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RESEARCH

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# Neighborhood socioeconomic status and postpartum depression among commercial health insurance enrollees: a retrospective cohort study

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## Abstract

**Background** Postpartum depression (PPD) is a prevalent psychological condition. Although the effect of obstetrical and maternal complications on PPD are well described, the impact of neighborhood socioeconomic status (SES) on PPD is relatively unexplored.

**Objectives** This study examined the relationship between neighborhood SES score and PPD.

**Methods** A summary SES measure for each U.S. zip code was constructed using income, education, and occupational 2021 Census data and linked to national commercial claims for 2017–2023. PPD status using diagnosis codes at outpatient and inpatient visits, and prescription drug use 3, 6, 9, and 12 months postpartum, were determined. Multivariate analysis controlled for potential confounders.

**Results** PPD prevalence in commercial claims was 11.48%. Patients with PPD had higher rates of obstetrical (OR: 1.555, $p < .0001$) and maternal complications (OR: 1.145, $p < .0001$), and more lifestyle risk factors (OR: 1.113, $p < .0001$). Comorbidity scores were higher for patients with PPD. Controlling for age and clinical factors, living in a disadvantaged neighborhood was associated with an increased incidence of PPD (OR: 1.137, $p < .0001$).

**Limitations** Claims data may include potential inaccurate coding of diagnoses/procedures. Clinical information is limited to conditions and treatments defined by ICD-10-CM codes. Area-based SES measures inevitably misclassify people on both ends of the socioeconomic spectrum (this misclassification is random; direction of bias is known).

**Conclusions** The inverse and significant effect of area-based high SES on PPD rates demonstrates that preventive efforts may require interventions focusing on both the patient and the lived environment.

**Keywords** Postpartum depression, Socioeconomic status, Maternal age, Lifestyle factors, Obstetric factors

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## Background

Postpartum depression (PPD) is a major depressive episode that typically occurs within one to 12 months after childbirth and is a highly prevalent psychological condition [1–15]. A 2021 meta-analysis by Wang et al. found that 17.22% of postpartum women worldwide had experienced PPD [1].

Several risk factors are associated with PPD, including obstetric factors (gestational diabetes, cesarean section, multiple births), lifestyle factors (reduced sleep, poor diet), and maternal age [1, 2, 4, 7–9, 11–13, 15]. Measures of socioeconomic status (SES) relating to neighborhood are generally defined by educational attainment, income level, and employment status within areas of residence, and tend to play a large role in determining individual health outcomes [4, 8]. One neighborhood characteristic associated with low SES is limited accessibility to healthcare resources, which may elevate the risk of PPD [1–13].

Although economic segregation is growing in the U.S. [16], the extent to which neighborhood characteristics are related to the incidence of PPD has not been established on a nationally representative scale. Previous studies analyzing this association have looked only at U.S. regional or state-level data or data from countries outside the U.S [2, 4–7, 9, 10, 12, 13].

The aim of this study is to investigate the effect of neighborhood SES score on PPD within 12 months postpartum among commercial health insurance enrollees. This study allows us to examine, for the first time, the association of SES score and PPD rates in the U.S. on a nationally representative scale.

## Methods

This retrospective cohort study is based on Kythera Labs data for the years 2017–2023. Kythera Labs data contain medical and pharmacy claims with 79% coverage of all U.S. patients. The data covers 310 million patients, 6.1 million practitioners, 1.6 million organizations, and 1.4 million facilities, generating at least 40 billion healthcare claims [17]. The data contains both open claims and closed claims. The closed claims contain around 172 million patients with commercial healthcare insurance, which is used for this study.

Data included the unique de-identified numbers of patients, age, gender, types of insurance, zip codes, diagnostic codes according to the *International Classification of Diseases* (ICD-10), procedures, and medications. The details of the data have been published elsewhere, and the healthcare outcomes derived from these data were compared with other data sets for validity and consistency [17, 18].

We identified women who delivered (ICD-10: O80-O84) during the identification period (January 2018–July 2022). The delivery date was designated as the index date. Patient claims were required to be in the data continuously for 12 months pre-index date (baseline period) and post-index date (follow-up period) (Fig. 1). PPD is defined in 3-month intervals within a year as follows: (a) at least one PPD diagnosis (ICD-10: F53), (b) at least one depression diagnosis (ICD-10: F32, F33, F34, F38, F39, F41) or (c) at least one pharmacy claim for Zulresso (National Drug Code: 72152-547-20) within 12 months postpartum.

To distinguish new onset of depressive illness during the postpartum period from an ongoing episode, we excluded women with prenatal depression disorder during the baseline, using appropriate ICD-10 codes.

