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Influence of Neighborhood Socioeconomic Status on Adverse Outcomes in Pregnancy

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Abstract

Purpose To evaluate whether ZIP-code level neighborhood socioeconomic status (SES) is associated with adverse pregnancy outcomes.

Methods A retrospective study of 2009–2014 Oregon Health and Science University (OHSU) births with maternal ZIP codes in one of 89 Portland metropolitan area ZIP codes. Deliveries with ZIP codes outside of the Portland metro area were excluded. Deliveries were stratified by SES based on ZIP code median household income: low (below 10th percentile), medium (11th–89th percentile), and high (above 90th percentile). Univariate analysis and multivariable logistic regression with medium SES as the reference group evaluated perinatal outcomes and strength of association between SES and adverse events.

Results This study included 8118 deliveries with 1654 (20%) classified as low SES, 5856 (72%) medium SES, and 608 (8%) high SES. The low SES group was more likely to be younger, have a higher maternal BMI, have increased tobacco use, identify as Hispanic or Black, and less likely to have private insurance. Low SES was associated with a significantly increased risk of preeclampsia (RR 1.23 95% CI 1.01–1.49), but this was no longer significant after adjusting for confounders (aRR 1.23 95% CI .971–1.55). High SES was negatively associated with gestational diabetes mellitus (GDM), even after adjusting for confounders (aRR 0.710, 95% CI 0.507–0.995).

Conclusion In the Portland metropolitan area, high SES was associated with a lower risk of GDM. Low SES was associated with a higher risk of preeclampsia before accounting for covariates. ZIP code-based risk assessment may be a useful indicator in detecting healthcare disparities.

Significance

Low socioeconomic status (SES) is associated with adverse pregnancy outcomes. However, literature exploring neighborhood SES and pregnancy outcomes, particularly using Neighborhood Socioeconomic Status and Perinatal Outcomes ZIP code as a SES surrogate, is limited. Our study suggests that even within a single metropolitan area living in a ZIP-code in the lowest 10th percentile SES is associated with preeclampsia. However, this association is no longer significant after adjusting for confounders such as BMI and tobacco use, suggesting these lifestyle factors may be playing a role in preeclampsia in low SES populations. Understanding this relationship may help guide counseling for this vulnerable population.

Keywords Healthcare Disparities · Neighborhood Socioeconomic Status · Preeclampsia · Adverse Pregnancy Outcomes

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Introduction

In 2019, 13.5% of women lived in poverty (US Census Bureau, 2019; Christensen & Haeffner, 2021). Single women with dependent children are at increased risk of living in poverty compared to men of similar demographics (Bongaarts, 2016). Lower socioeconomic status (SES), defined by factors such as income and education attainment (Larrañaga et al., 2013), has been associated with increased adverse perinatal outcomes including cesarean section, preeclampsia, obstetric hemorrhage, and infant mortality (Kim et al., 2018; Yu et al., 2017). Beyond individual SES, neighborhood SES may also be predictive of health outcomes as residents of lower SES neighborhoods often face decreased access to healthcare and higher rates of negative health behaviors like smoking (Jimenez et al., 2019).

The impact of SES on pregnancy outcomes is widespread and exists even in countries with universal healthcare. For example, in Korea, women who require subsidized health insurance have higher rates of adverse maternal and neonatal outcomes than women with standard National Health Insurance (Kim et al., 2018). Women living in low SES neighborhoods are known to have more exposure to environmental stressors, such as crime, and less access to quality foods and recreational activities (Adhikari et al., 2019). Pregnancy induced hypertension, low birthweight, and preterm birth (PTB) have been associated with higher levels of physical incivilities, or neighborhood degradation (Vinikoor-Imler et al., 2011). Using insurance status as a measure of SES, women with hypertensive disorders who use Medicaid have higher blood pressure readings, and higher rates of preeclampsia, neonatal intensive care unit (NICU) admissions, and PTB than women with private insurance (Greiner et al., 2018).

Despite the number of studies exploring SES and pregnancy outcomes, the association between neighborhood SES, using ZIP code as a SES surrogate, and adverse pregnancy outcomes is not well described. ZIP-code income has been increasingly used as a surrogate for SES in healthcare disparity studies, as it may provide data within a framework of family, friends, and community resources that individual measures do not (Jolly et al., 2010; Robert, 1999). The objective of this study was to determine the association between neighborhood SES and adverse pregnancy outcomes in the Portland Metropolitan area using average household income for maternal ZIP-code as a surrogate for SES. We hypothesized that living in a lowest 10th percentile SES ZIP-code would be significantly associated with increased adverse pregnancy outcomes compared to higher income ZIP-codes.

