acute Kidney Injury | 481,447 (45%) | 75,050 (46%) | <0.001 | 556,497 (45%) |
| Acute Respiratory Failure | 331,168 (31%) | 48,708 (30%) | <0.001 | 379,876 (30%) |
| Vasopressor Use | 27,971 (2.6%) | 3,451 (2.1%) | <0.001 | 31,422 (2.5%) |
| Mechanical Ventilation | 144,939 (13%) | 18,241 (11%) | <0.001 | 163,180 (13%) |
| Length of Stay Category |  |  | <0.001 |  |
| ≤4 | 457,078 (42%) | 50,751 (31%) |  | 507,829 (41%) |
| >4 | 624,381 (58%) | 114,142 (69%) |  | 738,522 (59%) |
| Discharged to Non-Home Setting | 462,985 (43%) | 71,750 (44%) | 0.003 | 534,735 (43%) |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Descriptive Statistics:

### Readmission Rate:

# A tibble: 1 × 6  
 unweighted\_n weighted\_N weighted\_N\_se readmit\_rate readmit\_rate\_low  
 <int> <dbl> <dbl> <dbl> <dbl>  
1 690569 1246351. 16253. 0.132 0.131  
# ℹ 1 more variable: readmit\_rate\_upp <dbl>

### In-Hospital Mortality by Readmission Status:

# A tibble: 1 × 5  
 deaths deaths\_se rate rate\_low rate\_upp  
 <dbl> <dbl> <dbl> <dbl> <dbl>  
1 118760. 1700. 0.0953 0.0936 0.0970

# A tibble: 1 × 5  
 deaths deaths\_se rate rate\_low rate\_upp  
 <dbl> <dbl> <dbl> <dbl> <dbl>  
1 11560. 233. 0.0702 0.0681 0.0722

### LOS and Cost by Readmission Status:

# A tibble: 1 × 6  
 mean\_LOS mean\_LOS\_low mean\_LOS\_upp mean\_cost mean\_cost\_low mean\_cost\_upp  
 <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  
1 7.74 7.66 7.81 81787. 79815. 83759.

# A tibble: 1 × 6  
 mean\_LOS mean\_LOS\_low mean\_LOS\_upp mean\_cost mean\_cost\_low mean\_cost\_upp  
 <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  
1 6.72 6.64 6.79 75662. 71786. 79537.

## Multivariable Regression

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age Category |  |  |  |
| 18–49 | — | — |  |
| 50–64 | 0.98 | 0.95, 1.01 | 0.3 |
| 65–79 | 0.86 | 0.83, 0.89 | <0.001 |
| 80+ | 0.73 | 0.70, 0.76 | <0.001 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.03 | 1.02, 1.05 | <0.001 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.42 | 1.37, 1.47 | <0.001 |
| Medicare | 1.35 | 1.32, 1.40 | <0.001 |
| Other | 0.98 | 0.93, 1.03 | 0.4 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.96 | 0.93, 0.98 | <0.001 |
| 51st to 75th percentile | 0.93 | 0.90, 0.95 | <0.001 |
| 76th to 100th percentile | 0.94 | 0.91, 0.97 | <0.001 |
| Admission Day |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.00 | 0.99, 1.02 | 0.8 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 1.01 | 0.98, 1.05 | 0.4 |
| Medium | 1.03 | 1.0, 1.07 | 0.093 |
| Hospital Location and Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.96 | 0.93, 0.99 | 0.004 |
| Non-metropolitan | 0.91 | 0.87, 0.95 | <0.001 |
| Type of Diabetes |  |  |  |
| T1DM | — | — |  |
| T2DM | 0.74 | 0.71, 0.77 | <0.001 |
| Other | 0.71 | 0.66, 0.76 | <0.001 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 1.27 | 1.25, 1.30 | <0.001 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | 1.20 | 1.18, 1.22 | <0.001 |
| Chronic Kidney Disease |  |  |  |
| No | — | — |  |
| Yes | 1.20 | 1.18, 1.22 | <0.001 |
| Liver Disease |  |  |  |
| No | — | — |  |
| Yes | 1.08 | 1.05, 1.11 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.87 | 0.85, 0.88 | <0.001 |
| Coagulopathy |  |  |  |
| No | — | — |  |
| Yes | 0.95 | 0.93, 0.97 | <0.001 |
| Lymphoma |  |  |  |
| No | — | — |  |
| Yes | 1.25 | 1.18, 1.33 | <0.001 |
| Metastatic Cancer |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.96, 1.06 | 0.8 |
| Solid Tumor (No Metastasis) |  |  |  |
| No | — | — |  |
| Yes | 1.22 | 1.17, 1.26 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.98, 1.02 | >0.9 |
| Acute Kidney Injury |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.97, 1.00 | 0.033 |
| Acute Respiratory Failure |  |  |  |
| No | — | — |  |
| Yes | 0.90 | 0.88, 0.92 | <0.001 |
| Vasopressor Use |  |  |  |
| No | — | — |  |
| Yes | 0.84 | 0.79, 0.89 | <0.001 |
| Mechanical Ventilation |  |  |  |
| No | — | — |  |
| Yes | 0.74 | 0.72, 0.76 | <0.001 |
| Length of Stay Category |  |  |  |
| ≤4 | — | — |  |
| >4 | 1.64 | 1.61, 1.68 | <0.001 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.96, 1.00 | 0.024 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |