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Article

Socioeconomic Position and Low Birth Weight: Evaluating Multiple and Alternative Measures Across Race in Michigan

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Abstract: In health research, socioeconomic position (SEP) is used to measure the context of social inequality. Studies on low birth weight (LBW) that attempt to capture social inequality have generally used single measures of SEP or have employed conventional SEP measures, such as income and education, without regard to how other indicators could influence findings. This study investigates the association between SEP and LBW across blacks and whites using multiple and alternative indicators of SEP. We use a stratified random sample of 13,513 postpartum mothers, obtained from the Michigan Pregnancy Risk Assessment Monitoring System (2000–2006), and evaluate four SEP measures across race: maternal education, Medicaid before pregnancy, Women, Infants and Children (WIC) enrollment during pregnancy and paternal acknowledgment. Results indicate that associations between SEP and LBW vary depending on the SEP measure used and the racial subpopulation under consideration. To explain and reduce social inequalities in LBW, a more differentiated approach that does not assume equivalence among SEP measures and across racial/ethnic groups should be employed.

Keywords: low birth weight; socioeconomic position; health; race; Michigan; WIC; Medicaid; paternal acknowledgement

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1. Background

Health research has been increasingly focused on social factors as "fundamental causes" of disease. This is predicated on the understanding that social factors are fundamentally linked to access to critical resources, affect multiple health outcomes through multiple mechanisms and ultimately maintain an association with disease, even when intervening mechanisms change [1]. Regardless of the time period, geographic location, demographic group or measure of health, the better-off members of society typically live longer, healthier lives [2]. Although there has been much attention on individual health behaviors and the reform of the U.S. fragmented healthcare system, it has been argued that the social and economic inequality inherent in the configuration of U.S. society affects population health profoundly more than any other factor [3]. Therefore, understanding the context of social and economic inequality is key to understanding health.

In health research, the concept of "socioeconomic position" has been used to reflect and measure the context of inequality that may have consequences for health. Socioeconomic position (SEP) refers to the position(s) individuals or groups occupy within the social structure that is influenced by social and economic factors [2]. Individual-level indicators, such as education, occupation and income, are often used in health research based on the assumption that they constitute fundamental links between social stratification and health [2]. The indicator of SEP used in health research often depends on assumptions of how socioeconomic position is linked to health damaging exposures, health protective resources and, ultimately, to health. For instance, is it a lack of resources/material deprivation that causes poor health or is it low social prestige? Is it a combination of these things? The use of indicators is not based on the belief that one is universally better than the others, but rather, which indicator is most appropriate in understanding the association between social and economic realities and health outcomes, as well as the stage of life in question.

Several health studies have used a single indicator of SEP (*i.e.*, education or income), which, though convenient, fails to consider how other ways of measuring SEP may influence findings [4]. A single measure of SEP may capture only a part of the multi-dimensional impact of socioeconomic position on health [5]. Conclusions emerging from those studies that have used single measures erroneously suggest that SEP indicators are interchangeable and reflect the same aspects of social or material disadvantage for different subpopulations [6]. For example, education as a measure of SEP provides information about the likelihood of success and reflects knowledge and skills acquired that may affect an individual's cognitive functioning, which ultimately protect health [7]. However, it has been found that the economic returns on education may differ across racial/ethnic and gender groups. Women and minorities realize lower returns with respect to health for the same investment in their education than do white men [7].

The relationship between low SEP and poor health outcomes is well established [2,8,9]. However, the continued use of "traditional" SEP indicators in health research (*i.e.*, income and education) may provide limited insight into the association between inequality and health [10]. For health research to effectively inform interventions, there must be a practical approach to measuring SEP that considers the specific ways in which socioeconomic conditions can impact health outcomes. For instance, data related to specific factors, such as type of health insurance and support systems, may be more useful in the development of interventions designed to reduce health disparities. Additionally, research that

incorporates specific social and economic factors captures a more in-depth understanding of the social context, which may provide a more accurate representation of a demographic at a given stage in the life course.

Some SEP measures may reflect specific aspects of social position that influence a particular health outcome better than other measures [11]. Based on this, some studies have used multiple measures to enable a better understanding of how different dimensions of inequality affect birth outcomes. A recent study by Shankardas and colleagues [12] used multiple income-related indicators to investigate the relationship between SEP and perinatal outcomes at the family and neighborhood levels in Canada. The SEP measures assessed and compared included: total family income, before and after tax (adjusted for family size and inflation), expressed in 2003 Canadian dollars; the proportion of income from government transfers as an indicator of relative reliance on redistributed income; total family income (after tax) below the low income measure (LIM) as an indicator of poverty; any income derived from investments as an indicator of wealth; and contributions made to a registered retirement savings plan (RRSP) as an indicator of being in the middle social class. They found that both individual level income and neighborhood level deprivation were significant predictors for most of the perinatal outcomes examined. However, there was no consistent pattern in the directions and strengths of associations for the different predictors examined. Although this study used multiple income-related measures, other aspects of SEP, such as education, were not considered.

A study by Parker *et al*. [8] used data from the 1988 National Maternal and Infant Health Survey to compare the associations between several socioeconomic indicators (maternal education, paternal education, paternal occupation and family income) and birth outcomes. Factors that are not directly income related, but that may have an impact on birth outcomes, were also considered. They found that all socioeconomic indices were inversely associated with low birth weight (LBW). However, the association between SEP and LBW differed depending on race and the SEP indicator used. Studies like this avoid the pitfalls of using just one kind of SEP measure. However, their reliance on traditional indicators, such as education and occupation, does not go far enough to accurately and fully understand the SEP association with birth outcomes.

The association between traditional SEP measures and birth outcomes is already well established, and therefore, there is little more to be gained by continuing to assess SEP with only traditional measures, such as income and education. In order to attain a more accurate understanding of the social conditions that may affect birth outcomes (*i.e.*, medical care, adequate diet), the assessment of other SEP measures is needed.

Responding to the need for alternative and nontraditional measures of SEP that may have value for public health policy, a study by Gazmararian *et al*. [4] evaluated multiple SEP measures and investigated associations between socioeconomic status and maternal health behavior [4]. This study used population-based data for Caucasian women from Alaska, Maine, Oklahoma and West Virginia who delivered a live infant in 1990–1991 and participated in the Pregnancy Risk Assessment Monitoring System (PRAMS). The study also utilized maternal education, Medicaid payment for delivery and Women, Infants and Children (WIC) enrollment during pregnancy to reflect specific aspects of social position that influence maternal health behavior. By virtue of their eligibility criteria, Medicaid payment for delivery, as well as WIC during pregnancy were conceptualized as measures of poverty.

The research represented a practical approach to measuring SEP that reflects specific ways in which different dimensions of inequality could affect health behaviors.

While increased attention has been paid to SEP as the main variable of interest [8,13,14], there is a further need to explore the relationship of multiple and lesser-known SEP measures with health, as well as how these relationships may differ across subpopulations. The Gazmararian *et al*. [4] study attained a deeper understanding of the social context of health by using multiple measures, including WIC and Medicaid. However, the study did not include racial minorities, despite evidence showing that the association between SEP and health differs across racial subpopulations [8].

Infant mortality is usually examined as an important measure of society or community health, because early life health contributes to overall population health. However, understanding low birth weight (LBW) within a broader health context is crucial, because LBW has direct implications for infant mortality, as well as long-term impacts on health outcomes in adult life. LBW infants are at higher risk for various developmental and health outcomes, including cognitive development, higher prevalence of respiratory distress and asthma [15]. Lewitt *et al*. [16] estimated that 35% of all healthcare spending on newborn children in the U.S. is related to LBW children, even though they make up less than 8% of newborns. The conventional definition of low birth weight is an infant born at a weight less than 2500 grams or five pounds, eight ounces.