We analyzed a set of demographic and clinical variables at baseline. Age was determined from the relevant field in the Kythera data and was categorized as <20, 21–24, 25–29, 30–34, and 35 years and older. Three different comorbidity indices were derived during the baseline

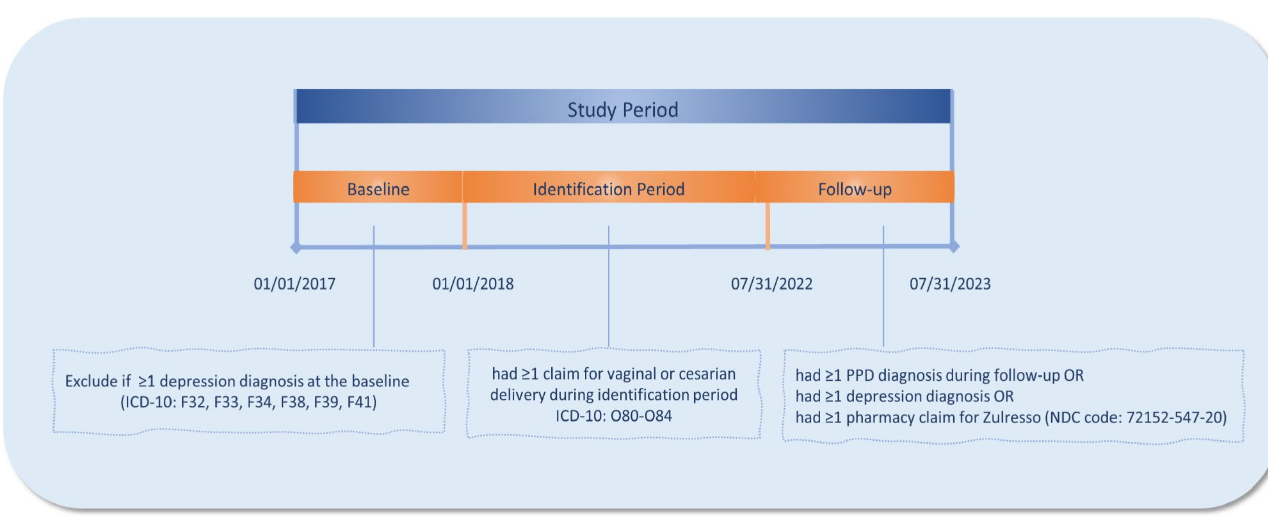


**Fig. 1** Study timeline

period to control for differences in overall comorbidities between patients with and those without PPD: updated Charlson Comorbidity Index (CCI), Chronic Disease Score (CDS), and Elixhauser Index. The original CCI encompassed 19 categories of medical comorbidities that were identifiable within medical conditions [19]. The original index has since adopted several weights, some of which allow outpatient diagnoses to contribute to the score, and was translated to the updated ICD-10 codes [19]. CDS is an aggregate comorbidity measure based on current medication use [20]. The score increases with the number of chronic diseases under treatment and the complexity of the treatment regimen. The Elixhauser Index is based on a comprehensive set of 30 ICD-9-CM comorbidity flags and has been updated to ICD-10 codes [21]. Current coding for the index is available from the Agency for Healthcare Research and Quality. It has been shown that using all these indexes improves the performance of the outcomes research models [22]. Obstetrical and maternal complications as well as lifestyle factors were identified using appropriate ICD-10 codes (Appendix Table A1).

#### Socioeconomic status

This study utilized a summary measure of SES for each U.S. zip code using data on income, education, and occupation from the five-year estimates for 2021 U.S. Census data [23]. These data are compiled over a period of five years to provide more reliable estimates, particularly for smaller geographic areas and smaller population subgroups. The five-year estimates typically cover a period of five calendar years leading up to the census year. For instance, the 2021 estimates would cover data collected from 2017 to 2021. The longer survey period allows for more accurate estimation of characteristics that may have low prevalence or fluctuate over time, such as certain demographic traits or socioeconomic indicators in small geographic areas. These five-year estimates are widely accepted and used by researchers, policymakers, businesses, and community organizations precisely because they offer a more comprehensive and statistically robust view of the population and its characteristics [24]. These estimates refer to statistical projections released by the Census Bureau every five years, covering various geographic, demographic, and socioeconomic factors. Using five-year estimates has two main advantages: it [1] provides a larger sample size for more credible data and [2] considers trends over five years for a comprehensive perspective. We then linked this information to the enrollees' zip code of residence in the Kythera files. Previous research identified six variables by factor analysis of census block groups that could be meaningfully combined into a summary SES score [25]. These variables include three measures of wealth/income (log of the median household income [26], log of the median value of housing units [27], and the percentage of household receiving interest, dividend, or net rental income [28]), two measures of education (the percentage of adults ≥ 25 years of age who had completed high school or the percentage of adults ≥ 25 years of age who had completed college) [29], and one measure of occupation/employment (the percentage of employed persons ≥ 16 years of age in executive, managerial, or professional specialty occupations) [29]. The $z$ score for each variable is calculated by subtracting the overall mean and dividing it by the standard deviation. For example, if the $z$ score for zip code 10,013 for the median housing income is 5, the median housing income among the residents in that zip code is five standard deviations higher than the overall median of housing income in the U.S. The SES score was then constructed by summing the $z$ scores for each of the six variables. Of the 33,774 zip code areas, 4,912 had missing data, with 4,161 having three or fewer missing variables. To address this, we applied the method of missing data imputation with grouping or stratification. We divided each variable into 10 tiers based on data set size and filled missing data using medians within each tier. After imputation, we combined the data with the existing population data, resulting in comprehensive information for 29,167 zip code areas. Summary SES scores ranged from −10.6320 to 23.0279, with larger scores corresponding to greater socioeconomic disadvantage. Subjects were sorted according to summary SES scores and grouped in terciles. SES characteristics are shown in Table 1.

