The Impact of Obstructive Sleep Apnea on Maternal Pregnancy Outcomes

National Inpatient Sample Analysis (2018–2020)

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## Preamble:

* **Study Objective**: Evaluate the association between obstructive sleep apnea (OSA) and maternal outcomes during pregnancy across U.S. hospitals from 2018 to 2020, adjusting for demographic, clinical, and hospital-related factors.
* **Data Source**: Cross-sectional analysis using the National Inpatient Sample (NIS) from 2018 to 2020, a nationwide database that captures inpatient admissions in the U.S., and is weighted to provide nationally representative estimates.
* **Patient Selection**: Included all inpatient admissions for pregnancy-related diagnoses (ICD Diagnosis Table), identified using ICD-10 diagnosis codes. Patients were categorized based on the presence or absence of obstructive sleep apnea, identified using ICD-10-CM code G47.33.
* **Outcomes of Interest:**
  + Eclampsia/Preeclampsia
  + Postpartum Hemorrhage
  + Gestational Diabetes
  + Gestational Hypertension
  + Cesarean Section
  + Length of Stay (days)
  + Inflation-Adjusted Total Charge (adjusted to 2020, $)
* **Adjustment Variables:**
  + **Demographics and Socioeconomic Factors:** Age, race/ethnicity, residential income quartile, insurance payer.
  + **Hospital Characteristics:** Region, bed size, and teaching status.
  + **Clinical Factors:** Charlson comorbidity index, alcohol use disorder, anemia, cardiac arrhythmias, chronic obstructive pulmonary disease, diabetes mellitus, substance use disorder, heart failure, hypertension, hypothyroidism, obesity, and tobacco use disorder.
* **Statistical Analysis**:
  + **Univariable Analysis:**
    - **Continuous Outcomes:** Design-based Kruskal-Wallis test for continuous outcomes e.g., length of stay and total charges.
    - **Categorical Outcomes:** Rao & Scott-adjusted Pearson’s Chi-square test for categorical outcomes e.g., eclampsia/preeclampsia, postpartum hemorrhage, gestational diabetes, etc.
  + **Multivariable Analysis:**
    - **Logistic Regression:** For binary outcomes (e.g., eclampsia/preeclampsia, postpartum hemorrhage, gestational diabetes, etc.). Report adjusted odds ratios (ORs) with 95% confidence intervals (CIs).
    - **Linear Regression:** For continuous outcomes (e.g., length of stay, total charges). Report adjusted beta coefficients with 95% CIs.
  + **Model Adjustment:** All models adjusted for the demographic, clinical, and hospital factors listed above, as well as OSA status (yes/no).
  + **Survey Weights:** The NIS survey design and discharge weights were applied to account for the complex sampling methodology and ensure nationally representative estimates.
* **Software:** All analyses were conducted using the R Statistical Language (Version 4.4.2; R Foundation for Statistical Computing, Vienna, Austria), utilizing the *survey* package to account for complex sampling designs of the NIS.

## Baseline Table:

| **Characteristic** | **Overall** N = 1,112,285*1* | **Pregnancy without OSA** N = 1,111,470*1* | **Pregnancy with OSA** N = 815*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age, y | 28.6 (5.7) | 28.6 (5.7) | 32.0 (6.6) | <0.001 |
| Race |  |  |  | <0.001 |
| White | 537,380 (50%) | 537,025 (50%) | 355 (45%) |  |
| Asian or Pacific Islander | 74,070 (6.9%) | 74,025 (6.9%) | 45 (5.7%) |  |
| Black | 157,775 (15%) | 157,565 (15%) | 210 (27%) |  |
| Hispanic | 249,420 (23%) | 249,255 (23%) | 165 (21%) |  |
| Other | 58,855 (5.5%) | 58,840 (5.5%) | 15 (1.9%) |  |
| Income quartile |  |  |  | 0.7 |
| $1 - $51,999 | 305,535 (28%) | 305,295 (28%) | 240 (29%) |  |
| $52,000 - $65,999 | 281,195 (26%) | 281,010 (26%) | 185 (23%) |  |
| $66,000 - $87,999 | 271,485 (25%) | 271,260 (25%) | 225 (28%) |  |
| $88,000 or more | 244,080 (22%) | 243,915 (22%) | 165 (20%) |  |
| Insurance payer |  |  |  | <0.001 |
| Private | 567,230 (51%) | 566,800 (51%) | 430 (53%) |  |
| Medicaid | 473,685 (43%) | 473,370 (43%) | 315 (39%) |  |
| Medicare | 6,790 (0.6%) | 6,745 (0.6%) | 45 (5.6%) |  |
| Other | 63,295 (5.7%) | 63,275 (5.7%) | 20 (2.5%) |  |
| Hospital region |  |  |  | <0.001 |
| Midwest | 193,520 (17%) | 193,385 (17%) | 135 (17%) |  |
| Northeast | 193,885 (17%) | 193,715 (17%) | 170 (21%) |  |
| South | 441,835 (40%) | 441,640 (40%) | 195 (24%) |  |
| West | 283,045 (25%) | 282,730 (25%) | 315 (39%) |  |
| Hospital bedsize |  |  |  | 0.8 |
| Large | 544,395 (49%) | 543,975 (49%) | 420 (52%) |  |
| Medium | 337,655 (30%) | 337,430 (30%) | 225 (28%) |  |
| Small | 230,235 (21%) | 230,065 (21%) | 170 (21%) |  |
| Hospital location/teaching status |  |  |  | <0.001 |
| Rural | 98,785 (8.9%) | 98,755 (8.9%) | 30 (3.7%) |  |
| Urban, non-teaching | 201,660 (18%) | 201,590 (18%) | 70 (8.6%) |  |
| Urban, teaching | 811,840 (73%) | 811,125 (73%) | 715 (88%) |  |
| Alcohol use disorder | 299,025 (27%) | 298,750 (27%) | 275 (34%) | 0.060 |
| Anemia | 16,625 (1.5%) | 16,580 (1.5%) | 45 (5.5%) | <0.001 |
| Cardiac arrhythmias | 9,140 (0.8%) | 9,095 (0.8%) | 45 (5.5%) | <0.001 |
| Chronic obstructive pulmonary disease | 49,030 (4.4%) | 48,825 (4.4%) | 205 (25%) | <0.001 |
| Diabetes mellitus | 3,990 (0.4%) | 3,935 (0.4%) | 55 (6.7%) | <0.001 |
| Substance use disorder | 23,300 (2.1%) | 23,245 (2.1%) | 55 (6.7%) | <0.001 |
| Heart failure | 425 (<0.1%) | 410 (<0.1%) | 15 (1.8%) | <0.001 |
| Hypertension | 1,770 (0.2%) | 1,715 (0.2%) | 55 (6.7%) | <0.001 |
| Hypothyroidism | 29,385 (2.6%) | 29,305 (2.6%) | 80 (9.8%) | <0.001 |
| Obesity | 72,905 (6.6%) | 72,460 (6.5%) | 445 (55%) | <0.001 |
| Tobacco use disorder | 32,435 (2.9%) | 32,395 (2.9%) | 40 (4.9%) | 0.13 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Outcomes Table:

| **Characteristic** | **Overall** N = 1,112,285*1* | **Pregnancy without OSA** N = 1,111,470*1* | **Pregnancy with OSA** N = 815*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Length of stay (days) | 2.00 (2.00, 3.00) | 2.00 (2.00, 3.00) | 3.00 (2.00, 4.00) | <0.001 |
| Inflation-adjusted total charge ($) | 15,861 (10,778, 23,869) | 15,858 (10,776, 23,862) | 22,995 (15,298, 39,730) | <0.001 |
| Eclampsia/pre-eclampsia | 24,325 (2.2%) | 24,220 (2.2%) | 105 (13%) | <0.001 |
| Postpartum hemorrhage | 34,285 (3.1%) | 34,210 (3.1%) | 75 (9.2%) | <0.001 |
| Gestational diabetes | 37,100 (3.3%) | 37,010 (3.3%) | 90 (11%) | <0.001 |
| Gestational hypertension | 32,490 (2.9%) | 32,400 (2.9%) | 90 (11%) | <0.001 |
| Cesarean section | 171,260 (15%) | 170,950 (15%) | 310 (38%) | <0.001 |
| *1*Median (Q1, Q3); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Multivariable Regression:

### Eclampsia/Preeclampsia:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| OSA status |  |  |  |
| Pregnancy without OSA | — | — |  |
| Pregnancy with OSA | 2.45 | 1.44, 4.15 | <0.001 |
| Age, y | 1.00 | 1.00, 1.01 | 0.3 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.03 | 0.90, 1.18 | 0.7 |
| Black | 1.63 | 1.49, 1.78 | <0.001 |
| Hispanic | 1.21 | 1.11, 1.33 | <0.001 |
| Other | 1.18 | 1.03, 1.35 | 0.019 |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.96 | 0.89, 1.03 | 0.2 |
| Medicare | 1.13 | 0.80, 1.59 | 0.5 |
| Other | 0.91 | 0.79, 1.05 | 0.2 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.98 | 0.90, 1.07 | 0.7 |
| $66,000 - $87,999 | 1.02 | 0.93, 1.12 | 0.7 |
| $88,000 or more | 0.93 | 0.84, 1.03 | 0.2 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.29 | 1.15, 1.46 | <0.001 |
| South | 0.87 | 0.78, 0.98 | 0.016 |
| West | 1.10 | 0.98, 1.24 | 0.10 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.92 | 0.84, 1.00 | 0.058 |
| Small | 0.83 | 0.75, 0.93 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.47 | 1.21, 1.80 | <0.001 |
| Urban, teaching | 2.40 | 2.01, 2.87 | <0.001 |
| Charlson comorbidity index | 1.08 | 0.96, 1.23 | 0.2 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.24 | 1.13, 1.36 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.66 | 1.40, 1.97 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 2.47 | 2.03, 3.00 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.18 | 1.00, 1.40 | 0.055 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 2.60 | 1.93, 3.50 | <0.001 |
| Substance use disorder |  |  |  |
| No | — | — |  |
| Yes | 2.10 | 1.82, 2.43 | <0.001 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 2.56 | 1.03, 6.33 | 0.043 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.35 | 0.16, 0.77 | 0.009 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 1.42 | 1.22, 1.64 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 2.90 | 2.68, 3.15 | <0.001 |
| Tobacco use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.34 | 1.16, 1.55 | <0.001 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Postpartum Hemorrhage:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| OSA status |  |  |  |
| Pregnancy without OSA | — | — |  |
| Pregnancy with OSA | 1.54 | 0.81, 2.94 | 0.2 |
| Age, y | 1.00 | 1.0, 1.00 | 0.9 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.52 | 1.38, 1.67 | <0.001 |
| Black | 0.98 | 0.90, 1.07 | 0.7 |
| Hispanic | 1.23 | 1.14, 1.34 | <0.001 |
| Other | 1.15 | 1.03, 1.29 | 0.015 |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.81 | 0.76, 0.86 | <0.001 |
| Medicare | 0.87 | 0.60, 1.27 | 0.5 |
| Other | 0.83 | 0.73, 0.93 | 0.002 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.15 | 1.06, 1.24 | <0.001 |
| $66,000 - $87,999 | 1.20 | 1.10, 1.30 | <0.001 |
| $88,000 or more | 1.31 | 1.20, 1.44 | <0.001 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.02 | 0.90, 1.15 | 0.8 |
| South | 0.73 | 0.65, 0.81 | <0.001 |
| West | 1.11 | 0.99, 1.23 | 0.068 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.83 | 0.76, 0.91 | <0.001 |
| Small | 0.84 | 0.76, 0.92 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.06 | 0.91, 1.22 | 0.5 |
| Urban, teaching | 1.53 | 1.34, 1.74 | <0.001 |
| Charlson comorbidity index | 1.09 | 0.97, 1.23 | 0.2 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.11 | 1.02, 1.22 | 0.019 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 2.28 | 1.98, 2.63 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 3.53 | 3.01, 4.14 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.33 | 1.14, 1.55 | <0.001 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 0.80 | 0.53, 1.22 | 0.3 |
| Substance use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.16 | 0.98, 1.38 | 0.086 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 0.70 | 0.20, 2.46 | 0.6 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.67 | 0.34, 1.30 | 0.2 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 1.36 | 1.21, 1.55 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 1.95 | 1.79, 2.12 | <0.001 |
| Tobacco use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.25 | 1.07, 1.46 | 0.004 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Gestational Diabetes:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| OSA status |  |  |  |
| Pregnancy without OSA | — | — |  |
| Pregnancy with OSA | 1.59 | 0.95, 2.66 | 0.078 |
| Age, y | 1.09 | 1.08, 1.09 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 2.81 | 2.60, 3.04 | <0.001 |
| Black | 0.96 | 0.88, 1.05 | 0.3 |
| Hispanic | 1.39 | 1.30, 1.49 | <0.001 |
| Other | 1.60 | 1.44, 1.77 | <0.001 |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.99 | 0.93, 1.05 | 0.7 |
| Medicare | 0.89 | 0.65, 1.22 | 0.5 |
| Other | 0.86 | 0.77, 0.97 | 0.014 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.19 | 1.10, 1.28 | <0.001 |
| $66,000 - $87,999 | 1.13 | 1.05, 1.22 | 0.002 |
| $88,000 or more | 1.06 | 0.97, 1.15 | 0.2 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.13 | 1.03, 1.25 | 0.012 |
| South | 0.81 | 0.74, 0.89 | <0.001 |
| West | 0.99 | 0.90, 1.08 | 0.8 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.94 | 0.88, 1.00 | 0.069 |
| Small | 0.91 | 0.84, 0.98 | 0.018 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.19 | 1.04, 1.36 | 0.012 |
