Impact of Diabetes and Inpatient Outcomes in Pneumonia: Insights from the National Inpatient Sample

Analysis for RCOP 2025-August-NIS-12-Internal Medicine

Eliza Aisha

Ruqiat Masooma Batool

## Preamble:

* **Reference Papers:**
  + [Shah et al. 2021](https://pubmed.ncbi.nlm.nih.gov/34660142/)

## Preamble:

* **Study Objective**: To examine the impact of diabetes on outcomes among admissions with pneumonia.
* **Data Source**: Cross-sectional analysis of the National Inpatient Sample (NIS) from 2018 to 2020. The NIS is part of the Healthcare Cost and Utilization Project (HCUP) and provides a stratified sample of inpatient discharges from U.S. community hospitals across all payers.
* **Cohort Definition:** Patients were included if they met the following criteria
  + Age ≥18 years
  + Had a primary diagnosis of pneumonia (CCSR: RSP002 -> Pneumonia (except that caused by tuberculosis))
* **Primary Outcomes**:
  + In-hospital all-cause mortality
  + Total hospital length of stay (days)
  + Total charge, inflation adjusted to 2020 ($)
* **Secondary Outcomes**:
  + Patient requiring mechanical ventilation
  + Sepsis
  + Acute myocardial infarction
  + Acute ischemic stroke
  + Non-home discharge
* **Covariates for Adjustment:** All models adjusted for the following
  + Demographics: Age, sex, race, income, insurance, location of patient’s residence, hospital region, hospital bedsize, hospital location, and teaching status.
  + Medical History: Hypertension, cardiac arrhythmias, hyperlipidemia, coronary artery disease, peripheral vascular disease, pulmonary circulation disorders, heart failure, chronic kidney disease, chronic pulmonary disease, obstructive sleep apnea, anemia, liver disease, alcohol abuse, drug abuse, obesity, electrolyte and fluid imbalance, paralysis, depression, psychoses.
* **Statistical Methods:**
  + **Univariable Analysis:**
    - Categorical variables: Compared using Pearson’s chi-square test with Rao & Scott adjustment
    - Continuous variables: Analyzed using the design-based Kruskal–Wallis test, a non-parametric alternative suitable for survey-weighted data
  + **Multivariable Analysis:**
    - Binary outcomes (e.g., mortality): Survey-weighted logistic regression using the quasibinomial family
    - Continuous outcomes (e.g., LOS, hospital charges): Survey-weighted linear regression using the gaussian family
    - Results reported as adjusted odds ratios (aORs) or beta coefficients with 95% confidence intervals
* **Software:** All statistical analyses were performed using the R Statistical Language (Version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria), incorporating survey-weighted procedures via the *survey* package to account for the complex sampling design of NIS.

## Baseline Table:

| **Characteristic** | **Overall** N = 2,012,430*1* | **Pneumonia with Diabetes** N = 650,020*1* | **Pneumonia without Diabetes** N = 1,362,410*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age, y | 69 (16) | 70 (13) | 68 (17) | <0.001 |
| Sex |  |  |  | <0.001 |
| Female | 1,059,905 (53%) | 326,860 (50%) | 733,045 (54%) |  |
| Male | 952,470 (47%) | 323,150 (50%) | 629,320 (46%) |  |
| Race |  |  |  | <0.001 |
| White | 1,456,510 (74%) | 429,300 (68%) | 1,027,210 (77%) |  |
| Asian or Pacific Islander | 41,310 (2.1%) | 17,245 (2.7%) | 24,065 (1.8%) |  |
| Black | 248,825 (13%) | 98,355 (15%) | 150,470 (11%) |  |
| Hispanic | 160,020 (8.1%) | 68,225 (11%) | 91,795 (6.9%) |  |
| Native American | 13,865 (0.7%) | 6,015 (0.9%) | 7,850 (0.6%) |  |
| Other | 45,550 (2.3%) | 16,435 (2.6%) | 29,115 (2.2%) |  |
| Residential income |  |  |  | <0.001 |
| $1 - $51,999 | 655,235 (33%) | 228,965 (36%) | 426,270 (32%) |  |
| $52,000 - $65,999 | 561,050 (28%) | 183,415 (29%) | 377,635 (28%) |  |
| $66,000 - $87,999 | 436,785 (22%) | 136,635 (21%) | 300,150 (22%) |  |
| $88,000 or more | 325,005 (16%) | 90,305 (14%) | 234,700 (18%) |  |
| Expected primary payer |  |  |  | <0.001 |
| Private | 389,985 (19%) | 102,170 (16%) | 287,815 (21%) |  |
| Medicaid | 218,130 (11%) | 62,580 (9.6%) | 155,550 (11%) |  |
| Medicare | 1,361,405 (68%) | 471,830 (73%) | 889,575 (65%) |  |
| Other | 40,520 (2.0%) | 12,715 (2.0%) | 27,805 (2.0%) |  |
| Hospital region |  |  |  | <0.001 |
| Midwest | 493,105 (25%) | 158,995 (24%) | 334,110 (25%) |  |
| Northeast | 345,000 (17%) | 105,820 (16%) | 239,180 (18%) |  |
| South | 854,045 (42%) | 282,460 (43%) | 571,585 (42%) |  |
| West | 320,280 (16%) | 102,745 (16%) | 217,535 (16%) |  |
| Hypertension | 1,398,695 (70%) | 554,660 (85%) | 844,035 (62%) | <0.001 |
| Hyperlipidemia | 822,400 (41%) | 361,830 (56%) | 460,570 (34%) | <0.001 |
| Coronary artery disease | 482,960 (24%) | 213,210 (33%) | 269,750 (20%) | <0.001 |
| Peripheral vascular disease | 154,115 (7.7%) | 45,800 (7.0%) | 108,315 (8.0%) | <0.001 |
| Cardiac arrhythmias | 612,305 (30%) | 210,035 (32%) | 402,270 (30%) | <0.001 |
| Pulmonary circulation disorders | 145,775 (7.2%) | 52,600 (8.1%) | 93,175 (6.8%) | <0.001 |
| Heart failure | 591,855 (29%) | 257,210 (40%) | 334,645 (25%) | <0.001 |
| Chronic kidney disease | 466,925 (23%) | 241,240 (37%) | 225,685 (17%) | <0.001 |
| Chronic obstructive pulmonary disease | 972,415 (48%) | 314,360 (48%) | 658,055 (48%) | 0.7 |
| Liver disease | 89,065 (4.4%) | 33,150 (5.1%) | 55,915 (4.1%) | <0.001 |
| Obstructive sleep apnea | 193,315 (9.6%) | 95,810 (15%) | 97,505 (7.2%) | <0.001 |
| Anemia | 119,165 (5.9%) | 41,300 (6.4%) | 77,865 (5.7%) | <0.001 |
| Alcohol use disorder | 536,521 (27%) | 171,715 (26%) | 364,806 (27%) | 0.062 |
| Obesity | 319,060 (16%) | 162,415 (25%) | 156,645 (11%) | <0.001 |
| Electrolyte and fluid imbalance | 801,270 (40%) | 269,790 (42%) | 531,480 (39%) | <0.001 |
| Drug abuse | 93,440 (4.6%) | 20,025 (3.1%) | 73,415 (5.4%) | <0.001 |
| Paralysis | 19,370 (1.0%) | 5,745 (0.9%) | 13,625 (1.0%) | <0.001 |
| Psychoses | 41,665 (2.1%) | 14,645 (2.3%) | 27,020 (2.0%) | <0.001 |
| Depression | 306,855 (15%) | 101,290 (16%) | 205,565 (15%) | <0.001 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

| **Characteristic** | **Pneumonia with Diabetes** N = 650,020*1* | **Pneumonia without Diabetes** N = 1,362,410*1* | **p-value***2* |
| --- | --- | --- | --- |
| Died during hospitalization | 16,565 (2.5%) | 36,445 (2.7%) | 0.022 |
| Sepsis | 12,110 (1.9%) | 23,835 (1.7%) | 0.012 |
| Mechanical ventilation |  |  |  |
| No | 650,020 (100%) | 1,362,410 (100%) |  |
| Acute myocardial infarction | 18,340 (2.8%) | 28,170 (2.1%) | <0.001 |
| Acute ischemic stroke | 2,530 (0.4%) | 4,015 (0.3%) | <0.001 |
| Non-home discharge | 25,200 (3.9%) | 61,465 (4.5%) | <0.001 |
| Length of stay (days) | 5.1 (4.9) | 4.8 (4.8) | <0.001 |
| Inflation-adjusted total charge ($) | 49,749 (70,271) | 44,037 (67,371) | <0.001 |
| *1*n (%); Mean (SD) | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; NA; Design-based KruskalWallis test | | | |

## Multivariable Logistic Regression:

### All-Cause Mortality:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | 1.04 | 0.99, 1.09 | 0.086 |
| Age, y | 1.03 | 1.03, 1.03 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.16 | 1.11, 1.21 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.20 | 1.06, 1.36 | 0.005 |
| Black | 1.14 | 1.06, 1.22 | <0.001 |
| Hispanic | 0.98 | 0.90, 1.07 | 0.7 |
| Native American | 1.17 | 0.92, 1.49 | 0.2 |
| Other | 1.16 | 1.01, 1.33 | 0.033 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.92 | 0.87, 0.97 | 0.001 |
| $66,000 - $87,999 | 0.89 | 0.84, 0.95 | <0.001 |
| $88,000 or more | 0.86 | 0.80, 0.92 | <0.001 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.90 | 0.82, 1.00 | 0.049 |
| Medicare | 0.88 | 0.82, 0.94 | <0.001 |
| Other | 1.81 | 1.56, 2.09 | <0.001 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.34 | 1.25, 1.44 | <0.001 |
| South | 1.01 | 0.95, 1.07 | 0.7 |
| West | 1.13 | 1.06, 1.22 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.73 | 0.69, 0.76 | <0.001 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 0.73 | 0.70, 0.77 | <0.001 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 0.95 | 0.90, 1.00 | 0.033 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 1.69 | 1.61, 1.77 | <0.001 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 1.49 | 1.40, 1.59 | <0.001 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.97, 1.11 | 0.3 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.65 | 1.57, 1.73 | <0.001 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.10 | 1.05, 1.15 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 0.89 | 0.85, 0.92 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 2.08 | 1.93, 2.25 | <0.001 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | 0.77 | 0.71, 0.83 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 0.90 | 0.83, 0.98 | 0.014 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.27 | 1.20, 1.33 | <0.001 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | 0.60 | 0.51, 0.69 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.78 | 0.73, 0.84 | <0.001 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 2.23 | 2.13, 2.33 | <0.001 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 2.58 | 2.21, 3.00 | <0.001 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.79, 1.10 | 0.4 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.87 | 0.82, 0.93 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Mechanical Ventilation:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | 1.00 | 0.99, 1.01 | >0.9 |
| Age, y | 1.00 | 1.00, 1.00 | >0.9 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.00 | 0.99, 1.01 | >0.9 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.00 | 0.94, 1.06 | >0.9 |
| Black | 1.00 | 0.97, 1.03 | >0.9 |
| Hispanic | 1.00 | 0.96, 1.05 | >0.9 |
| Native American | 1.00 | 0.91, 1.10 | >0.9 |
| Other | 1.00 | 0.93, 1.08 | >0.9 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.00 | 0.97, 1.03 | >0.9 |
| $66,000 - $87,999 | 1.00 | 0.97, 1.03 | >0.9 |
| $88,000 or more | 1.00 | 0.96, 1.05 | >0.9 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.00 | 0.98, 1.02 | >0.9 |
| Medicare | 1.00 | 0.98, 1.02 | >0.9 |
| Other | 1.00 | 0.96, 1.04 | >0.9 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.00 | 0.95, 1.05 | >0.9 |
| South | 1.00 | 0.97, 1.04 | >0.9 |
| West | 1.00 | 0.96, 1.04 | >0.9 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.98, 1.02 | >0.9 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.98, 1.02 | >0.9 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.98, 1.02 | >0.9 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.02 | >0.9 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.98, 1.02 | >0.9 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.95, 1.05 | >0.9 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.98, 1.02 | >0.9 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.98, 1.02 | >0.9 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.97, 1.03 | >0.9 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.97, 1.03 | >0.9 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.99, 1.01 | >0.9 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Sepsis:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | 0.92 | 0.87, 0.97 | 0.003 |
| Age, y | 0.99 | 0.99, 1.0 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.25 | 1.18, 1.31 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.12 | 0.95, 1.33 | 0.2 |
| Black | 1.12 | 1.04, 1.22 | 0.005 |
| Hispanic | 1.08 | 0.98, 1.19 | 0.11 |
| Native American | 0.89 | 0.66, 1.19 | 0.4 |