Patients with PPD within 12 months and patients without PPD were analyzed descriptively by demographic factors, clinical factors, obstetrical complications, maternal comorbidities, and lifestyle risk factors within 12 months at baseline. Numbers and percentages were provided for the categorical variables; means and standard deviations were provided for continuous variables. Student's $t$-tests and Pearson chi-square tests were used to test statistically significant differences between the two cohorts at the 5% level for continuous and categorical variables, respectively. Standardized differences were also calculated for each variable. We constructed a logistic regression model to predict the likelihood of PPD within 12 months postpartum for each SES score group (low, medium, and high).

## Results

Of 1,565,789 commercial enrollees, a total of 179,728 (11.48%) PPD events occurred during the 12-month follow-up period after applying inclusion and exclusion criteria. Of the commercial cohort for whom SES score was categorized as unknown, 3.5% were not included in the descriptive and multivariate analysis. Around 45% of the PPD events occurred within 3 months, and 15% of

**Table 1** Characteristics of U.S. zip codes of commercially enrolled patients according to summary SES score tercile

| | 1 (Low) | 2 (Middle) | 3 (High) |
|---|---|---|---|
| **No. of patients** | 498,782 | 498,745 | 513,852 |
| Median SES summary score (range) | 1.16 (-10.63, 3.03) | 4.65 (3.03, 6.55) | 9.90 (6.55, 23.03) |
| **Wealth/income** | | | |
| Median household income ($) | 50,895 | 70,215 | 105,802 |
| Median value of housing unit ($) | 154,400 | 250,300 | 465,000 |
| Household with interest, dividend, or rental income (%) | 12.06 | 19.59 | 29.22 |
| **Education** | | | |
| Adult residents who completed at least high school (%) | 84.00 | 92.30 | 96.00 |
| Adult residents who completed at least college (%) | 19.20 | 34.00 | 56.90 |
| **Employment** | | | |
| Employed residents with management, professional, and related occupations (%) | 29.04 | 40.50 | 56.79 |

SES: socioeconomic status

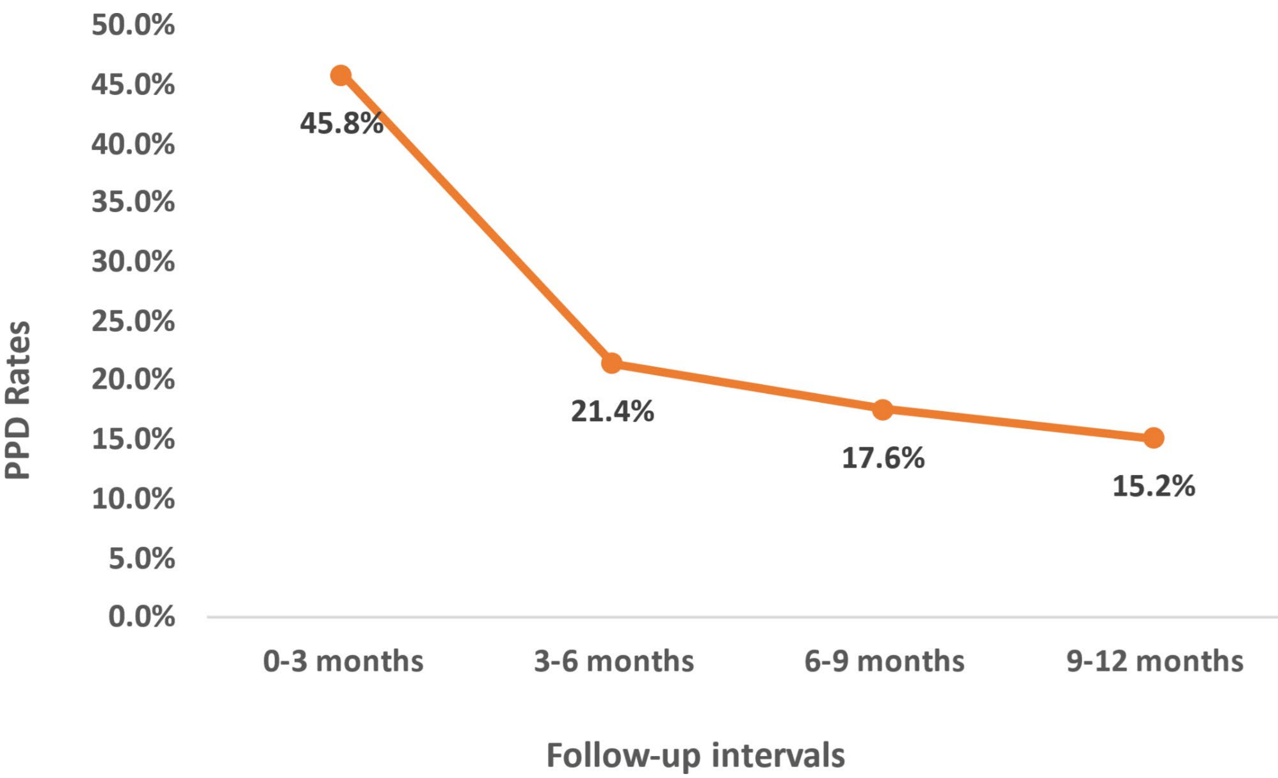


**Fig. 2** Timing of first PPD diagnosis during follow-up intervals within one year postpartum
PPD, postpartum depression

the events occurred between 9 and 12 months. Approximately 21% of PPD events occurred between 3 and 6 months. Around 18% of PPD events occurred between 6 and 9 months (Fig. 2).