Our study evaluates four SEP indicators (maternal education, WIC during pregnancy, Medicaid before pregnancy and paternal acknowledgement) that may have an impact on low birth weight. In the process, we assess indicators that are not directly related to income, but may reflect a wider range of socio-economic circumstances. Unlike Parker *et al*. [8], we explore SEP indicators that are less frequently used in health research. We also build on the practical approach utilized by Gazmararian *et al*. [4] by investigating the association between SEP and LBW across race. Subsequently, we investigate how race interacts with SEP to determine variations in low birth weight. By observing variations between associations of less known measures of SEP (WIC during pregnancy, Medicaid before pregnancy and paternal acknowledgement) and one traditional measure of SEP (education) with low birth weight, we discern the socioeconomic context of black and white mothers in Michigan.

2. Data and Methods

We used seven annual cohorts of data (2000–2006) collected by the Pregnancy Risk Assessment and Monitoring System (PRAMS) in Michigan. Michigan PRAMS is part of an ongoing surveillance project of the Centers for Disease Control and Prevention (CDC) in which state-specific population-based data on maternal attitudes and experiences before, during and shortly after pregnancy are collected. PRAMS surveys mothers who have delivered a live-born infant within a calendar year. Natality information, collected by Michigan's Office of Vital Records and Health Statistics, serves as the sampling frame from which Michigan PRAMS selects its survey respondents. Mothers who had delivered a live-born infant who subsequently died are included in the sampling frame. Only one infant of a multiple gestation is included, unless the gestation includes four or more siblings. Michigan PRAMS uses stratified random sampling that allows separate estimates of subgroups of interest, as well as comparisons across groups. PRAMS uses a mixed methodology, where a combination of mail and telephone surveys is used to maximize response rates.

After Michigan PRAMS data collection is concluded, mothers' responses are linked to their corresponding birth certificate data. The linked Michigan PRAMS response/birth certificate data set is then sent to the CDC for weighting [17]. Weighting of the data set allows researchers to estimate the statistics for the entire state's population of women who delivered a live-born infant from data gathered from a sample of mothers in that population. In Michigan PRAMS, there are three weighting components that adjust for sample design, non-response and omissions in the sampling frame. Non-response adjustments used in PRAMS attempt to compensate for the tendency of women having certain characteristics (such as being unmarried or of lower education) to respond at lower rates than women without those characteristics. The rationale for applying non-response weights is the assumption that non-respondents would have provided similar answers to respondents' answers for the stratum and adjustment category under consideration [17]. The total sample we used in this study consisted of 13,513 individuals; 4260 black mothers and 9253 white mothers (excluding other racial/ethnic categories due to inadequate sample sizes of those groups and excluding mothers below 18 years of age).

2.1. Dependent Variable

Low birth weight: We used infant birth weight as the main dependent variable, because of its implications for overall population health [18]. MI PRAMS provided us with infant birth weight information using information on birth certificates. Although infant birth weight was a continuous variable, we dichotomized it for this study. Mothers who gave birth to infants that weigh less than 2500 grams (5 lbs, 8 oz) at birth were classified as "low birth weight" (LBW), and mothers who had infants weighing 2500 grams or more at birth were classified as "not low birth weight". The designation of LBW as infants born below 2500 grams (5 lbs, 8 oz) is based on convention [13], as well as higher risk for various developmental and health outcomes [15].

2.2. Independent Variables

SEP measures: This study utilizes four individual-level SEP measures available in Michigan PRAMS (maternal education, WIC during pregnancy, Medicaid receipt before pregnancy and paternal acknowledgement on the infant's birth certificate). Maternal education is a commonly used traditional SEP indicator, while participation in the Special Supplemental Food Program for Women, Infants and Children (WIC) during pregnancy and "Medicaid receipt before pregnancy" are less common indicators of poverty. "Paternal acknowledgement" is used as an additional measure related to SEP status.

Maternal education was coded into three categories; $0 \geq 12$ years, $1 = 12$ years (high school graduate) or $2 \leq 12$ years of education. This categorization assumes that time spent in education reflects the material and social resources available to attend school over a period of time, which may cumulatively effect low birth weight. This categorization of maternal education also assumes high school graduation as a specific educational achievement that has material and social implications for SEP and health.

The Medicaid eligibility requirement for pregnant women and women with infants is income at or below 185% of the federal poverty income guidelines in Michigan and having no or inadequate health

insurance. Mothers who are on Medicaid before pregnancy are viewed as having encountered specific conditions that may affect health, such as lack of access to medical care, low income and various statuses of poverty. We classified mothers as either on Medicaid before pregnancy (1) or not on Medicaid before pregnancy (0).

Although state WIC eligibility criteria vary somewhat, in general, women qualify if they meet a state residency requirement, are at a nutritional risk and have income at or below 185% of the federal poverty income guidelines or participate in other federally-funded programs, such as food stamps [4]. Specifically for Michigan, the most recent criteria for eligibility for WIC include a gross income range from $21,257 (for a family of 1) to $73,316 (for a family of 8), with a $7437 increase for each additional family member [17]. WIC was used as a SEP measure of poverty that reflects material deprivation that affects health directly or indirectly (through poor nutrition). We classified women as either "yes, WIC participant" (1); or "no, not on WIC" (0).

Research has shown that spousal support is associated with social and economic wellbeing, which ultimately impacts health [19]. Given that using marital status as an indicator of spousal support may exclude many demographic groups, we used paternal acknowledgement (presence of the father's name on the birth certificate rather than whether the mother and father are married) as a factor that may be related to social and economic wellbeing. We classified mothers based on the presence or absence of the father's name on birth certificates, coded as name present (0) or name not present (1).

Race: Mothers were categorized as 0 = white, 1 = black and 2 = other (American Indian, Chinese, Japanese, Filipino, Hawaiian, Alaska Native, other non-white and other). As mentioned above, we limited our analysis to black and white mothers due to the small sample sizes of the other racial/ethnic subgroups.

2.3. Statistical Analysis

For the purposes of this study, we aggregated Michigan PRAMS data from 2000 to 2006 to maximize sample size and to allow for stratification of the sample based on mothers' race (black and white). The data were analyzed using STATA 10 s.e., incorporating the sampling weights associated with each case/respondent. Pearson's correlation coefficients were used for comparisons of different SEP measures to determine the agreement and multicollinearity between SEP measures. Matrices of correlations between variables provided a fast check for multicollinearity. Pearson's correlation coefficients greater than 0.50 were used to indicate that measures were comparable enough to show similar dimensions of SEP. A correlation coefficient below 0.50 was used to suggest that the selected SEP measures capture different dimensions of socioeconomic stratification. In the aggregated sample, item response rates were high for SEP measures with values ranging from 78.56% to 100.0%. When the aggregated sample was stratified by race, the response rates did not vary considerably between black and white women.

We used binary logistic regression to determine the relationship between individual SEP measures and LBW. In our regression models, some predictors of maternal demographic characteristics (such as age and race) are controlled. We modeled interactions between selected SEP measures and race by investigating the effect of specific SEP measures across and within groups through examining the magnitude of the odds ratios produced from stratified multivariate analyses; thus allowing for the

assessment of interaction effects between SEP and the stratification variable (race). We also modeled interactions between the SEP measures and race by developing a statistical model for the total population (black and white) that included the interaction terms for race with maternal education, WIC, Medicaid and paternal acknowledgment.

3. Results

As seen in the weighted percentages of Table 1, in our study sample, white women accounted for approximately 62% of the population, while blacks (26.3%) were the most prevalent minority group. The largest proportion of births was for women aged 20–29 years of age. Approximately 40% of mothers reported being on WIC during pregnancy, and approximately 16% reported being on Medicaid before pregnancy. The majority of women (75%) indicated paternal acknowledgement on infant birth certificates. Approximately 37% of mothers reported less than 12 years of formal education.

Table 1. Maternal demographic characteristics (all races).

