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How does high socioeconomic status affect maternal and neonatal pregnancy outcomes? A population-based study among American women

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ABSTRACT

Objectives: The purpose of this study was to evaluate the effect of high SES on multiple pregnancy outcomes, while controlling for confounding factors.
Methods: Using the Healthcare Cost and Utilization Project Nationwide Inpatient Sample (HCUP-NIS), the largest American medical database including 20 % of annual hospital admissions, we studied the years 2004–2014 inclusively. We conducted a population-based retrospective cohort study consisting of women from different median household income quartiles throughout the United States. Women in the highest household income quartile were compared to those in all other lower income quartiles combined. Chi-square and Fischer exact tests were used to compare demographic and baseline characteristics. Univariate and multivariate regression analyses were carried to adjust for confounding factors, including ethnicity, pre-existing conditions, smoking status, obesity, illicit drug use and insurance type.
Results: Among 5,448,255 deliveries during the study period with income data, 1,218,989 deliveries were to women from the wealthiest median household income. These women were more likely to be older, Caucasian, and have private medical insurance ($P < 0.05$, all). They were less likely to smoke, have chronic hypertension, pre-gestational diabetes, and use illicit drugs ($P < 0.05$, all). They were less likely to develop complications including gestational hypertension (aOR 0.87 95 %CI 0.85–0.88), preeclampsia (aOR 0.88 95 %CI 0.86–0.89), eclampsia (aOR 0.81 95 %CI 0.66–0.99), gestational diabetes (aOR 0.91 95 %CI 0.89–0.92), preterm premature rupture of membranes (PPROM) (aOR 0.92 95 %CI 0.88–0.96), preterm birth (aOR 0.90 95 %CI 0.89–0.92), and placental abruption (aOR 0.89 95 %CI 0.85–0.93). They were less likely to have an intra-uterine fetal death (IUFD) (aOR 0.80 95 %CI 0.74–0.86), but more likely to deliver neonates with congenital anomalies (aOR 1.10 95 %CI 1.04–1.20).
Conclusions: Higher SES predisposes to better pregnancy outcomes, even when controlled for confounding factors such as ethnicity and underlying baseline health status. Efforts are required in order to eliminate health disparities in pregnancy.

Introduction

Socio-economic status (SES) refers to the economic and social factors that determine what position an individual or group holds within society [1]. Though a complex entity encompassing many aspects, SES is usually measured by income, occupation, education, or a combination of these [2]. SES is considered one of the most important determinants of health disparities, which are preventable differences in the burden of disease or opportunities to achieve optimal health usually experienced by socially disadvantaged peoples [3]. Lower SES is associated with various adverse

Abbreviations: SES, Socioeconomic status; PPROM, Preterm premature rupture of membranes; IUFD, Intra-uterine fetal death; GDM, Gestational diabetes; HCUP-NIS, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample; ICD-9 CM, International Classification of Diseases, ninth edition, Clinical Modification; CD, Cesarean delivery; BMI, Body mass index; HTN, Hypertension; PTB, Preterm birth; PPH, Postpartum hemorrhage; VTE, Venous thrombo-embolism; SGA, Small for gestational age; LBW, Low birthweight; DIC, Disseminated intravascular coagulation.

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health consequences such as cardiovascular disease, diabetes, and cancer [4–6] and worse outcomes, when adjusting for the baseline health status [7–10].

Most research has explored the effect of low SES on pregnancy outcomes [7,8]. In some studies, median household income based on residential ZIP code was used as a proxy for maternal SES [9,10]. Other surrogate measures used included parental education level, occupation or income assessed via questionnaire [7, 11, 12], census [8, 13, 14] or tax records [15]. These studies establish an association between low SES and adverse pregnancy outcomes, specifically an increased risk of gestational diabetes (GDM)[7,11], preterm birth (PTB) [13], small for gestational age (SGA) [15] and congenital anomalies [12].

Few studies have appraised the role of high SES on adverse pregnancy outcomes. These studies vary in size and location, and the specific outcomes compared. Several Canadian studies have been published. Bushnik et al. evaluated 127,694 women and found preterm birth to be associated with decreased maternal education, while Joseph et al. analyzing a population of 92 914 subjects found the risk of SGA to be inversely related to SES [13,15]. Two smaller Chinese studies enrolled 6886 patients and evaluated 17,659 patients respectively[7,11]. Both these studies found higher education and income were associated with decreased GDM risk. A European study consisting of 227 696 patients found PTB to be inversely associated to maternal education [8]. It is clear from this literature search that the studies are relatively small and lack American representation. Therefore, the purpose of our study is to assess the effect of high SES on multiple maternal, fetal and pregnancy outcomes, in the hopes that this knowledge will aid in recognizing health disparities for American pregnant patients in a very large database of deliveries.