Methods

We conducted a retrospective cohort study of all Oregon Health and Science University (OHSU) Portland, OR metro area resident, singleton births from 2009 to 2014 comparing adverse perinatal outcomes among patients who live in low, median, and high SES ZIP codes. Patients were stratified into three SES groups using the median household income of their residential ZIP code, based on data from the US Census Bureau's 2016 American Community Survey. The low-SES group consisted of deliveries with maternal ZIP codes in the lowest 10th percentile for median household income. The high-SES group consisted of deliveries with maternal ZIP codes in the highest 10th percentile. The medium SES group (referent) consisted of the remainder of deliveries with Portland metro area maternal ZIP codes. All patients living in a Portland metro area ZIP code in the designated time frame were included without exclusions. Patients referred for delivery with a ZIP code outside the metro area were excluded. We did not exclude pregnancies with anomalies, as rates were not significantly different between the SES groups.

Demographics analyzed included race (self-reported in the medical record) which was abstracted into the database directly from the electronic health record. Our perinatal outcomes of interest included preeclampsia, gestational diabetes mellitus (GDM), small or large for gestational age infants (SGA < 10th percentile for gestational age & LGA > 90th percentile for gestational age), and NICU admissions. This study was conducted ethically, and institutional review board approval was obtained from OHSU (IRB 5415).

STATA Software (STATA Version SE 14) was used for data analysis. Univariate Chi-squared analysis was used for the statistical comparison of demographics and adverse perinatal outcomes between the three SES groups. Multivariable logistic regression analysis was employed to determine the strength of association of adverse perinatal outcomes and SES with medium SES as the referent group. Analysis was adjusted for confounders including insurance status, BMI, maternal race, maternal age at delivery, anomalies, and tobacco use. Statistical significance was defined as a P value < 0.05 or a 95% confidence interval that did not cross the null.

Results

Of the 8112 births delivered during the study period that met inclusion criteria, 1651 women (20.4%) were in the low SES group, 5,854 (72.2%) were in the middle SES group, and 607 (7.5%) were in the high SES group. Individuals in the low SES group were more likely to be Hispanic or

Table 1 Demographics by socio-economic group

	≤ 10th % n = 1651	11-89th % n = 5854	≥ 90th % n = 607	P value
Maternal Age (years; mean ± SD)	28 ± 6.22	30 ± 5.97	32 ± 5.29	< 0.01
Maternal Race; n(%)				
Non-Hispanic White	596 (36)	3,578 (61)	463 (76)	< 0.01
Non-Hispanic Black	121 (7)	247 (4)	13 (2)	
Hispanic	659 (40)	1218 (21)	27 (4)	
Non-Hispanic Asian	152 (9)	390 (7)	76 (13)	
Mean BMI (kg/m^2; mean ± SD)	28.36 ± 7.08	26.93 ± 6.49	25.34 ± 5.87	< 0.01
Private Insurance; n(%)	238 (15)	2,738 (48)	473 (79)	0.08
Pre-existing DM; n(%)	52 (3)	149 (3)	9 (2)	0.08
Chronic HTN; n(%)	78 (5)	232 (4)	27 (5)	0.37
Tobacco Use; n(%)	132 (8)	297 (5)	22 (4)	< 0.01

BMI, Body mass index

Table 2 Adverse outcome rates by socioeconomic group

	≤ 10th % n = 1651	11-89th % n = 5854	≥ 90th % n = 607	P value
Preeclampsia; n(%)	149 (9)	438 (8)	36 (6)	0.03
GDM; n(%)	179 (11)	642 (11)	46 (8)	0.04
SGA; n(%)	175 (11)	535 (9)	39 (7)	0.01
LGA; n(%)	167 (10)	578 (10)	60 (10)	0.98
Birthweight (grams; mean ± SD)	3280.18 ± 662.17	3340.55 ± 1609.30	3592.39 ± 4339.08	< 0.01

GDM, gestational diabetes mellitus; SGA, small for gestational age; LGA, large for gestational age

Table 3 Adjusted and unadjusted strength of association of adverse outcomes and socioeconomic group with medium SES as the referent group