Demographic Characteristic	Sample Frequency (n)	Weighted Percent
Maternal Race		
Black	4389	26.32
White	9438	62.15
Other	1605	11.53
Maternal Age		
<18	697	5.12
18–19	1241	8.11
20–24	4052	27.34
25–29	4192	28.01
30–34	3378	22.34
35–39	1551	9.45
40+	356	9.08
Maternal Education		
<12 years	8175	37.43
12 years	3472	31.82
>12 years	3389	30.75
WIC during pregnancy		
Yes	4597	40.34
No	6210	58.32
Missing	25	1.34
Medicaid before pregnancy		
Yes	1951	16.45
No	8866	80.77
Missing	18	2.78
Paternal acknowledgement		
Yes	12,261	75.36

The selected measures of SEP are unevenly distributed among white and black mothers (Table A1). The majority of blacks (67.37%) had fewer than 12 years of education, while almost half of whites in the sample (49.85%) had 12 years or fewer school years. Almost four in every 10 white women

(26.52%) had more than 12 years of education, while less than 10% of black women had attained similar years of schooling. The majority of black women in the study sample (63.4%) reported being on WIC during pregnancy, while most white women (63.3%) did not participate in that program. While most women reported not being on Medicaid before pregnancy, a greater proportion of black women (37.7%) were recipients of Medicaid compared to white women (12.1%). The majority of both black and white women did report the father's name on the infants' birth certificate; however, a considerably greater proportion of black women (44.53%) did not have a father's name on their infant birth certificates as compared to white women (11.15%). A *t*-test for mean comparison for maternal education of black and white mothers indicates that there is a significant difference in mean education between the black and white populations ($p < 0.001$). Three tests of proportions were also carried out for the dichotomous variables, WIC during pregnancy, Medicaid before pregnancy and paternal acknowledgement. Hypothesis tests indicate that the proportions of women on WIC during pregnancy, on Medicaid before pregnancy and having paternal acknowledgement are significantly different for black and white populations with *p*-values < 0.001 in all three cases (See Appendix Table 1 for details).

Approximately 31% of infants in the sample weighed less than 2500 grams. The prevalence of low birth weight (LBW) infants varies by selected maternal characteristics. Specifically, the rate of LBW was higher among black women (35.96%) than among white women. Women with fewer than 12 years of education reported the highest prevalence of LBW infants (nearly 35%); the rate of LBW births decreased with increasing years of schooling. Medicaid recipients and those women who participated in WIC reported a somewhat higher prevalence of LBW infants compared with women who did not participate in these programs. Women who had given birth to infants who did not have paternal acknowledgement on their birth certificates also reported a substantially high prevalence of LBW (Table A2).

There were low overall correlations between the four selected measures of SEP with values ranging from 0.054 to 0.346 (Table A3). The lowest correlation was obtained between paternal acknowledgment and WIC participation (0.054), whereas the highest correlation was obtained between education and WIC participation (−0.346). The low correlations between SEP measures, such as paternal acknowledgment and WIC, indicate that these measures are capturing different dimensions of SEP. The relatively high correlation (still below < 0.5) between Medicaid and WIC was not surprising, since low income is one of the eligibility requirements for both Medicaid and WIC participation. Consequentially, the "income" variable showed high correlations with both Medicaid (0.651) and WIC participation (0.582). Income was also highly correlated with maternal education (−0.509) and paternal acknowledgement (−0.781) and, hence, removed from our analysis, due to issues of multicollinearity.

In Table 2, we report results of four separate binary logistic regression models (Models A, B, C and D) that evaluate the associations between each individual SEP measure and LBW (controlling for maternal race and age in each model). All four SEP measures show significant associations with LBW in the respective models. However, there is variation in the magnitude of association for each measure, ranging from an odds ratio of 1.27 (95% CI = 1.129–1.425) for those who were on Medicaid before pregnancy (Model C), to 1.52 (95% CI = 1.387–1.677) for mothers who did not report paternal acknowledgment on birth certificates (Model D).

Table 2. Models representing odds ratios for socioeconomic position (SEP) measures and low birth weight (LBW) (total population).