Materials & methods

Study design and setting

This retrospective cohort study used all 5,448,255 births in the United States from 2004–2014 inclusively with complete SES information in the Healthcare Cost and Utilization Project, Nationwide Inpatient Sample (HCUP-NIS) [16] Database. During the study period, there was a total of 9 million deliveries, the rest of which lacked SES data. The HCUP-NIS is the largest database of healthcare inpatient encounters that includes over seven million hospital-stays per year in the United States. This database, including patient demographics, comorbidities, procedures, hospital stay, discharge diagnoses and deaths, is systematized according to the International Classification of Diseases, ninth edition, Clinical Modification (ICD-9 CM). It is comprised of inpatient stays submitted by hospitals from 48 states and the District of Columbia. The data represents 20 % of US hospital admissions annually and 96 % of the American population geographically.

By using ICD-9-CM codes for delivery-related discharge diagnoses (650.xx, 677.xx, 651.xx-676.xx; fifth digit is 0, 1, or 2), and birth-related procedural diagnoses (72.x, 73.x, 74.0–74.2), we limited our study group to admissions that ended with delivery or maternal death to exclude multiple admissions with the same pregnancy.

Study variables

Our primary outcomes were pregnancy, delivery and neonatal outcomes. Pregnancy outcomes included pregnancy induced hypertension, gestational hypertension, preeclampsia, eclampsia, gestational diabetes (GDM) and placenta previa. Delivery outcomes included preterm premature rupture of membranes (PPROM), preterm birth (PTB), placental abruption, CD, maternal infection, chorioamnionitis, postpartum hemorrhage (PPH), hysterectomy, and venous thromboembolism (VTE). Neonatal outcomes included small for gestational age (SGA) defined as birthweight less than tenth percentile for gestational age, intrauterine fetal death (IUFD), and congenital anomalies.

The independent variable is the income quartile. After developing a birth cohort for 2004–2014 inclusively, we divided this cohort into household income quartiles based on the patients' ZIP codes as representations of household income according to the US census. This procedure allowed us to define four quartiles of SES ranging from lowest to highest. The lowest income quartile (Q1) represented an estimated median household income of up to 38,999$. The second (Q2) and third quartile (Q3) represented an estimated median household income of 39,000–47,999$ and 48,000–62 999$, respectively. For the sake of this analysis, these three groups were combined. Finally, the highest income quartile (Q4) represented an estimated median household income of at least 63,000$. For this study, the highest income quartile (Q4) constitutes the cases; all other quartiles combined constitute the controls.

Demographic characteristics, maternal baseline characteristics, and delivery and neonatal outcomes of all deliveries were identified using ICD-9 codes. Baseline maternal characteristics included patient age, race, medical insurance type, hospital type, previous caesarean delivery (CD), multiple gestations, tobacco smoking, obesity (body mass index (BMI) $\geq$ 30 kg/m^2), pre-existing hypertension (HTN), pre-existing diabetes, pre-existing thyroid disease, in vitro fertilization (IVF), and illicit drug use.

Statistical analysis

Analyses were performed with the SPSS version 25.0 statistical software package (IBM corporation, Chicago, USA). Chi-square tests were used to compare the demographic and baseline characteristics among both groups. A p value < 0.05 was recognized as statistically significant. Univariate and multivariate logistic regression analysis was performed to determine associations between household income grouping (high vs other) and obstetrical and neonatal incomes through the estimation of unadjusted and adjusted odds ratios (aORs) and 95 % confidence intervals (CIs), respectively. Any of the baseline characteristics (Table 1) with difference between the groups ($p < 0.05$) were selected as potential confounding factors and adjusted for in our multivariate logistic regression analysis. According to the Tri-Council Policy Statement (2018), institutional review board approval was not required since this study used data that is publicly available and de-identified.

Results

The HCUP-NIS database contained 9096,788 deliveries during the study period. We included 5448,255 deliveries, with 1486,733 (27.2 %) deliveries in the lowest quartile, 1387,004 (25.4 %) in the second quartile, 1355,529 (24.8 %) in the third quartile and 1218,989 (22.3 %) in the wealthiest income quartile.

The clinical and demographic characteristics of the higher SES cohort compared to all other income cohorts combined can be found in Table 1. Women from the wealthiest income quartile were more likely to be older, Caucasian and have private insurance. They were less likely to be smokers, have chronic hypertension, pre-gestational diabetes, and use illicit drugs.

The effects of higher SES on pregnancy and delivery outcomes are shown in Tables 2 and 3, respectively. Confounding factors which were controlled for are listed under the table. Women with greater SES were less likely to develop pregnancy complications including gestational-HTN, preeclampsia, eclampsia, and GDM. They were also less likely to develop delivery complications such as PPROM, PTB, placental abruption and require transfusion. No significant difference was observed in the risk of CD, instrumental delivery, VTE, PPH, hysterectomy, wound complications or maternal death.

Table 4 displays the effect of higher SES on neonatal outcomes. Women with greater SES were less likely to have an IUFD, but more likely to deliver neonates with congenital anomalies. No significant difference was observed in the risk of SGA.