	≤ 10th % RR (95th CI)	≤ 10th % aRR (95th CI)	≥ 90th % RR (95th CI)	≥ 90th % aRR (95th CI)
Preeclampsia	1.23 (1.01–1.49)	1.23 (0.971 – 1.55)	0.78 (0.549 – 1.11)	0.92 (0.633 – 1.35)
GDM	0.99 (0.828 – 1.18)	1.01 (0.813 – 1.25)	0.67 (0.487–909)	0.71 (0.507-0.995)
SGA	1.67 (0.975 – 1.40)	1.21 (0.975 – 1.51)	0.69 (0.491-0.962)	0.76 (0.534 – 1.09)
LGA	1.01 (0.848 – 1.21)	1.03 (0.820 – 1.29)	1.01(0.761 – 1.34)	1.07 (0.789 – 1.44)
Preterm Birth	1.05 (0.883 – 1.26)	1.10 (0.893 – 1.36)	0.89 (0.668 – 1.19)	1.07 (0.788 – 1.47)
NICU Admit	0.93 (0.799 – 1.09)	0.95 (0.784 – 1.15)	0.87 (0.678 – 1.11)	1.00 (0.765 – 1.31)

GDM, gestational diabetes mellitus; SGA, small for gestational age; LGA, large for gestational age; NICU, neonatal intensive care unit; RR, unadjusted right ratio, aRR adjust risk ratio (payer source, BMI, maternal race, maternal age at delivery, anomalies, and tobacco use)

Black women, have a higher mean BMI, have a higher rate of tobacco use and a younger mean maternal age than the high SES group; Table 1.

The low SES group, when compared to the medium and high SES groups, had a significantly higher rate of preeclampsia (9% vs. 8% and 6%, $P < 0.03$). The low SES and medium SES groups had the same GDM rate, which was significantly higher than the high SES group (11% vs. 11% vs. 8%, $P < 0.04$). Rates of SGA neonates were significantly increased in the low SES group compared to the medium and high SES group (11% vs. 9% vs. 7%, $P < 0.01$), with lower average birthweights (3280 g vs. 3340 g vs. 3592 g, $P < 0.01$); Table 2.

After modeling with multivariable logistic regression, high SES was associated with lower rates of GDM (RR 0.67, 95% CI 0.49–0.91), even after adjusting for potential confounding variables (aRR 0.71, 95% CI 0.51-1.00). Low SES was associated with increased rates of preeclampsia (RR 1.23, 95% CI 1.10–1.49), but was no longer significant when adjusting for confounding variables (aRR 1.23, 95% CI 0.97–1.55); Table 3.

Discussion

We found that living in a high SES neighborhood is associated with a significantly lower risk of GDM even after adjusting for significant covariates, although the upper limit of the confidence interval is very close to the null. We also found an association between living in a low SES neighborhood and a higher risk of preeclampsia, before adjusting for covariates. Adjusting for potential confounders eliminated the association. The low SES cohort had higher rates of GDM, SGA, and lower birth weights compared to higher SES ZIP codes during univariate analysis (Table 2), but this difference was no longer significant after multivariable analysis.

While a relationship is established between individual SES and preeclampsia, the association between neighborhood SES and preeclampsia has not been extensively studied. On an individual level, women with less education are more likely to develop preeclampsia than women with more education (Silva et al., 2008). On a neighborhood SES level, increased community incivilities and negative behaviors, such as low-quality housing and tobacco use, have been associated with worse pregnancy outcomes (Vinikoor-Imler et al., 2011). Lower SES neighborhoods are also more abundant in unhealthy food options, often with an increased density of fast food or convenience stores (Hilmers et al., 2012). Factors like BMI, which was significantly higher in the low SES group, have been associated with preeclampsia (Lisonkova & Joseph, 2013). The absence of association between preeclampsia and neighborhood SES after adjusting for significant covariates, including lifestyle factors like BMI and tobacco use, suggests neighborhood influence on lifestyle and behaviors is partially responsible for the unadjusted association observed.

GDM has been inversely correlated with individual maternal SES (Anna et al., 2008; Cullinan et al., 2012), consistent with the negative association between GDM and high neighborhood SES in this study. However, the relationship between GDM and neighborhood SES specifically as not been widely studied in the past. Other studies have found a greater prevalence of GDM in lower SES populations than higher SES, suggesting a relationship resembling a gradient between the two variables (Cullinan et al., 2012). Contrasting decreased access to high quality foods in lower SES neighborhoods, higher SES neighborhood have been associated with more access. Largely non-Hispanic White residential areas have four times as many supermarkets in close proximity as primarily Black neighborhoods (Morland et al., 2002). Additionally, higher SES on both a zip code and municipality level has been associated with an increased interest in one's own health (Airaksinen et al., 2016). These factors may contribute to differences in metabolism or lifestyle that reduce the risk of developing GDM during pregnancy for patients in high SES neighborhoods, even without a significant difference in rates of pregestational diabetes between the SES groups.