| Urban, teaching | 1.32 | 1.16, 1.49 | <0.001 |
| Charlson comorbidity index | 1.18 | 1.06, 1.32 | 0.003 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.17 | 1.10, 1.25 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.20 | 0.99, 1.45 | 0.060 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 1.12 | 0.89, 1.42 | 0.3 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.89, 1.21 | 0.6 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 0.07 | 0.03, 0.18 | <0.001 |
| Substance use disorder |  |  |  |
| No | — | — |  |
| Yes | 0.63 | 0.51, 0.79 | <0.001 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 0.15 | 0.02, 1.32 | 0.087 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.09 | 0.57, 2.08 | 0.8 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 1.65 | 1.48, 1.84 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 3.13 | 2.91, 3.36 | <0.001 |
| Tobacco use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.36 | 1.18, 1.57 | <0.001 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Gestational Hypertension:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| OSA status |  |  |  |
| Pregnancy without OSA | — | — |  |
| Pregnancy with OSA | 1.60 | 0.93, 2.75 | 0.089 |
| Age, y | 1.00 | 1.00, 1.01 | 0.8 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.79 | 0.70, 0.90 | <0.001 |
| Black | 1.21 | 1.11, 1.32 | <0.001 |
| Hispanic | 0.77 | 0.70, 0.85 | <0.001 |
| Other | 0.89 | 0.78, 1.01 | 0.080 |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.86 | 0.81, 0.92 | <0.001 |
| Medicare | 0.74 | 0.52, 1.04 | 0.081 |
| Other | 0.85 | 0.75, 0.98 | 0.020 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.91 | 0.84, 0.98 | 0.015 |
| $66,000 - $87,999 | 0.95 | 0.87, 1.04 | 0.2 |
| $88,000 or more | 0.91 | 0.83, 1.00 | 0.058 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.19 | 1.04, 1.37 | 0.011 |
| South | 0.80 | 0.71, 0.90 | <0.001 |
| West | 0.92 | 0.81, 1.04 | 0.2 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.81 | 0.74, 0.89 | <0.001 |
| Small | 0.65 | 0.58, 0.72 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.36 | 1.15, 1.61 | <0.001 |
| Urban, teaching | 2.34 | 2.02, 2.71 | <0.001 |
| Charlson comorbidity index | 0.95 | 0.82, 1.11 | 0.5 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.11 | 1.01, 1.22 | 0.025 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.55 | 1.31, 1.82 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 2.04 | 1.69, 2.47 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.40 | 1.16, 1.68 | <0.001 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 1.67 | 1.20, 2.33 | 0.002 |
| Substance use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.53 | 1.32, 1.77 | <0.001 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 0.61 | 0.13, 2.86 | 0.5 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.28 | 0.11, 0.72 | 0.009 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 1.45 | 1.28, 1.65 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 3.14 | 2.92, 3.39 | <0.001 |
| Tobacco use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.50 | 1.31, 1.71 | <0.001 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Cesarean Section:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| OSA status |  |  |  |
| Pregnancy without OSA | — | — |  |
| Pregnancy with OSA | 1.41 | 0.97, 2.05 | 0.073 |
| Age, y | 1.04 | 1.04, 1.04 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.32 | 1.26, 1.39 | <0.001 |
| Black | 1.20 | 1.16, 1.25 | <0.001 |
| Hispanic | 1.07 | 1.03, 1.11 | <0.001 |
| Other | 1.19 | 1.12, 1.26 | <0.001 |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.80 | 0.77, 0.82 | <0.001 |
| Medicare | 0.82 | 0.70, 0.95 | 0.011 |
| Other | 0.76 | 0.71, 0.80 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.05 | 1.01, 1.09 | 0.010 |
| $66,000 - $87,999 | 1.08 | 1.03, 1.12 | <0.001 |
| $88,000 or more | 1.08 | 1.03, 1.12 | 0.002 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.21 | 1.15, 1.28 | <0.001 |
| South | 1.07 | 1.02, 1.13 | 0.003 |
| West | 0.94 | 0.89, 0.99 | 0.015 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.94 | 0.90, 0.97 | <0.001 |
| Small | 0.90 | 0.86, 0.94 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.12 | 1.05, 1.20 | 0.001 |
| Urban, teaching | 1.28 | 1.20, 1.36 | <0.001 |
| Charlson comorbidity index | 1.04 | 0.96, 1.13 | 0.3 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.06 | 1.02, 1.10 | 0.002 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.69 | 1.55, 1.86 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 2.22 | 2.00, 2.47 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.39 | 1.25, 1.54 | <0.001 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 2.78 | 2.31, 3.33 | <0.001 |
| Substance use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.25 | 1.15, 1.36 | <0.001 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.15 | 0.62, 2.13 | 0.7 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.37 | 0.24, 0.55 | <0.001 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 1.56 | 1.46, 1.66 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 2.80 | 2.68, 2.93 | <0.001 |
| Tobacco use disorder |  |  |  |
| No | — | — |  |
| Yes | 1.63 | 1.51, 1.75 | <0.001 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Length of Stay:

| **Characteristic** | **Beta** | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| OSA status |  |  |  |
| Pregnancy without OSA | — | — |  |
| Pregnancy with OSA | 1.3 | 0.41, 2.2 | 0.004 |
| Age, y | 0.00 | 0.00, 0.00 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.17 | 0.15, 0.19 | <0.001 |
| Black | 0.15 | 0.13, 0.17 | <0.001 |
| Hispanic | 0.02 | 0.00, 0.04 | 0.047 |
| Other | 0.08 | 0.06, 0.10 | <0.001 |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | -0.05 | -0.07, -0.04 | <0.001 |
| Medicare | 0.27 | 0.14, 0.40 | <0.001 |
| Other | -0.11 | -0.14, -0.08 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.03 | 0.01, 0.05 | <0.001 |
| $66,000 - $87,999 | 0.05 | 0.03, 0.07 | <0.001 |
| $88,000 or more | 0.09 | 0.07, 0.12 | <0.001 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.24 | 0.21, 0.27 | <0.001 |
| South | 0.02 | -0.01, 0.04 | 0.2 |
| West | -0.11 | -0.14, -0.09 | <0.001 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | -0.07 | -0.10, -0.05 | <0.001 |
| Small | -0.12 | -0.14, -0.09 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.14 | 0.12, 0.17 | <0.001 |
| Urban, teaching | 0.26 | 0.23, 0.28 | <0.001 |
| Charlson comorbidity index | 0.35 | 0.23, 0.47 | <0.001 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | -0.10 | -0.12, -0.07 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 0.31 | 0.24, 0.39 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 0.62 | 0.53, 0.71 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | -0.15 | -0.27, -0.03 | 0.015 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 0.45 | 0.20, 0.70 | <0.001 |
| Substance use disorder |  |  |  |
| No | — | — |  |
| Yes | 0.44 | 0.35, 0.53 | <0.001 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 0.18 | -0.71, 1.1 | 0.7 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.90 | 0.37, 1.4 | <0.001 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 0.27 | 0.22, 0.32 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.37 | 0.34, 0.40 | <0.001 |
| Tobacco use disorder |  |  |  |
| No | — | — |  |
| Yes | 0.02 | -0.02, 0.06 | 0.4 |
| *1*CI = Confidence Interval | | | |