Table 1
Maternal Characteristics- Highest income quartile vs all others.

Characteristics	Highest income quartile N = 1,218,989	Other N = 4,229,266	P-value
Maternal age (years)			<0.0001
<25	230,046 (18.9 %)	1,768,986 (41.8 %)	
25–34	697,486 (57.2 %)	1,944,196 (46 %)	
≥35	291,1267 (23.9 %)	515,775 (12.2 %)	
Race			<0.0001
White	683,727 (61.9 %)	189,7782 (50.6 %)	
Black	81,034 (7.3 %)	605,972 (16.1 %)	
Hispanic	156,640 (14.2 %)	904,706 (24.1 %)	
Asian and Pacific	121,452 (11 %)	139,672 (3.7 %)	
Native American	4577 (0. 4 %)	33,348 (0.9 %)	
Other	56,694 (5.1 %)	170,698 (4.5 %)	
Plan type			<0.0001
Medicare	4892 (0.4 %)	31,737 (0.8 %)	
Medicaid	250,187 (20.5 %)	2,106,334 (49.9 %)	
Private including HMO	906,288 (74.4 %)	1,834,299 (43.5 %)	
Self-pay	25,596 (2.1 %)	116,972 (2.8 %)	
No charge	890 (0.1 %)	7272 (3 %)	
Other	29,802 (2.4 %)	124,982 (3 %)	
Hospital type			<0.0001
Rural	4466 (1.4 %)	203,978 (17.5 %)	
Urban	318,095 (98.6 %)	964,714 (82.5 %)	
Previous CS	209,749 (17.2 %)	703,429 (16.6 %)	<0.0001
Obesity	41,935 (3.4 %)	219,627 (5.2 %)	<0.0001
Tobacco Smoking during pregnancy	25,113 (2.1 %)	269,910 (6.4 %)	<0.0001
Chronic HTN	20,487 (1.7 %)	90,918 (2.1 %)	<0.0001
Pregestational DM	8062 (0.7 %)	41,979 (1 %)	<0.0001
Illicit drug use	7985 (0.7 %)	73,882 (1.7 %)	<0.0001
Thyroid disease	52,488 (4.3 %)	102,873 (2.4 %)	<0.0001
IVF	5859 (0.5 %)	4580 (0.1 %)	<0.0001
Multiple gestations	27,053 (2.2 %)	65,399 (1.5 %)	<0.0001

Discussion

In this retrospective cohort study, women with higher SES appear to start their pregnancy in more favourable conditions with lower rates of risky behaviour. We found that higher SES women had significantly decreased risks of pregnancy-induced HTN, gestational-HTN, preeclampsia, and GDM. This contrasts a Swedish study which found lower SES was associated with chronic-HTN, but not with gestational-HTN or preeclampsia [17]. They approximated SES by parental education and social class from registers, which may explain how this differs from our results.

Several studies have examined the association between SES and GDM. Our results mirror those of an Australian population-based study, in which SES based on residential ZIP code was inversely associated with GDM risk [18]. Fieg et al. found that women from higher-income neighbourhoods were less likely to have GDM [19]. Bouthoorn et al. found that lower maternal education was associated with increased GDM risk [20]. A Chinese study found no association between household income and GDM, but a strong association between higher education and decreased GDM risk [11]. Liu et al. showed that women from the middle-, high-income and tertiary education groups had decreased GDM risk [7]. Women with higher SES, determined by income, education, occupation or living in a wealthier neighbourhood, are likely more health-educated, and therefore are more likely to make health-conscious lifestyle choices and have access to prenatal care, education or public health programs, promoting healthy pregnancies.

The association between SES and CD remains inconsistent in published studies. Several have shown that higher SES women, estimated by income [21] or education [22] were more likely to have a CD. Contrarily, studies from Canada and Finland found that women from highest-income neighbourhoods had significantly lower age-adjusted CD rates [23,24]. Another study found CD rates to be highest in women with private insurance or a graduate degree, but overall, SES was not significantly associated with CD risk [25]. Our findings show that higher SES does not significantly increase CD risk, though there is a trend towards higher CD rate with higher SES. In the lower SES cohort, CD rate was decreased. Although CD indication is unavailable, this may represent that lower SES women are less likely to undergo elective CD. Older age is a known risk factor for CD [25]. Those with lower SES were younger, yet the lower CD risk occurred even after controlling for age differences.

Prematurity is a leading cause of perinatal morbidity and mortality [26], however the relationship between SES and prematurity is not well studied. Studies from Taiwan [27], New Zealand [28] and Canada [15] reported no association between SES and prematurity while a North Carolina study found increased PTB risk in Caucasian mothers with low education and income [29]. A systematic review demonstrated that income and education were not associated with adverse birth outcomes, except for PTB in Black mothers [30]. Our results demonstrate an association between lower SES and PTB, even after controlling for maternal race. Two Canadian studies reported an association between neighbourhood SES, and iatrogenic and spontaneous PTB [14,31]. Bushnik et al. found that PTB was inversely associated with maternal education, but not income, after adjustment for maternal age, ethnicity and marital status [13]. Parker et al. found that lower SES, proxied by

Table 2
Pregnancy outcomes [a] - Highest income quartile vs all others.