While our study did not show an association between neighborhood SES and preterm birth, debate exists in literature. One large US prospective cohort study did not demonstrate an association between neighborhood SES and spontaneous preterm birth among Black pregnant people even when adjusted for maternal factors, or stratified by maternal age, geographic region, or education (Phillips et al., 2013). However, another study demonstrated an association between neighborhood SES and preterm birth when maternal BMI and gestational weight gain were both used as mediators in analysis. (Clayborne et al., 2017).

Although univariate analysis demonstrated a significantly higher rate of SGA among low SES neighborhoods, an association was not found when adjusting for significant confounders, which may be attributable to the statistical power of this outcome in our study. Other studies have associated low neighborhood SES or maternal occupation as a surrogate for SES with increased LGA or SGA infants (Boubred et al., 2020; Räisänen et al., 2013).

Limitations of this study are inherent to a retrospective study. While the overall study sample size was large, we are a large referral center for the entire state of Oregon and limited our study population to pregnant persons in the surrounding, greater Portland metro area ZIP-codes. As a single-center study in an urban area, generalizability to the rural and other US regional areas may be challenging. However, our findings are supported by similar relationships seen in other studies. Additionally, assigning a single variable as a surrogate for SES poses challenges. Our study chose to investigate SES as defined by the median household income of residential ZIP code (i.e. where pregnant persons live and not individual income). While ZIP code median household income provides valuable data within context of community, it may overlook nuances related to educational and social determinants of SES. Moreover, the urban city from which the ZIP codes were derived from has taken significant efforts of economic integration in the various neighborhoods, which may have played a factor in the strength of association with outcomes based solely on the median income of residential ZIP codes.

Adverse outcomes like preeclampsia and GDM may impact both maternal and fetal health for decades after pregnancy. The Developmental Origins of Health and Disease (DoHAD) models have demonstrated that fetal exposure to abnormal uterine environments, which are implicated in GDM, preeclampsia and SGA, may alter fetal programming of physiological pathways, increasing long-term adverse outcomes such as cardiovascular and metabolic risks. In our univariate analysis, we observed higher rates of SGA and lower birthweights in the low SES group. Low birthweight has been associated with coronary heart disease and stroke later in life, a finding reproduced in various populations (Barker, 2006). Offspring exposed to preeclampsia in utero have also been found to have significantly higher rates cardiovascular disease, arrythmias, and heart failure. (Nahum Sacks et al., 2018). The findings of our study are consistent with the hypothesis that these adverse pregnancy outcomes disproportionately effect low SES neighborhoods, raising questions of how factors like SGA, GDM and preeclampsia effect neighborhood health long-term and their contribution to a cycle of poverty.

The association between neighborhood SES and adverse pregnancy outcomes, and the relationship of potential confounders, suggested by our study is multifaceted. In addition to lifestyle factors that may be influenced by neighborhood SES, such as BMI and access to healthy foods discussed above, difficulty accessing quality healthcare and decreased social support may also pose barriers to women who live in lower SES neighborhood (Adhikari et al., 2019). Using ZIP codes as a tool to identify disparities and high-risk groups, we may be able to provide increased resources and implement outcome specific surveillance in certain populations, preventing both the short-term and long-term consequences of adverse pregnancy outcomes. Of note, a disproportionate majority of Hispanic and Black pregnant people fell into the low SES group. Beyond neighborhood SES, this result highlights systemic disparities related to race and ethnicity, including residential segregation. Further exploration of the association of neighborhood SES and pregnancy outcomes, as well as racial inequalities, is warranted so that we may be better able to implement neighborhood SES specific interventions to improve health outcomes.

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Data Availability (data transparency) Data was abstracted from patient EHR and is managed in a departmental RedCap database.

Code Availability (software application or custom code) The code used for statistical analysis in STATA was written by Dr. Amy Valent.

Declarations

Conflicts of interest The authors have no conflicts of interest to disclose.

Ethics Approval (include appropriate approvals or waivers) Our study was approved by the Oregon Health and Science University institutional review board (IRB 1545).

Consent to Participate (include appropriate consent statements) Our IRB deems minimal risk based on the deidentified nature of the database.

Consent for Publication Our IRB deems minimal risk based on the deidentified nature of the database.

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