Model	Variable	Total Population LBW (1 = Yes, 0 = No)	95% Confidence Interval
A	Maternal Education		
	<12 years	1.519 ***	1.405–1.625
	12 years	1.083 *	1.009–1.542
	>12 years	1.0	
	Age	1.007 *	1.000–1.014
	Race (black = 1)	1.343 ***	1.240–1.454
B	On WIC during pregnancy	1.15 **	1.046–1.272
	Age	1.00	0.995–1.010
	Race (black = 1)	1.45 ***	1.314–1.603
C	Medicaid before pregnancy	1.27 ***	1.129–1.425
	Age	1.002	0.995–1.010
	Race (black = 1)	1.41 ***	1.277–1.562
D	Paternal Acknowledgment	(1 = No, 0 = Yes) 1.525 ***	1.387–1.677
	Age	1.003	0.997–1.009
	Race (black = 1)	1.222 ***	1.123–1.328

Two-tailed test: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

We modeled interactions between the selected SEP measures and race in two ways. Firstly, a model for the total population was developed that included the interaction effects for race, with maternal education, WIC, Medicaid and paternal acknowledgment (Table 3). Secondly, to further investigate the interaction effects of race, we developed two separate regression models for black and white subpopulations, stratified by race, and controlled for age. These two models help determine variations in odds ratio measures for each SEP measure across race (Table 4).

Table 3. Odds ratios for SEP measures and LBW (interaction effects).

Variable	LBW (1 = Yes, 0 = No)	95% Confidence Interval
Maternal Education		
12 years	1.013 *	1.003–1.989
<12 years	1.258 **	1.108–1.360
>12 years	1.0	
WIC	0.987	0.872–1.118
Medicaid	1.216 *	1.026–1.441
Paternal Acknowledgment	1.826 ***	1.523–2.188
Maternal Education × Race	1.302 ***	1.211–1.401
WIC × Race	0.896	0.741–1.082
Medicaid × Race	0.890	0.699–1.133
Paternal Acknowledgment × Race	0.597 ***	0.468–0.762
Age	1.006 **	1.003–1.027

Two-tailed test: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 4. Odds ratios for SEP measures and LBW for blacks and whites (stratified analysis).

SEP Measure	Black, LBW (1 = Yes, 0 = No)	White, LBW (1 = Yes, 0 = No)
Maternal Education		
<12 years	1.348 **	1.209 **
12 years	1.231	0.937
>12 years	1.0	1.0
Medicaid	1.004	1.261 **
WIC	0.759 **	1.107
Paternal Acknowledgment	(1 = No, 0 = Yes) 1.005	(1 = No, 0 = Yes) 1.939 ***
Age	1.012	1.016 **

Two-tailed test: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The interaction model in Table 3 shows that race and education, as well as race and paternal acknowledgment have significant interaction effects on LBW in the total population. This is indicative of significant racial differences in the way education attainment and paternal acknowledgment affect LBW among black and white subpopulations. On the other hand, we did not find any significant interaction effects for WIC and Medicaid. The main effect for Medicaid indicates that, while there are no racial differences, mothers who are on Medicaid before pregnancy are 1.216-times more likely to have LBW children than mothers who are not on Medicaid.

In the (race) stratified analysis (Table 4), we once again notice the racial differences in education and paternal acknowledgement. We also find an association between paternal acknowledgment and LBW among white women. White women who do not indicate paternal acknowledgment are 1.939-times more likely to have a LBW child compared to those who indicate paternal acknowledgment, when controlled for the effects of maternal education, age, WIC and Medicaid. Overall, the results indicate that education is more important for blacks, that paternal acknowledgment is more important for whites and that poverty (as measured by Medicaid) appears to matter for both black and white women.

4. Conclusions

The findings of this study add to the growing body of knowledge pertaining to the SEP-birth outcomes association. Findings point to an association between SEP and low birth weight, where the worst-off in society have higher odds of having low birth weight infants; a result consistent with countless previous health research studies investigating the fundamental social causes of poor health. However, associations observed using multiple and alternative measures suggest that the SEP-LBW connection is more complicated than previously discerned with the use of singular traditional indicators.

The association between SEP and LBW varies depending on what SEP measure is being used. For instance, in the total population, varying associations were observed between selected SEP indicators (WIC, Medicaid, maternal education and paternal acknowledgement) and LBW. Each SEP measure employed summarizes distinct social and economic components of the overall risk of LBW. Findings suggest that certain measures reflect specific aspects of socio-economic position that influence LBW more accurately than others. For the total population, maternal education and paternal acknowledgement

show clear associations with LBW. Therefore, in this case, it is arguable that the type of resources used to sustain more years of schooling, as well as social and material resources indicated by paternal acknowledgement may be associated with low birth weight.