Outcomes	Highest income quartile N = 1,218,989 (%)	Other N = 4,229,266 (%)	Crude OR (95 % CI)	Adjusted OR (95 % CI)	Adjusted p-value
Pregnancy induced hypertension	82,245 (6.7 %)	341,302 (8.1 %)	0.871 (0.861–0.881)	0.867 (0.853–0.882)	**<0.0001**
Gestational hypertension	38,681 (3.2 %)	153,419 (3.6 %)	0.871 (0.861–0.881)	0.872 (0.852–0.893)	**<0.0001**
Preeclampsia	38,834 (3.2 %)	162,966 (3.9 %)	0.821 (0.812–0.830)	0.876 (0.855–0.897)	**<0.0001**
Eclampsia	596 (0 %)	3289 (0.1 %)	0.628 (0.576–0.686)	0.812 (0.666–0.989)	**0.038**
Preeclampsia or Eclampsia superimposed on pre-existing HTN	5322 (0.4 %)	26,817 (0.6 %)	0.687 (0.667–0.708)	0.862 (0.808–0.920)	**<0.0001**
GDM	80,944 (6.6 %)	255,883 (6.1 %)	1.104 (1.095–1.113)	0.907 (0.892–0.923)	**<0.0001**
Placenta previa	8826 (0.7 %)	21,749 (0.5 %)	1.411 (1.376–1.446)	1.004 (0.952–1.06)	0.874

HMO: health maintenance organization; CS: caesarean section; HTN: hypertension; DM: diabetes mellitus; IVF: in vitro fertilization; GDM: gestational diabetes mellitus; SVD: spontaneous vaginal delivery; PPROM: preterm premature rupture of membranes; PPH: post-partum hemorrhage; DVT: deep venous thrombosis; VTE: venous thromboembolism; DIC: disseminated intravascular coagulation; SGA: small for gestational age; IUFD: intra-uterine fetal demise.

[a] Pregnancy Outcomes: Adjusted for Race, medical insurance Plan Type, Hospital location, Age, Obesity, Illicit Drug Use, Tobacco Smoking during pregnancy, Previous CS, Chronic HTN, Thyroid Disease, Multiple Pregnancy, Pregestational DM and IVF.

Table 3
Delivery outcomes [b] - Highest income quartile vs all others.

Outcomes	Highest income quartile N = 1 218,989 (%)	Other N = 4 229,266 (%)	Crude OR (95 % CI)	Adjusted OR (95 % CI)	Adjusted p-value
PPROM	13,499 (1.1 %)	49,056 (1.2 %)	0.954 (0.936–0.973)	0.916 (0.877–0.955)	**<0.0001**
Preterm delivery	74,879 (6.1 %)	299,295 (7.1 %)	0.859 (0.852–0.866)	0.904 (0.887–0.922)	**<0.0001**
Abruptio placenta	11,084 (0.9 %)	16,692 (1.1 %)	0.822 (0.805–0.839)	0.892 (0.853–0.934)	**<0.0001**
Chorioamnionitis	23,199 (1.9 %)	77,942 (1.8 %)	1.033 (1.018–1.049)	1.079 (1.046–1.113)	**<0.0001**
SVD	738,005 (60.5 %)	2,647,260 (62.6 %)	0.917 (0.913–0.921)	1.002 (0.991–1.012)	0.759
Operative vaginal delivery	79,980 (6.6 %)	262,641 (6.2 %)	1.061 (1.052–1.069)	1.002 (0.983–1.021)	0.845
CS	418,409 (34.2 %)	1,376,936 (32.6 %)	1.083 (1.078–1.087)	1.0 (0.989–1.012)	0.932
Hysterectomy	1199 (0.1 %)	4046 (0.1 %)	1.026 (0.962–1.095)	0.928 (0.812–1.061)	0.273
PPH	34,873 (2.9 %)	125,448 (3.0 %)	0.963 (0.952–0.975)	1.025 (1.0–1.051)	0.055
Wound complications	4611 (0.4 %)	14,003 (0.3 %)	1.143 (1.105–1.182)	1.021 (0.944–1.104)	0.605
Maternal Death	50 (0 %)	311 (0 %)	0.558 (0.414–0.752)	0.554 (0.276–1.110)	0.096
Transfusion	10,965 (0.9 %)	49,923 (1.2 %)	0.758 (0.743–0.774)	0.948 (0.909–0.990)	**0.015**
Maternal infection	26,591 (2.2 %)	93,415 (2.2 %)	0.987 (0.974–1.001)	1.055 (1.025–1.086)	**<0.0001**
VTE	704 (0.1 %)	2462 (0.1 %)	0.992 (0.912–1.079)	1.1 (0.921–1.314)	0.293
DIC	2838 (0.2 %)	9640 (0.2 %)	1.021 (0.979–1.065)	0.934 (0.862–1.033)	0.206

[b] Delivery Outcomes: Adjusted for Race, medical insurance Plan Type, Hospital location, Age, Obesity, Illicit Drug Use, Tobacco Smoking during pregnancy, Previous CS, Chronic HTN, Thyroid Disease, Multiple Pregnancy, Pregestational DM, IVF, Pregnancy Induce Hypertension, Gestational hypertension, Preeclampsia and Pre-eclampsia Eclampsia superimposed Hypertension.