Among the commercial enrollees, 3.5% were excluded from the descriptive and multivariate analysis because their SES score was categorized as unknown. The distributions of each of the component SES-related variables according to tercile of the overall summary SES score are given in Table 1. For example, median household income in the zip code of residence increased in a linear fashion from $50,895 for patients in the lowest SES tercile to $105,802 for patients in the highest SES tercile; the percentage of adult residents who completed college increased from 19.20% in the lowest SES tercile to 56.90% in the highest; and the percentage of employed residents with management, professional, and related occupations increased from 29.04% in the lowest SES tercile to 56.79% in the highest.

Table 2 shows a comprehensive summary of PPD rates and various demographic and clinical factors stratified by sSES score terciles. Without any risk adjustment, PPD rates are highest in the middle SES group and lowest in the high-SES group, suggesting an inverse relationship

**Table 2** Postpartum depression rates and summary of demographic and clinical factors by SES score tercile

| | 1 (Low) | 2 (Middle) | 3 (High) |
|---|---|---|---|
| **No. of patients** | 498,782 | 498,745 | 513,852 |
| PPD rates | 12.10% | 12.17% | 10.19% |
| **Age group (y)** | | | |
| ≤ 20 | 38,158 | 23,366 | 13,036 |
| 21–24 | 87,709 | 67,933 | 43,025 |
| 25–29 | 148,883 | 144,233 | 113,947 |
| 30–34 | 139,094 | 162,238 | 194,450 |
| 35+ | 84,923 | 100,969 | 149,382 |
| ADI score | | | |
| Low | 274,778 | 22,337 | 89,412 |
| Middle | 148,660 | 104,689 | 272,377 |
| High | 73,645 | 385,097 | 135,429 |
| **Comorbidity scores** | | | |
| Charlson Comorbidity Index ≥ 2 | 76,610 | 58,294 | 70,384 |
| Chronic Disease Score ≥ 2 | 3,620 | 2,845 | 2,945 |
| Elixhauser index ≥ 2 | 46,671 | 36,559 | 38,749 |
| **Baseline characteristics** | | | |
| Obstetrical complications | 379,566 | 367,287 | 382,511 |
| Maternal complications | 97,582 | 88,821 | 88,784 |
| Lifestyle risk factors | 76,830 | 65,255 | 62,358 |

PPD: postpartum depression; SES: socioeconomic status

between SES and PPD rates. (12.1% vs. 10.18%, $p<.001$). The data show a higher concentration of younger mothers (≤20 and 21–24 age groups) in the low-SES category compared to the high-SES category, which has a higher proportion of older mothers (30–34 and 35+age groups). The low-SES group has higher comorbidity scores, rates of obstetrical and maternal complications, as well as lifestyle risk factors, compared to the middle and high-SES groups.

Table 3 shows the obstetrical, maternal, and lifestyle risk factors among patients with and without PPD. Some of the most frequent comorbidities for PPD and non-PPD cohorts were other maternal diseases (60.16% vs. 45.26%, $p<.0001$) and abnormal findings (48.64% vs. 43.96%, $p<.0001$); pre-eclampsia or eclampsia comorbidities were significantly higher for the PPD cohort (14.30% vs. 10.23%, $p<.0001$).

Table 4 shows baseline characteristics of women with and without PPD within 12 months. Increased age was associated with decreased PPD rates. Additionally, comorbidity indexes and individual comorbidities are higher in patients with PPD than in those without PPD. Without adjusting for age and comorbidities, there is an inverse relationship between SES and PPD since the SES score is significantly lower in patients with PPD than those without (4.87 vs. 5.23, $p<.0001$).

All variables contributing to SES score, including household and educational attainment values, demonstrate statistically significant differences between patients with and without PPD.

Figure 3 shows that older ages have a significant inverse association with PPD. Both individual comorbidities and index values showed that PPD rates are higher with a higher number of comorbidities. Patients with PPD had higher rates of obstetrical (OR: 1.555, $p<.0001$) and maternal complications (OR: 1.145, $p<.0001$), and more lifestyle risk factors (OR: 1.113, $p<.0001$). Comorbidity scores were higher for patients with PPD. After adjusting for age and comorbidities, the low-SES or medium-SES group had significantly higher odds of having PPD than the high-SES group (adjusted OR: 1.137, 95% CI: [1.124, 1.149], $p<.0001$).

## Discussion

Our study reveals a significant association between neighborhood SES and PPD diagnosis. These findings contribute to the growing body of literature examining the impact of neighborhood-level factors on perinatal mental health outcomes. To our knowledge, this study is the first to report the association of SES and PPD rates in national commercial health claims in the U.S. Some of the prior research on the association between high PPD rates and low SES showed an inverse relationship using national data outside the U.S., local U.S. data sets, surveys, clinical data, and meta-analysis [1–13]. Wang and Geng [30] found that higher SES was associated with significantly improved physical health. Cai et al. concluded that increased educational attainment was correlated with a decreased risk of developing major depressive disorder [31]. One study concluded that PPD prevalence was greater in Palestine than in higher-income countries [4]. Another found that mothers with four characteristics related to decreased SES (low-income, unmarried, unemployed, and less than a college degree) were at 11 times greater risk of developing increased depressive symptoms 3 months postpartum than women without characteristics of decreased SES [7]. Some of the previous research, however, showed a more tenuous association between depression and SES [32, 33]. In a meta-analysis, Lorant showed that only 5 out of 11 specific studies showed a higher prevalence in the lower-SES group [32]. Mirotznik also showed such inconclusive results for depression, suggesting inequalities in depression should be further investigated [33]. Our findings indicate that, on a national scale, one's neighborhood of residence contributes to the risk of PPD. We found a consistent inverse relationship between PPD and SES score. Therefore, excluding SES as a risk factor in any outcome research studies might result in omitted variable bias and therefore bias the effect of exposure variables on outcomes.

Our findings demonstrating a negative association between SES scores and PPD in national commercial claims data also align with those of a recent study conducted in Northern California [34]. The cross-sectional

**Table 3** Obstetrical, maternal, and lifestyle risk factors among commercially insured patients with and without PPD measured within 12 months of delivery

| | PPD (*N* = 173,416) | | Without PPD (*N* = 1,337,963) | | *P* Value |
|---|---|---|---|---|---|
| | ***N*/Mean** | **%/Std** | ***N*/Mean** | **%/Std** | |
| **Obstetrical complications*** | | | | | |
| Severe perineal laceration | 358 | 0.21% | 2,692 | 0.20% | 0.6474 |
| Postpartum hemorrhage | 5,159 | 2.97% | 30,850 | 2.31% | < 0.0001 |
| Puerperal sepsis | 97 | 0.06% | 440 | 0.03% | < 0.0001 |
| Infection of obstetric surgical wound | 134 | 0.08% | 611 | 0.05% | < 0.0001 |
| Venous complication in puerperium | 344 | 0.20% | 2,551 | 0.19% | 0.4900 |
| Obstetric embolism | 312 | 0.18% | 1,428 | 0.11% | < 0.0001 |
| Complication of anesthesia | 443 | 0.26% | 2,417 | 0.18% | < 0.0001 |
| Complication of the puerperium | 6,545 | 3.77% | 36,065 | 2.70% | < 0.0001 |
| Other maternal diseases | 104,334 | 60.16% | 605,531 | 45.26% | < 0.0001 |
| Cesarean section | 26,938 | 15.53% | 191,180 | 14.29% | < 0.0001 |
| Multiple births | 5 | 0.00% | 35 | 0.00% | 0.8387 |
| Preterm and low-birth-weight infants | 84 | 0.05% | 519 | 0.04% | 0.0584 |
| Abnormal findings | 84,353 | 48.64% | 588,145 | 43.96% | < 0.0001 |
| Postpartum anemia | 3,984 | 2.30% | 25,155 | 1.88% | < 0.0001 |
| Negative birth experience | 7,066 | 4.07% | 41,299 | 3.09% | < 0.0001 |
| Meconium passage | 320 | 0.18% | 2,139 | 0.16% | 0.0165 |
| Umbilical cord prolapse | 195 | 0.11% | 1,343 | 0.10% | 0.1380 |
| Prior history of abortion | 8,548 | 4.93% | 63,218 | 4.72% | 0.0002 |
| Prior history of ectopic pregnancy | 83 | 0.05% | 562 | 0.04% | 0.2665 |
| Prior history of hydatidiform mole | 29 | 0.02% | 167 | 0.01% | 0.1445 |
| Other obstetric trauma | 8,555 | 4.93% | 51,700 | 3.86% | < 0.0001 |
| Premature rupture of membranes | 14,204 | 8.19% | 89,956 | 6.72% | < 0.0001 |
| Placental disorders | 10,338 | 5.96% | 71,115 | 5.32% | < 0.0001 |
| Placenta previa | 8,257 | 4.76% | 59,070 | 4.41% | < 0.0001 |
| Premature separation of the placenta | 1,437 | 0.83% | 8,436 | 0.63% | < 0.0001 |
| **Maternal comorbidities ** ** | | | | | |
| Preexisting hypertension | 6,220 | 3.59% | 31,297 | 2.34% | < 0.0001 |
| Gestational hypertension | 8,727 | 5.03% | 46,351 | 3.46% | < 0.0001 |
| Pre-eclampsia or eclampsia | 24,797 | 14.30% | 136,844 | 10.23% | < 0.0001 |
| Gestational diabetes mellitus | 14,962 | 8.63% | 106,577 | 7.97% | < 0.0001 |
| Pre-existing diabetes | 2,212 | 1.28% | 13,967 | 1.04% | < 0.0001 |
| **Lifestyle risk factors ** ** | | | | | |
| Vitamin D deficiency | 5,915 | 3.41% | 45,699 | 3.42% | 0.9194 |
| Obese and overweight | 23,003 | 13.26% | 129,271 | 9.66% | < 0.0001 |
| Sleep disorders | 2,873 | 1.66% | 9,689 | 0.72% | < 0.0001 |
| Lack of physical exercise | 22 | 0.01% | 138 | 0.01% | 0.3663 |
| Poor eating habits | 32 | 0.02% | 145 | 0.01% | 0.0058 |
| Vitamin B6 deficiency | 10 | 0.01% | 29 | 0.00% | 0.0055 |
| Smoking | 855 | 0.49% | 2,684 | 0.20% | < 0.0001 |

PPD: postpartum depression; STD: standardized difference

* Measured 12 months prior to first date of PPD. For the no PPD group assign an end date (delivery + randomly between minimum of (PPD dates-delivery dates) and maximum of (PPD dates-delivery dates) rates from PPD group