The results of this study also suggest that some SEP indicators may more accurately reflect the circumstances of some racial subpopulations than others. This is particularly true when considering the impact of race on the SEP-LBW association. Although factors associated with social and economic circumstances may appear identical irrespective of racial background, the implications for adverse birth outcomes differ substantially between blacks and whites. Consequently, some SEP measures may be more useful in assessing risk for LBW among white women, whereas others may more accurately reflect the circumstances of black women. For instance, while paternal acknowledgement was strongly associated with LBW among whites, no significant association was observed among blacks. Maternal education attainment also indicated strong racial differences in its effects on LBW.

Our results suggest that the unique characteristics of a racial/ethnic subpopulation cannot be overlooked and may account for differences in the association between selected SEP indicators and low birth weight. Although there is uncertainty as to why we did not observe racial differences in the effects of WIC and Medicaid on LBW, we can suggest some plausible explanations for some other significant racial differences observed. Although poverty as indicated by Medicaid reveals no racial differences, socioeconomic differences exemplified by paternal acknowledgment seem to be detrimental to the white subpopulation more than the black subpopulation. It is possible that the lack of a significant association between paternal acknowledgment and LBW among blacks is reflective of how the structure of the black family in the U.S. has adapted to historical patterns of racial discrimination [20]. Consequentially, one can argue that a lack of paternal acknowledgement in itself may not reflect conditions detrimental to birth outcomes among blacks [21].

Alder and Newman [22] argue that education is the "most basic" component of SEP, because it influences future occupational opportunities and earning potentials. Education captures socioeconomic position from childhood to adulthood, as well as reflecting the knowledge and skills acquired that may affect an individual's cognitive functioning, which ultimately may protect his/her health [7]. Our study found that maternal education is an important determinant of LBW; and it is even more important for the black subpopulation than the white subpopulation. We believe that this is most likely due to the additive effects of race. In other words, black women with low levels of education are more likely to have LBW infants as a result of combined disadvantages that stem from poor education and racial discrimination. Ultimately, whether we see differences of association across race really depends on the SEP indicator used, because some measures may capture and contrast the socioeconomic reality of a given racial/ethnic group better than others. Unique socio-historical realities, as well as current patterns of discrimination may compound LBW among certain racial subpopulations. In essence, a colorblind approach should not be employed when evaluating SEP measures.

In a number of ways, our study is a departure from the conventional approaches to understanding the association between SEP and low birth weight. The use of multiple SEP measures in this study reflects the multifaceted nature of SEP as mentioned in the relevant literature. Since more than one measure was employed, the findings did not show only a singular strength of association. The inclusion of relatively less utilized measures has allowed for alternative and more precise socioeconomic factors related to low birth weight to be considered in the analysis.

There are several notable limitations regarding the use of the selected SEP measures in the study. First, the differences in the eligibility requirements for both Medicaid and WIC across states make regional and state comparisons complicated. Secondly, WIC, Medicaid and paternal acknowledgment are inherently dichotomous measures that illustrate striking comparisons between the most socio-economically deprived and other specific groups in society. However, there is a range of socio-economic circumstances that fall between the implied extremes. For instance, not being on WIC does not necessarily mean access to having a balanced, low-fat diet, rich in fresh fruit, grains and vegetables. Ultimately, incremental improvements in socioeconomic position may correspond to improvements in pregnancy outcomes, such as low birth weight. Third, because we gained access to education as a discrete variable, it has limited our data analysis and interpretation to some extent. There are potential additional health benefits that accrue for several educational milestones beyond what would equate to a high school education. An argument for more equitable redistribution of socio-economic resources could be more strongly made if maternal education were further stratified. Additionally, it should also be noted that the quantity of schooling as measured by years of schooling does not necessarily equate to quality of schooling. Observed disparities in LBW in the total population, as well as across racial groups may be amplified if the quality of the education received were taken into consideration.