Table 4
Neonatal outcomes [c] - Highest income quartile vs all others.

Outcomes	Highest income quartile N = 1 218,989 (%)	Other N = 4 229,266 (%)	Crude OR (95 % CI)	Adjusted OR (95 % CI)	Adjusted p-value
SGA	26,923 (2.2 %)	104,087 (2.5 %)	0.895 (0.883–0.907)	0.988 (0.960–1.016)	0.383
IUFD	3837 (0.3 %)	18,748 (0.4 %)	0.709 (0.685–0.734)	0.801 (0.743–0.863)	**<0.0001**
Congenital Anomalies	7029 (0.6 %)	21,444 (0.5 %)	1.138 (1.108–1.169)	1.096 (1.042–1.152)	**<0.0001**

[c] Neonatal outcomes: Adjusted for Race, medical insurance Plan Type, Hospital location, Age, Obesity, Illicit Drug Use, Tobacco Smoking during pregnancy, Previous CS, Chronic HTN, Thyroid Disease, Multiple Pregnancy, Pregestational DM, IVF, Pregnancy Induce Hypertension, Gestational hypertension, Preeclampsia and Pre-eclampsia Eclampsia superimposed Hypertension.

education, parental occupation and family income, was associated with LBW, but not SGA or PTB, but lower SES was associated with both these outcomes in Black women more than Caucasian [32]. A large retrospective cohort study from Alberta found that women from highest-income neighbourhoods had significantly lower spontaneous PTB rates. Due to the nature of our data, we are unable to distinguish between spontaneous and iatrogenic PTB. However, Wood et al. also used postal codes to determine a woman's average income [9] and obtained similar results to ours; the lower SES cohort had increased PTB risk, while the higher SES cohort had decreased PTB risk, when controlling for ethnicity and other confounding factors.

Sparse research has examined the relationship between SES and PPROM, placental abruption, chorioamnionitis, PPH, and wound complications. Raisanen et al. found lower SES to increase the risk of abruption in multiparous women only [33], while a Ghanaian study also found low SES to be a risk factor [34]. Noor et al. found that PPROM was more common in patients with low SES, and primary-middle school education [35]. Our study shows decreased risk for these outcomes in women with higher SES. Several studies have found lower SES to be associated with increased risk of PPH [36–38], a finding not mirrored in our results. However, lower SES women in our study were more likely to receive blood transfusions. The increased transfusion risk could indicate increased anemia during pregnancy or lack of pre-delivery optimization, all potentially requiring transfusions. The nature of the data used does not allow for confirmation. Higher SES women did not have an altered risk of PPH.

Several studies have shown an association between lower SES and increased VTE risk in non-pregnant populations [39,40]. A Korean study found VTE to be associated with low SES among peripartum women [41]. We found no increased risk of VTE in either cohort.

Kern-Goldberger et al. found lower maternal education to increase the risk for a composite of maternal complications including hysterectomy, uterine atony, blood transfusion, surgical injury, and wound complications [42]. Our study found no significant difference in the risk of wound complications, DIC and hysterectomy for either cohort.

Maternal socioeconomic disadvantage has been associated with SGA infants in various studies worldwide [43–45]. Joseph et al. found that lower SES according to family income was significantly associated with SGA [15]. A Canadian study found that both higher maternal income and education were associated with decreased SGA risk, suggesting both factors together contribute [13]. We found no significant difference in SGA rates, even after adjusting for confounding factors. This can be explained by the use of ICD-9 codes not specifically collected for this study. SGA rates, usually quoted at 10 % in the general population, were much lower in both cohorts, suggesting we were unable to find a difference that exists due to the nature of our data.

Worldwide, the risk of stillbirth is highest among the least socioeconomic privileged groups [46–49]. An observational study demonstrated that stillbirth risk in women with lower education was double that of women with tertiary education, with a higher risk in African mothers [50]. A European study found that higher-level education and occupation were correlated with reduced stillbirth risk [48]. This is similar to our results demonstrating that women with higher SES had decreased stillbirth risk, while women with lower SES had a higher risk of IUFD, even after adjustment for maternal age and other characteristics.