** Measured 1 year prior to delivery

study, which included 122,995 postpartum individuals, indicated that higher neighborhood disadvantage was correlated with increased PPD risk, with significant racial and ethnic variations. Specifically, Black individuals exhibited the highest overall risk, while Hispanic individuals showed no significant association between neighborhood disadvantage and PPD [34]. A study by Giurgescu et al. also found that women living in neighborhoods with higher deprivation had increased odds of postpartum depressive symptoms, even after controlling for individual-level factors [35]. Similarly, Meltzer-Brody et al. (2018) reported that neighborhood-level poverty was associated with increased risk of PPD diagnosis in a large cohort study [36]. Several mechanisms may explain

**Table 4** Baseline characteristics of women with and without PPD within 12 months of delivery

| Age and comorbidity characteristics | PPD (*N* = 173,416) | | Without PPD (*N* = 1,337,963) | | *P* Value | Std. Diff. |
|---|---|---|---|---|---|---|
| | N/Mean | %/Std | N/Mean | %/Std | | |
| Age group (y) | 29.43 | 5.69 | 30.13 | 5.65 | < 0.0001 | 0.1233 |
| ≤ 20 | 10,414 | 6.01% | 64,151 | 4.79% | < 0.0001 | 0.0559 |
| 21–24 | 26,526 | 15.30% | 172,146 | 12.87% | < 0.0001 | 0.0719 |
| 25–29 | 49,551 | 28.57% | 357,521 | 26.72% | < 0.0001 | 0.0418 |
| 30–34 | 53,193 | 30.67% | 442,599 | 33.08% | < 0.0001 | 0.0513 |
| 35+ | 33,732 | 19.45% | 301,546 | 22.54% | < 0.0001 | 0.0743 |
| **Comorbidity scores** | | | | | | |
| Charlson Comorbidity Index ≥ 2 | 1,604 | 0.92% | 7,471 | 0.56% | < 0.0001 | 0.0475 |
| Chronic Disease Score ≥ 2 | 33,324 | 19.22% | 171,937 | 12.85% | < 0.0001 | 0.1861 |
| Elixhauser index ≥ 2 | 20,577 | 11.87% | 98,113 | 7.33% | < 0.0001 | 0.1687 |
| **SES characteristics** | | | | | | |
| SES score | 4.87 | 4.11 | 5.23 | 4.43 | < 0.0001 | 0.0834 |
| Median household income ($) | 75,467 | 30,338 | 78,295 | 32,527 | < 0.0001 | 0.0876 |
| Median value of housing unit ($) | 312,677 | 227,555 | 352,525 | 258,991 | < 0.0001 | 0.1559 |
| Household with interest, dividend, or rental income (%) | 0.21 | 0.09 | 0.21 | 0.10 | < 0.0001 | 0.0369 |
| Adult residents who completed at least high school (%) | 89.76 | 7.76 | 89.45 | 8.24 | < 0.0001 | 0.0382 |
| Adult residents who completed at least college (%) | 36.04 | 18.31 | 37.88 | 18.93 | < 0.0001 | 0.0978 |
| Employed residents with management, professional, and related occupation (%) | 41.54 | 13.73 | 42.77 | 14.36 | < 0.0001 | 0.0859 |
| Baseline characteristics | | | | | | |
| **Baseline characteristics** | **N/Mean** | **%/Std** | **N/Mean** | **%/Std** | ***P* Value** | **Std. Diff.** |
| Obstetrical complications | 143,011 | 82.47% | 986,353 | 73.72% | < 0.0001 | 0.2017 |
| Maternal complications | 38,248 | 22.06% | 236,939 | 17.71% | < 0.0001 | 0.1127 |
| Lifestyle risk factors | 29,896 | 17.24% | 174,547 | 13.05% | < 0.0001 | 0.1227 |

PPD: postpartum depression; SES: socioeconomic status; Std. Diff: standardized difference

the link between neighborhood SES and PPD. Low-SES neighborhoods often have limited access to mental health services, support groups, and other resources crucial for maternal well-being [37]. Living in disadvantaged neighborhoods can expose women to chronic stressors such as crime, noise, and poor housing conditions, potentially exacerbating postpartum mental health issues [38]. Neighborhood disadvantage may correlate with reduced social cohesion and support networks, which are protective factors against PPD [39]. Poor neighborhood infrastructure, lack of green spaces, and limited recreational facilities may contribute to social isolation and reduced physical activity, both risk factors for PPD [40].

The prevalence of PPD in our study was 11.48%, which is higher than the previously reported estimates published in 2014, indicating 7% among privately insured women and 13% among women with Medicaid [41]. Although PPD remains underreported, several factors may contribute to this observed increase. Increased awareness of PPD has likely made healthcare providers more vigilant in screening for and diagnosing the condition, resulting in higher reported prevalence rates [42]. Improved access to mental health services, including the adoption of telemedicine, may have also facilitated the diagnosis and reporting of PPD [43]. Additionally, changes in insurance coverage, particularly those associated with the Affordable Care Act, may have enhanced access to postpartum care and mental health services [44, 45]. Economic uncertainties and social isolation, such as those experienced during the COVID-19 pandemic, have likely elevated stress levels among new mothers, thereby contributing to higher rates of PPD [46].