### Inflation-Adjusted Total Charge:

| **Characteristic** | **Beta** | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| OSA status |  |  |  |
| Pregnancy without OSA | — | — |  |
| Pregnancy with OSA | 7,727 | 1,425, 14,029 | 0.016 |
| Age, y | 74 | 56, 92 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 2,980 | 2,413, 3,548 | <0.001 |
| Black | 1,601 | 1,244, 1,958 | <0.001 |
| Hispanic | 2,382 | 1,983, 2,782 | <0.001 |
| Other | 2,031 | 1,564, 2,498 | <0.001 |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | -72 | -341, 198 | 0.6 |
| Medicare | 1,364 | -84, 2,812 | 0.065 |
| Other | -977 | -1,454, -501 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | -669 | -1,007, -331 | <0.001 |
| $66,000 - $87,999 | -420 | -808, -32 | 0.034 |
| $88,000 or more | 486 | -49, 1,021 | 0.075 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 6,352 | 5,356, 7,348 | <0.001 |
| South | 1,399 | 864, 1,934 | <0.001 |
| West | 5,788 | 5,067, 6,510 | <0.001 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | -1,122 | -1,821, -423 | 0.002 |
| Small | -2,752 | -3,399, -2,105 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 4,860 | 4,238, 5,482 | <0.001 |
| Urban, teaching | 5,603 | 5,108, 6,099 | <0.001 |
| Charlson comorbidity index | 6,625 | 4,729, 8,522 | <0.001 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 1,098 | 441, 1,755 | 0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 3,347 | 2,550, 4,144 | <0.001 |
| Cardiac arrhythmias |  |  |  |
| No | — | — |  |
| Yes | 10,234 | 8,176, 12,292 | <0.001 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | -4,755 | -6,710, -2,800 | <0.001 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 2,931 | -737, 6,599 | 0.12 |
| Substance use disorder |  |  |  |
| No | — | — |  |
| Yes | 2,347 | 1,636, 3,058 | <0.001 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 17,059 | -14,620, 48,737 | 0.3 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 6,315 | 223, 12,406 | 0.042 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 2,188 | 1,727, 2,648 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 3,431 | 2,966, 3,895 | <0.001 |
| Tobacco use disorder |  |  |  |
| No | — | — |  |
| Yes | -385 | -811, 42 | 0.077 |
| *1*CI = Confidence Interval | | | |

## Supplemental Information:

### ICD-10 Codes:

1. **Pregnancy:** O4202, O4212, O4292, O6020X0, O6020X1, O6020X2, O6020X3, O6020X4, O6020X5, O6020X9, O6022X0, O6022X1, O6022X2, O6022X3, O6022X4, O6022X5, O6022X9, O6023X0, O6023X1, O6023X2, O6023X3, O6023X4, O6023X5, O6023X9, O80, Z3201, Z331, Z333, Z3400, Z3401, Z3402, Z3403, Z3480, Z3481, Z3482, Z3483, Z3490, Z3491, Z3492, Z3493, Z390, Z391, Z392
2. **Eclampsia/Preeclampsia:** O111, O112, O113, O114, O115, O119, O1400, O1402, O1403, O1404, O1405, O1410, O1412, O1413, O1414, O1415, O1490, O1492, O1493, O1494, O1495, O1500, O1502, O1503, O151, O152, O159
3. **Postpartum Hemorrhage:** O721, O722
4. **Gestational Diabetes:** O24410, O24414, O24415, O24420, O24424, O24425, O24430, O24434, O24435
5. **Gestational Hypertension:** O131, O132, O133, O134, O135, O139
6. **Cesarean Section:** 10D00Z0, 10D00Z1, 10D00Z2

All other ICD-10 codes for co-morbidities were defined based on the individual components with the Charlson Comorbidity Index.