| Other | 1.25 | 1.05, 1.48 | 0.012 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.01 | 0.94, 1.08 | 0.8 |
| $66,000 - $87,999 | 0.95 | 0.88, 1.03 | 0.2 |
| $88,000 or more | 0.90 | 0.83, 0.98 | 0.017 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.07 | 0.97, 1.17 | 0.2 |
| Medicare | 1.12 | 1.04, 1.21 | 0.003 |
| Other | 1.12 | 0.93, 1.33 | 0.2 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.02 | 0.92, 1.12 | 0.8 |
| South | 0.90 | 0.84, 0.97 | 0.005 |
| West | 1.06 | 0.97, 1.16 | 0.2 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.75 | 0.70, 0.79 | <0.001 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 0.77 | 0.73, 0.82 | <0.001 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 0.88 | 0.82, 0.94 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 1.49 | 1.41, 1.57 | <0.001 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 1.26 | 1.16, 1.37 | <0.001 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 0.97 | 0.88, 1.06 | 0.5 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.56 | 1.47, 1.66 | <0.001 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.09 | 1.02, 1.16 | 0.012 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 0.85 | 0.81, 0.90 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 2.03 | 1.87, 2.21 | <0.001 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | 0.79 | 0.72, 0.87 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.10 | 1.00, 1.20 | 0.058 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.11 | 1.05, 1.18 | <0.001 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | 0.94 | 0.83, 1.06 | 0.3 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.89, 1.03 | 0.3 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 2.73 | 2.59, 2.87 | <0.001 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 2.74 | 2.35, 3.19 | <0.001 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.81, 1.13 | 0.6 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.91 | 0.85, 0.98 | 0.008 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Acute Myocardial Infarction:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | 0.97 | 0.92, 1.02 | 0.2 |
| Age, y | 1.01 | 1.01, 1.02 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.09 | 1.04, 1.14 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.01 | 0.86, 1.18 | >0.9 |
| Black | 0.95 | 0.88, 1.02 | 0.2 |
| Hispanic | 0.89 | 0.80, 0.98 | 0.018 |
| Native American | 1.25 | 0.95, 1.64 | 0.11 |
| Other | 1.17 | 1.01, 1.36 | 0.038 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.94 | 0.88, 1.00 | 0.035 |
| $66,000 - $87,999 | 0.82 | 0.77, 0.88 | <0.001 |
| $88,000 or more | 0.80 | 0.74, 0.87 | <0.001 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.08 | 0.97, 1.20 | 0.2 |
| Medicare | 0.96 | 0.89, 1.03 | 0.2 |
| Other | 1.09 | 0.92, 1.29 | 0.3 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.35 | 1.22, 1.48 | <0.001 |
| South | 0.93 | 0.86, 1.01 | 0.075 |
| West | 1.01 | 0.92, 1.11 | 0.8 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.08 | 1.01, 1.15 | 0.018 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 1.02 | 0.97, 1.07 | 0.5 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 1.89 | 1.80, 1.99 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 1.02, 1.13 | 0.006 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 1.30 | 1.22, 1.39 | <0.001 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.94, 1.08 | 0.8 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 2.52 | 2.39, 2.66 | <0.001 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.26 | 1.20, 1.32 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.96, 1.05 | >0.9 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.11 | 1.00, 1.23 | 0.042 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | 0.85 | 0.79, 0.92 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 0.98, 1.16 | 0.14 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.30 | 1.21, 1.39 | <0.001 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | 1.19 | 1.06, 1.34 | 0.004 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.90, 1.03 | 0.2 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 1.54 | 1.48, 1.61 | <0.001 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 1.38 | 1.11, 1.71 | 0.004 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.85, 1.20 | >0.9 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.92 | 0.86, 0.98 | 0.006 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Acute Ischemic Stroke:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | 0.79 | 0.70, 0.88 | <0.001 |
| Age, y | 1.03 | 1.03, 1.04 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.95 | 0.84, 1.08 | 0.5 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.49 | 0.29, 0.84 | 0.009 |