Congenital anomalies contribute greatly to long-term neonatal morbidity and mortality [12]. Studies on SES and congenital anomalies have reported either no association [51–53] or a higher prevalence among lower SES groups. Varela et al. found that respiratory congenital anomalies correlated with lower SES[12]. Vrijheid et al. found that non-chromosomal congenital anomalies increased with decreasing SES, estimated by ZIP code, with a trend towards increased risk with increasing SES [10]. A Glasgow study found a similar trend to our data for increasing congenital anomalies in higher SES groups after controlling for maternal age [54].

Our study has certain limitations. As our data is based on an administrative dataset, some variables of interest are unavailable, such as complications occurring outside the index delivery admission, early pregnancy loss and pregnancy termination data, as well as some neonatal outcomes. Furthermore, the database only allowed for median household income based on ZIP code to be used as an estimation of SES. Though this is generally reliable, we cannot guarantee that there are no discrepancies between incomes within the same ZIP code. We also recognize that household income only represents one facet of the complex entity that is SES. This database does not allow us to use other determinants of SES such as education or occupation. There is no exact method for measuring SES, with these measures being used as proxies. Therefore, the studies pertaining to SES and utilizing these different proxies may not be easily compared.

To the best of our knowledge, this is the largest population-based study to examine the effect of SES on multiple pregnancy outcomes, which allowed us to determine statistically significant differences in risk amongst different SES pregnancies when using estimated income based on ZIP code as a measure of SES. The large sample size allowed us to control for many potential confounding factors, such as race, age, smoking, and other comorbidities. It is important to acknowledge that though our results help paint a clearer picture of the effect of SES on pregnancy outcomes, it cannot fully assess how different health, population and personal factors influence SES and pregnancy outcomes and the intricacies of how these different factors interact with each other in order to impact these outcomes.

Conclusions

Published studies have demonstrated that women with low SES have worse pregnancy outcomes. This study compared women from the highest SES to all other SES groups combined. Our results show that greater SES predisposes women to better pregnancy outcomes, even when controlled for confounding factors, suggesting that access to healthcare or the means to obtain better prenatal care may significantly improve outcomes.

Furthermore, we hypothesize that women with higher SES were more likely to deliver a neonate with congenital anomalies, possibly because they are less likely to abort, given they are more likely to have the financial means necessary to care for such a child. Further studies are required to evaluate this.

Improving health disparities would benefit pregnant women and their offspring, but improving SES alone may not be sufficient to produce significant change for a majority of women. More research is required to determine which improvements in health care provision, patient education and socioeconomic disparities would be most impactful in improving outcomes for all, regardless of SES.

Ethical approval

The local Institutional Review Board deemed the study exempt from review.

Informed consent

Not applicable.

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Author contributions

All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Declaration of Competing Interest

Authors state no conflict of interest.