Past research has also shown that obstetric factors, lifestyle factors, and maternal age are associated with PPD [1, 2, 4, 7–9, 11–13, 15]. The results showed that maternal age is inversely associated with PPD. Comorbidities, including obstetrical complications and lifestyle factors, were generally associated with an increased risk for PPD [2, 13].

The results also demonstrated that the percentage of PPD events occurring within 12 months was highest from 0 to 3 months and continuously decreased from 3 to 12 months. This finding is consistent with previous literature, which found that most PPD events happen within 0 to 3 months postpartum [5].

## Sensitivity analysis

To enhance our understanding of the relationship between PPD rates and SES we conducted two distinct sensitivity analyses. These analyses aimed to address potential confounding factors and to provide a more

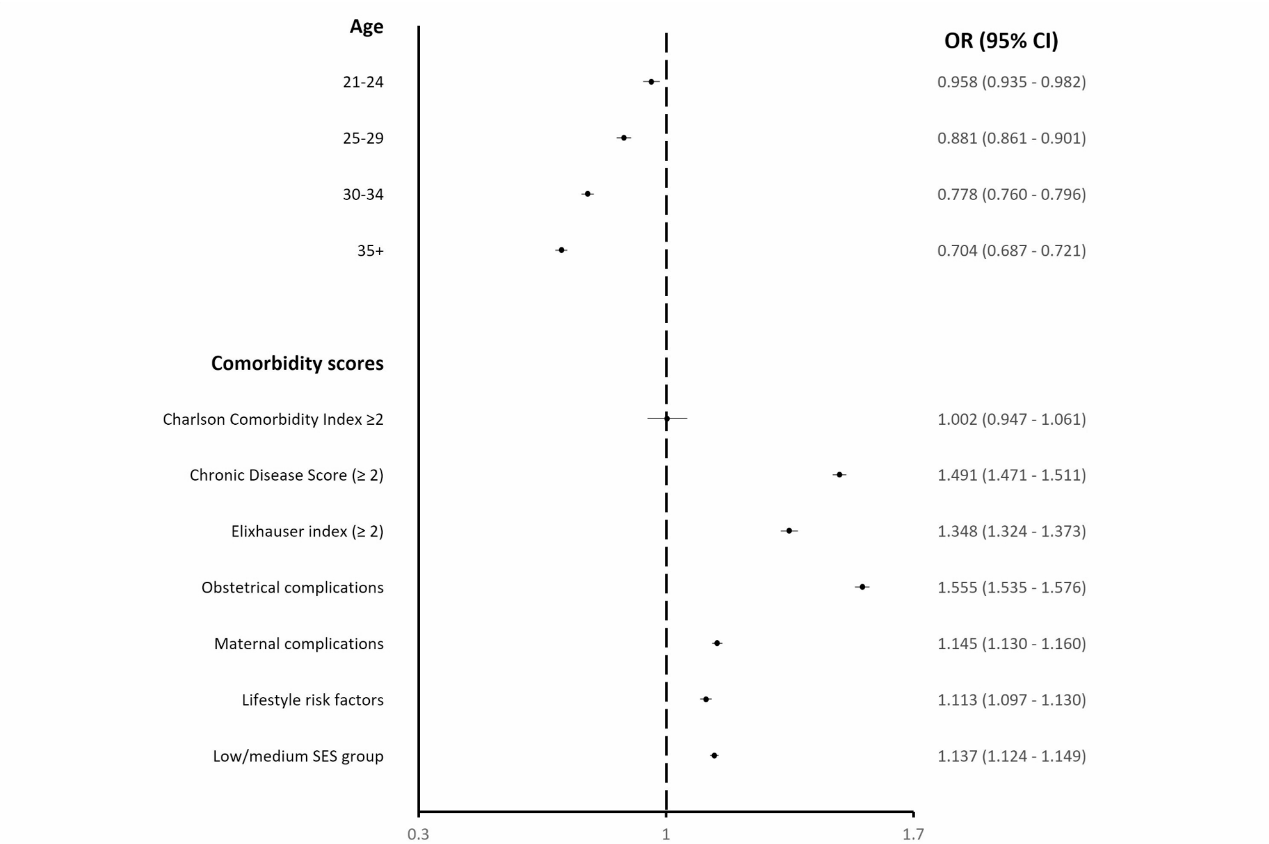


**Fig. 3** Odds Ratio for PPD Among Commercial Enrollees
OR: odds ratio; PPD: postpartum depression; SES: socioeconomic status