| Black | 1.26 | 1.06, 1.50 | 0.009 |
| Hispanic | 0.89 | 0.71, 1.12 | 0.3 |
| Native American | 1.17 | 0.58, 2.37 | 0.7 |
| Other | 0.89 | 0.60, 1.33 | 0.6 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.87 | 0.75, 1.01 | 0.066 |
| $66,000 - $87,999 | 0.92 | 0.78, 1.08 | 0.3 |
| $88,000 or more | 0.82 | 0.68, 0.99 | 0.042 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.87 | 0.66, 1.14 | 0.3 |
| Medicare | 0.77 | 0.64, 0.92 | 0.004 |
| Other | 1.11 | 0.76, 1.62 | 0.6 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.10 | 0.91, 1.34 | 0.3 |
| South | 1.27 | 1.10, 1.48 | 0.002 |
| West | 1.16 | 0.95, 1.41 | 0.14 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.08 | 0.92, 1.26 | 0.3 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.87, 1.11 | 0.8 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.83, 1.10 | 0.6 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 1.50 | 1.32, 1.70 | <0.001 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 1.15 | 0.95, 1.40 | 0.15 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 0.97 | 0.79, 1.18 | 0.7 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.37 | 1.20, 1.57 | <0.001 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.26 | 1.10, 1.44 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 0.80 | 0.71, 0.90 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.64 | 1.30, 2.08 | <0.001 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | 0.72 | 0.57, 0.91 | 0.005 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.12 | 0.91, 1.38 | 0.3 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.18 | 1.03, 1.34 | 0.015 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | 1.34 | 0.98, 1.82 | 0.063 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.67 | 0.56, 0.82 | <0.001 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 1.65 | 1.48, 1.85 | <0.001 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 45.7 | 39.2, 53.4 | <0.001 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.64, 1.67 | 0.9 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.90 | 0.76, 1.06 | 0.2 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Non-Home Discharge:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | 1.06 | 1.02, 1.10 | 0.004 |
| Age, y | 1.00 | 1.00, 1.00 | 0.7 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.23 | 1.19, 1.28 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.07 | 0.96, 1.20 | 0.2 |
| Black | 1.06 | 1.01, 1.12 | 0.021 |
| Hispanic | 0.97 | 0.90, 1.03 | 0.3 |
| Native American | 1.04 | 0.86, 1.25 | 0.7 |
| Other | 1.17 | 1.06, 1.29 | 0.003 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.87 | 0.84, 0.91 | <0.001 |
| $66,000 - $87,999 | 0.85 | 0.81, 0.89 | <0.001 |
| $88,000 or more | 0.80 | 0.75, 0.84 | <0.001 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.47 | 1.39, 1.56 | <0.001 |
| Medicare | 1.02 | 0.97, 1.07 | 0.5 |
| Other | 1.56 | 1.39, 1.75 | <0.001 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.47 | 1.38, 1.56 | <0.001 |
| South | 1.09 | 1.04, 1.14 | <0.001 |
| West | 1.25 | 1.18, 1.33 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.78 | 0.75, 0.81 | <0.001 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 0.74 | 0.71, 0.77 | <0.001 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.94, 1.02 | 0.4 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 1.40 | 1.35, 1.45 | <0.001 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 1.33 | 1.26, 1.41 | <0.001 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.98, 1.10 | 0.2 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.47 | 1.41, 1.53 | <0.001 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.09 | 1.05, 1.13 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.90, 0.96 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.49 | 1.40, 1.59 | <0.001 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | 0.70 | 0.66, 0.75 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 0.89 | 0.84, 0.96 | 0.001 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.32 | 1.27, 1.38 | <0.001 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | 2.14 | 2.02, 2.27 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.72 | 0.69, 0.76 | <0.001 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 1.57 | 1.52, 1.62 | <0.001 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 1.38 | 1.20, 1.58 | <0.001 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 1.22 | 1.10, 1.34 | <0.001 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.84 | 0.80, 0.88 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