References

[1] Conger RD, Donnellan MB. An interactionist perspective on the socioeconomic context of human development. Annu Rev Psychol 2007;58:175–99.
[2] Helm D, Laussmann D, Eis D. Assessment of environmental and socio-economic stress. Cent Eur J Public Health 2010;18(1):3–7.
[3] Penman-Aguilar A, Talih M, Huang D, Moonesinghe R, Bouye K, Beckles G. Measurement of health disparities, health inequities, and social determinants of health to support the advancement of health equity. J Public Health Manag Pr 2016;22(Suppl 1):S33–42.
[4] Thurston RC, El Khoudary SR, Derby CA, Barinas-Mitchell E, Lewis TT, McClure CK, et al. Low socioeconomic status over 12 years and subclinical cardiovascular disease: the study of women's health across the nation. Stroke 2014;45(4):954–60.
[5] Elgart JF, Caporale JE, Asteazaran S, De La Fuente JL, Camilluci C, Brown JB, et al. Association between socioeconomic status, type 2 diabetes and its chronic complications in Argentina. Diabetes Res Clin Pract 2014;104(2):241–7.
[6] Manser CN, Bauerfeind P. Impact of socioeconomic status on incidence, mortality, and survival of colorectal cancer patients: a systematic review. Gastrointest Endosc 2014;80(1):42–60 e9.
[7] Liu J, Liu E, Leng J, Pan L, Zhang C, Li W, et al. Indicators of socio-economic status and risk of gestational diabetes mellitus in pregnant women in urban Tianjin, China. Diabetes Res Clin Pract 2018;144:192–9.
[8] Genowska A, Fryc J, Szpak A, Tyszko P. Is socio-economic status associated with adverse birth outcomes in Poland? Ann Agric Environ Med 2019;26(2):369–74.
[9] Wood S, McNeil D, Yee W, Siever J, Rose S. Neighbourhood socio-economic status and spontaneous premature birth in Alberta. Can J Public Health 2014;105(5):e383–8.
[10] Vrijheid M, Dolk H, Stone D, Abramsky L, Alberman E, Scott JE. Socioeconomic inequalities in risk of congenital anomaly. Arch Dis Child 2000;82(5):349–52.
[11] Song L, Shen L, Li H, Liu B, Zheng X, Zhang L, et al. Socio-economic status and risk of gestational diabetes mellitus among Chinese women. Diabet Med 2017;34(10):1421–7.
[12] Varela MM, Nohr EA, Llopis-Gonzalez A, Andersen AM, Olsen J. Socio-occupational status and congenital anomalies. Eur J Public Health 2009;19(2):161–7.
[13] Bushnik T, Yang S, Kaufman JS, Kramer MS, Wilkins R. Socioeconomic disparities in small-for-gestational-age birth and preterm birth. Health Rep 2017;28(11):3–10.
[14] Meng G, Thompson ME, Hall GB. Pathways of neighbourhood-level socio-economic determinants of adverse birth outcomes. Int J Health Geogr 2013;12:32.
[15] Joseph KS, Liston RM, Dodds L, Dahlgren L, Allen AC. Socioeconomic status and perinatal outcomes in a setting with universal access to essential health care services. CMAJ 2007;177(6):583–90.
[16] HCUP National Inpatient Sample (NIS). Healthcare Cost and Utilization Project (HCUP). 2012. Agency for Healthcare Research and Quality R, MD. Available from: www.hcup-us.ahrq.gov/nisoverview.jsp.
[17] Heshmati A, Mishra G, Koupil I. Childhood and adulthood socio-economic position and hypertensive disorders in pregnancy: the Uppsala Birth Cohort Multigenerational Study. J Epidemiol Community Health 2013;67(11):939–46.
[18] Anna V, van der Ploeg HP, Cheung NW, Huxley RR, Bauman AE. Sociodemographic correlates of the increasing trend in prevalence of gestational diabetes mellitus in a large population of women between 1995 and 2005. Diabetes Care 2008;31(12):2288–93.
[19] Feig DS, Zinman B, Wang X, Hux JE. Risk of development of diabetes mellitus after diagnosis of gestational diabetes. CMAJ 2008;179(3):229–34.
[20] Bouthoorn SH, Silva LM, Murray SE, Steegers EA, Jaddoe VW, Moll H, et al. Low-educated women have an increased risk of gestational diabetes mellitus: the Generation R Study. Acta Diabetol 2015;52(3):445–52.
[21] Gould JB, Davey B, Stafford RS. Socioeconomic differences in rates of cesarean section. N Engl J Med 1989;321(4):233–9.
[22] Fabri RH, Murta EF. Socioeconomic factors and cesarean section rates. Int J Gynaecol Obstet 2002;76(1):87–8.
[23] Leeb K, Baibergenova A, Wen E, Webster G, Zelmer J. Are there socio-economic differences in caesarean section rates in Canada? Health Policy 2005;1(1):48–54.
[24] Raisanen S, Gissler M, Kramer MR, Heinonen S. Influence of delivery characteristics and socioeconomic status on giving birth by caesarean section - a cross sectional study during 2000-2010 in Finland. BMC Pregnancy Childbirth 2014;14:120.
[25] Adhikari K, McNeil DA, McDonald S, Patel AB, Metcalfe A. Differences in caesarean rates across women's socio-economic status by diverse obstetric indications: cross-sectional study. Paediatr Perinat Epidemiol 2018;32(4):309–17.
[26] Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, et al. Global, regional, and national causes of child mortality in 2000-13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet 2015;385(9966):430–40.

[27] Tuntiseranee P, Olsen J, Chongsuvivatwong V, Limbutara S. Socioeconomic and work related determinants of pregnancy outcome in southern Thailand. J Epidemiol Community Health 1999;53(10):624–9.

[28] Craig ED, Thompson JM, Mitchell EA. Socioeconomic status and preterm birth: New Zealand trends, 1980 to 1999. Arch Dis Child Fetal Neonatal Ed 2002;86(3). F142-6.

[29] Savitz DA, Kaufman JS, Dole N, Siega-Riz AM, Thorp JM, Jr, et al. Poverty, education, race, and pregnancy outcome. Ethn Dis 2004;14(3):322–9.

[30] de Sadovsky ADI. MK, Miranda AE, Silveira MF. The associations that income, education, and ethnicity have with birthweight and prematurity: how close are they? Rev Panam Salud Publica 2018;42(Aug).

[31] Luo ZC, Wilkins R, Kramer MS. Fetal, Infant Health Study Group of the Canadian Perinatal Surveillance S. Effect of neighbourhood income and maternal education on birth outcomes: a population-based study. CMAJ 2006;174(10):1415–20.

[32] Parker JD, Schoendorf KC, Kiely JL. Associations between measures of socioeconomic status and low birth weight, small for gestational age, and premature delivery in the United States. Ann Epidemiol 1994;4(4):271–8.

[33] Raisanen S, Gissler M, Nielsen HS, Kramer MR, Williams MA, Heinonen S. Social disparity affects the incidence of placental abruption among multiparous but not nulliparous women: a register-based analysis of 1,162,126 singleton births. Eur J Obstet Gynecol Reprod Biol 2013;171(2):246–51.