comprehensive assessment of the SES-PPD association. First, the authors acknowledge that the initial analysis period (2017–2023) encompassed the peak years of the COVID-19 pandemic, which may have significantly impacted mental health outcomes, healthcare delivery, and socioeconomic disparities. To account for this potential confounder, we excluded deliveries from 2019 to 2021 and re-estimated the PPD rates. In this adjusted analysis, each SES tercile comprised approximately 177,000 patients. The PPD rate for the lowest SES tercile was 11.98%, compared to 10.03% for the highest tercile. After adjusting for age and comorbidities, we found that women in the low-SES or medium-SES groups had significantly higher odds of experiencing PPD compared to those in the high-SES group (adjusted OR: 1.14, 95% CI: [1.117, 1.16], $p<.0001$). Notably, these estimates remained consistent to two decimal places with our primary analysis. Secondly, to capture a more nuanced understanding of the relationship between neighborhood characteristics and PPD prevalence, we employed the Neighborhood Deprivation Index (NDI) as an alternative measure of socioeconomic conditions. The NDI is a composite score that incorporates multiple indicators of deprivation, including income, education, employment, and housing conditions, allowing for a more comprehensive comparison of relative deprivation across different geographic areas [47]. In this analysis, each NDI tercile contained approximately 500,000 patients. The PPD rate for the lowest (most deprived) tercile was 13.82%, compared to 9.61%% for the highest (least deprived) tercile. After adjusting for age and comorbidities, findings again indicated that women in the low-SES or medium-SES groups had significantly higher odds of experiencing PPD compared to those in the high-SES group (adjusted OR: 1.02, 95% CI: [1.01, 1.04], $p<.01$). These sensitivity analyses corroborate our primary findings, demonstrating the robustness of the observed association between socioeconomic disadvantage and increased PPD risk, even when accounting for potential pandemic-related confounders and utilizing alternative measures of neighborhood socioeconomic status.

### Limitations

These findings may have limited generalizability due to the exclusion of Medicaid deliveries, which comprise approximately 40% of all deliveries in the U.S. This exclusion is particularly significant given that the SES of individuals covered by Medicaid tends to be systematically lower than that of those with private insurance. Moreover, this study was conducted using data exclusively from the U.S. healthcare system and population. While this provides valuable insights into PPD prevalence and its association with neighborhood socioeconomic status within the U.S. context, it is important to note that these findings may not be directly applicable to other countries or regions.

Both SES and mental health care are heavily influenced by racial factors in the U.S. However, this study does not include a discussion on race due to the absence of a race variable in the Kythera dataset, limiting our ability to explore racial disparities in the findings.

This study has several limitations related to the use of administrative datasets, which may be subject to inaccurate coding of patient clinical diagnoses and procedures, as well as clinical information limited to conditions and treatments defined by ICD-10-CM codes. Since the analysis was based on the review of claims data that were not originally designed for research, some information is bound to be missing. However, we were able to control for a number of important patient risk factors, including age, several comorbidity indexes, and individual comorbidities specific to PPD. This analysis focused on PPD diagnoses rather than PPD itself due to the limitations of the administrative data. It is well-documented that PPD is notoriously underdiagnosed, and literature suggests that this underdiagnosis occurs along SES lines. These findings pertain to diagnosed cases of PPD, and we acknowledge that the true prevalence of PPD may be higher and influenced by various socioeconomic factors.

Another potential limitation of this study is related to the use of area-based measures. Ideally, we would have been able to assess both individual and area-based socioeconomic measures, because using area-based measures alone inevitably misclassifies people within areas on both ends of the socioeconomic spectrum. This misclassification is random, and the direction of bias is known [48]. If area-based SES shows a disparity, the effect will likely be larger when one includes individual-based SES. One advantage of area-based measurements is their ability to incorporate contextual information pertaining to various elements that impact all individuals within a certain area, such as the geographical positioning and standard of public amenities such as hospitals [49]. Our estimates would also be better if they were based on more granular area-based scores such as census tracts rather than zip codes, since the former were designed to produce socioeconomically similar groupings. However, numerous studies have consistently indicated that employing zip code–level metrics yields comparable yet more conservative estimations of socioeconomic gradients in health [48].

## Conclusion

Socioeconomic disadvantage is unequivocally associated with higher rates of PPD in the U.S. This relationship underscores the necessity for comprehensive interventions that address not only the individual patient's needs but also the broader socioeconomic environment in which they reside. Effective prevention and management of PPD should therefore incorporate strategies that improve both healthcare access and the overall quality of life in disadvantaged neighborhoods.

### Implications for policy and practice

Based on U.S. commercial health claims, a mother's SES contributes to the risk of PPD, after controlling for age and comorbidities. To accurately assess the effect of exposure variables on outcomes, SES should be included as a risk factor for PPD. Effective preventive interventions might focus on the patient's lived environment including SES, as well as individual physical risk factors like age and comorbidities.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12884-024-06882-5.

Supplementary Material 1

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#### Author contributions

O.B. provided the supervision, conceptualization, methodology, validation, and visualization of the research and participated in the writing process from the original draft preparation to the reviewing and editing of the manuscript. L.I. participated in the project management, supervision, methodology, analysis, investigation of the literature review and the writing process from the original draft preparation to the reviewing and editing of the manuscript. E.B., W.L., and B.C. participated in the investigation of the data, methodology, software, validation, analysis, and data curation.

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#### Data availability

The data that support the findings of this study are available from Kythera Labs but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from Kythera Labs upon request and licensing agreement (https://www.kytheralabs.com/).

## Declarations

#### Ethics approval and consent to participate

The raw dataset on which this study is based is available through a commercial data licensing agreement with Kythera labs. Kythera data has been expertly determined by Datavant's Privacy Hub (Mirador) to comply with statistical de-identification required by HIPAA and associated regulations. The analysis of de-identified, publicly available data does not constitute human subjects research as defined by US Department of Health and Human Services 45 CFR 46.102 and does not require IRB review. The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Consent for publication**

This study utilized deidentified data. The analysis of de-identified, publicly available data does not constitute human subjects research as defined by US Department of Health and Human Services 45 CFR 46.102. As such, consent for publication is not applicable.

**Competing interests**

The authors declare no competing interests.

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