## Multivariable Linear Regression:

### Length of Stay:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | -0.09 | -0.13, -0.06 | <0.001 |
| Age, y | 0.01 | 0.00, 0.01 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.03 | 0.00, 0.07 | 0.045 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.35 | 0.21, 0.50 | <0.001 |
| Black | 0.25 | 0.19, 0.31 | <0.001 |
| Hispanic | 0.17 | 0.09, 0.24 | <0.001 |
| Native American | -0.03 | -0.21, 0.16 | 0.8 |
| Other | 0.30 | 0.15, 0.46 | <0.001 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | -0.04 | -0.09, 0.00 | 0.064 |
| $66,000 - $87,999 | -0.02 | -0.07, 0.03 | 0.4 |
| $88,000 or more | 0.06 | 0.00, 0.12 | 0.045 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.33 | 0.25, 0.41 | <0.001 |
| Medicare | 0.19 | 0.14, 0.24 | <0.001 |
| Other | 0.23 | 0.10, 0.35 | <0.001 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.56 | 0.48, 0.64 | <0.001 |
| South | 0.43 | 0.38, 0.49 | <0.001 |
| West | 0.02 | -0.04, 0.09 | 0.5 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | -0.10 | -0.14, -0.06 | <0.001 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | -0.25 | -0.28, -0.22 | <0.001 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | -0.15 | -0.19, -0.11 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 0.68 | 0.63, 0.72 | <0.001 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 1.1 | 1.0, 1.2 | <0.001 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | -0.04 | -0.10, 0.02 | 0.2 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 0.89 | 0.84, 0.93 | <0.001 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 0.36 | 0.32, 0.41 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 0.42 | 0.39, 0.46 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 0.81 | 0.71, 0.91 | <0.001 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | 0.06 | 0.01, 0.12 | 0.017 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 0.84 | 0.76, 0.92 | <0.001 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 0.11 | 0.05, 0.16 | <0.001 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | -0.07 | -0.15, 0.02 | 0.12 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.14 | 0.09, 0.18 | <0.001 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 1.4 | 1.3, 1.4 | <0.001 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 2.6 | 2.3, 2.9 | <0.001 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 0.85 | 0.68, 1.0 | <0.001 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.34 | 0.29, 0.38 | <0.001 |
| Abbreviation: CI = Confidence Interval | | | |

### Inflation Adjusted Total Charge:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Diabetes Categories |  |  |  |
| Pneumonia with Diabetes | — | — |  |
| Pneumonia without Diabetes | -1,973 | -2,454, -1,492 | <0.001 |
| Age, y | -244 | -267, -220 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1,957 | 1,507, 2,406 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 13,379 | 10,428, 16,329 | <0.001 |
| Black | 5,547 | 4,467, 6,626 | <0.001 |
| Hispanic | 13,741 | 12,175, 15,307 | <0.001 |
| Native American | -7,819 | -10,607, -5,030 | <0.001 |
| Other | 13,217 | 9,902, 16,532 | <0.001 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1,105 | 345, 1,864 | 0.004 |
| $66,000 - $87,999 | 3,804 | 2,898, 4,710 | <0.001 |
| $88,000 or more | 8,467 | 7,127, 9,807 | <0.001 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 993 | -132, 2,118 | 0.084 |
| Medicare | 1,698 | 944, 2,452 | <0.001 |
| Other | 539 | -1,129, 2,207 | 0.5 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 12,322 | 10,368, 14,276 | <0.001 |
| South | 10,596 | 9,566, 11,626 | <0.001 |
| West | 24,742 | 23,126, 26,359 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 391 | -157, 939 | 0.2 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | -1,134 | -1,629, -640 | <0.001 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | -379 | -892, 134 | 0.15 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 9,325 | 8,723, 9,927 | <0.001 |
| Pulmonary circulation disorders |  |  |  |
| No | — | — |  |
| Yes | 13,818 | 12,693, 14,943 | <0.001 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 268 | -499, 1,034 | 0.5 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 10,103 | 9,480, 10,727 | <0.001 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 3,416 | 2,780, 4,051 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 5,996 | 5,529, 6,463 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 12,158 | 10,713, 13,603 | <0.001 |
| Obstructive sleep apnea |  |  |  |
| No | — | — |  |
| Yes | -173 | -873, 527 | 0.6 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 8,352 | 7,337, 9,366 | <0.001 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 2,678 | 1,462, 3,893 | <0.001 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | -837 | -1,982, 307 | 0.2 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 2,739 | 2,031, 3,447 | <0.001 |
| Electrolyte and fluid imbalance |  |  |  |
| No | — | — |  |
| Yes | 16,968 | 16,385, 17,552 | <0.001 |
| Paralysis |  |  |  |
| No | — | — |  |
| Yes | 33,864 | 29,638, 38,091 | <0.001 |
| Psychoses |  |  |  |
| No | — | — |  |
| Yes | 4,978 | 3,353, 6,603 | <0.001 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 1,276 | 668, 1,885 | <0.001 |
| Abbreviation: CI = Confidence Interval | | | |