LBW is an important health outcome to consider, as it has direct implications for infant mortality, as well as long-term impacts on health outcomes in adult life [22]. LBW infants are at higher risk for various developmental and negative health outcomes, including reduced cognitive development, higher prevalence of respiratory distress and asthma, as discussed before [22]. However, we are cognizant of certain limitations regarding the use of LBW as a dependent variable. First, the dichotomization of LBW, while allowing for the binary logistic regression analysis, still caused a loss of valuable information. Further stratification of LBW to "very low birth weight" and "extremely low birth weight" might have yielded more useful information regarding the association between birth weight and SEP. Second, assessing LBW in this way conflates other birth outcomes, such as preterm birth and small for gestational age. Considering LBW alone limits our understanding of the biological or behavioral pathways through which SEP may influence various birth outcomes.

Our study addressed the need for more differentiated models of the relationship between SEP and birth outcomes. Ultimately, some additional issues have become apparent and, therefore, should also be addressed in future research. More individual SEP measures that reflect incremental changes in SEP, as well as ecological data (*i.e.*, zip code, census tract, block numbering) that capture area-level effects should be utilized. A growing body of racial heath disparity research has already begun to incorporate area-level/neighborhood effects. In particular, some studies have reported higher LBW risks for infants born in disadvantaged neighborhoods [23], racial disparities in birth outcomes across neighborhood socioeconomic contexts [24,25] and census track-based socioeconomic gradients in birth weights [26].

Several of our data limitations are tied to the realities of utilizing a secondary data set, which is not uncommon in research of this nature. While being cognizant of these limitations, we suggest that paternal acknowledgement, education and Medicaid be routinely collected in surveys related to birth outcomes. Although efforts to gather such additional information may be more difficult due to logistical/administrative limitations and participants' social desirability biases, the explanatory power

of these variables suggests that methodological efforts to collect these indicators of SEP are valuable. Ultimately, assessing paternal acknowledgement and Medicaid along with more traditional measures, such as education, can be useful for public health research and provide a number of avenues of intervention for society's most vulnerable populations.

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Author Contributions

Cedric A.L. Taylor obtained the PRAMS data, provided the theoretical framework and participated in the study design and data analysis. Dilshani Sarathchandra participated in the study design, data analysis and data interpretation. Both authors collaborated in preparing this manuscript.

Appendix

Table A1. Distribution of SEP measures by race.

SEP Indicator	% Total Population (n = 13,513)	% Black (n = 4260)	% White (n = 9253)	Mean Comparison
Maternal Education				$t = 17.82$ $p < 0.001$
<12 years	54.37	67.37	49.85	
12 years	23.09	22.68	23.62	
>12 years	22.54	9.95	26.52	
WIC during pregnancy				$z = 28.98$ $p < 0.001$
Yes	42.7	63.4	36.7	
No	57.3	36.6	63.3	
Medicaid before pregnancy				$z = 34.46$ $p < 0.001$
Yes	18.0	37.7	12.1	
No	82.0	62.3	87.9	
Paternal acknowledgment				$z = -43.75$ $p < 0.001$
Yes	79.47	55.47	88.85	
No	20.53	44.53	11.15	

Table A2. Prevalence of LBW by race and selected SEP measures.

Variable	Percent LBW
Maternal Race	
Black	35.9%
White	27.5%
Maternal Education	
<12 years	35.5%
12 years	29.5%
>12 years	27.7%
WIC during pregnancy	
Yes	33.8%
No	29.9%
Medicaid before pregnancy	
Yes	36.6%
No	30.3%
Paternal acknowledgment	
Yes	30.3%
No	40.3%

Table A3. Correlation coefficients for SEP measures.

Variables	Correlation Coefficient (r)
Medicaid/WIC	0.308
Paternal acknowledgement/WIC	0.054
Education/WIC	−0.346
Medicaid/Paternal acknowledgment	−0.077
Medicaid/Education	−0.269
Education/Paternal acknowledgment	−0.340

Conflicts of Interest

The authors declare no conflict of interest.

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