[34] Coleman J, Srofenyo EK, Ofori EK, Brakohiapa EK, Antwi WK. Maternal and fetal prognosis in abruptio placentae at Korle-Bu Teaching Hospital, Ghana. Afr J Reprod Health 2014;18(4):115–22.

[35] Noor S, Nazar AF, Bashir R, Sultana R. Prevalance of PPROM and its outcome. J Ayub Med Coll Abbottabad 2007;19(4):14–7.

[36] Amjad S, Chandra S, Osornio-Vargas A, Voaklander D, Ospina MB. Maternal area of residence, socioeconomic status, and risk of adverse maternal and birth outcomes in adolescent mothers. J Obstet Gynaecol Can 2019;41(12):1752–9.

[37] Choe SA, Min HS, Cho SI. The income-based disparities in preeclampsia and postpartum hemorrhage: a study of the Korean National Health Insurance cohort data from 2002 to 2013. Springerplus 2016;5(1):895.

[38] Prick BW, Auf Altenstadt JF, Hukkelhoven CW, Bonsel GJ, Steegers EA, Mol BW, et al. Regional differences in severe postpartum hemorrhage: a nationwide comparative study of 1.6 million deliveries. BMC Pregnancy Childbirth 2015;15:43.

[39] Kort D, van Rein N, van der Meer FJM, Vermaas HW, Wiersma N, Cannegieter SC, et al. Relationship between neighborhood socioeconomic status and venous thromboembolism: results from a population-based study. J Thromb Haemost 2017;15(12):2352–60.

[40] Jorgensen H, Horvath-Puho E, Laugesen K, Braekkan S, Hansen JB, Sorensen HT. Socioeconomic status and risk of incident venous thromboembolism. J Thromb Haemost 2021;19(12):3051–61.

[41] Park JE, Park Y, Yuk JS. Incidence of and risk factors for thromboembolism during pregnancy and postpartum: a 10-year nationwide population-based study. Taiwan J Obstet Gynecol 2021;60(1):103–10.

[42] Kern-Goldberger AR, Madden N, Baptiste CD, Friedman AM, Gyamfi-Bannerman C. Disparities in obstetric morbidity by maternal level of education. J Matern Fetal Neonatal Med 2020:1–5.

[43] Kramer MS, Seguin L, Lydon J, Goulet L. Socio-economic disparities in pregnancy outcome: why do the poor fare so poorly? Paediatr Perinat Epidemiol 2000;14(3):194–210.

[44] Sebayang SK, Dibley MJ, Kelly PJ, Shankar AV, Shankar AH, Group SS. Determinants of low birthweight, small-for-gestational-age and preterm birth in Lombok, Indonesia: analyses of the birthweight cohort of the SUMMIT trial. Trop Med Int Health 2012;17(8):938–50.

[45] Barros FC, Victora CG, Matijasevich A, Santos IS, Horta BL, Silveira MF, et al. Preterm births, low birth weight, and intrauterine growth restriction in three birth cohorts in Southern Brazil: 1982, 1993 and 2004. Cad Saude Publica 2008;24 (Suppl 3). S390-8.

[46] Farrant BM, Shepherd CC. Maternal ethnicity, stillbirth and neonatal death risk in Western Australia 1998-2010. Aust N Z J Obstet Gynaecol 2016;56(5):532–6.

[47] Flenady V, Koopmans L, Middleton P, Froen JF, Smith GC, Gibbons K, et al. Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. Lancet 2011;377(9774):1331–40.

[48] Zeitlin J, Mortensen L, Prunet C, Macfarlane A, Hindori-Mohangoo AD, Gissler M, et al. Socioeconomic inequalities in stillbirth rates in Europe: measuring the gap using routine data from the Euro-Peristat Project. BMC Pregnancy Childbirth 2016;16:15.

[49] Ravelli AC, Tromp M, Eskes M, Droog JC, van der Post JA, Jager KJ, et al. Ethnic differences in stillbirth and early neonatal mortality in The Netherlands. J Epidemiol Community Health 2011;65(8):696–701.

[50] Luque-Fernandez MA, Lone NI, Gutierrez-Garitano I, Bueno-Cavanillas A. Stillbirth risk by maternal socio-economic status and country of origin: a population-based observational study in Spain, 2007-08. Eur J Public Health 2012;22(4):524–9.

[51] Ericson A, Eriksson M, Zetterstrom R. The incidence of congenital malformations in various socioeconomic groups in Sweden. Acta Paediatr Scand 1984;73(5):664–6.

[52] Olsen J, Frische G. Social differences in reproductive health. A study on birth weight, stillbirths and congenital malformations in Denmark. Scand J Soc Med 1993;21(2):90–7.

[53] Tuohy PG, Counsell AM, Geddis DC. The Plunket National Child Health Study: birth defects and sociodemographic factors. N Z Med J 1993;106(968):489–92.

[54] Lopez PM, Stone D, Gilmour H. Epidemiology of Down's syndrome in a Scottish city. Paediatr Perinat Epidemiol 1995;9(3):331–40.