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The Black-White Disparity in Sexually Transmitted Diseases during Pregnancy: How Do Racial Segregation and Income Inequality Matter?

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Abstract

Background—We investigate the roles of residential racial segregation and income inequality for the black-white disparity in acquiring sexually transmitted diseases (STD) during pregnancy in a multilevel framework.

Methods—The analytic sample consisted of non-Hispanic white ($N = 79,271$) or non-Hispanic black ($N = 17,669$) mothers from 2012 population birth data from Pennsylvania. We used the 2009–2013 American Community Survey for neighborhood characteristics of mothers; we used multilevel models.

Results—First, neighborhood-level factors are important for understanding this disparity because racial segregation and income inequality are significantly associated with acquiring STD during pregnancy, regardless of race. Second, racial segregation moderates the relationships between race/ethnicity and the acquisition of STD during pregnancy. White mothers are more vulnerable to neighborhood segregation than black mothers, and black mothers are less likely to acquire STD during pregnancy than white mothers if they reside with co-ethnics. Third, mothers residing in the most socioeconomically disadvantaged neighborhoods—as indicated by both absolute and relative measures of income inequality—have the highest odds of acquiring STD during pregnancy, regardless of race.

Conclusions—Neighborhood-level segregation and income inequality are important for understanding the acquisition of sexually transmitted diseases during pregnancy. Our findings have important implications for future research and for place-specific prevention and intervention to reduce the racial disparity in STD during pregnancy.

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Keywords

Sexually transmitted diseases; pregnancy; racial segregation; income inequality

Introduction

Eliminating racial health disparities in maternal and child health has been identified as one of the main goals of Healthy People 2020 (1) as they can have serious lasting and cumulative implications for both women and their children. One important aspect of racial health disparities in maternal health (2, 3) is the acquisition of sexually transmitted diseases (hereafter, STDs) during pregnancy. Understanding the factors affecting the acquisition of STDs during pregnancy is particularly important for three reasons. First, rates of STDs during pregnancy are alarming. Second, in addition to the negative consequences associated with the acquisition of STDs for women's reproductive health in general, the acquisition of STDs during pregnancy has heightened risks for both mothers and their infants (4) including serious pregnancy complications and perinatal mortality (5). Third, pregnant women can acquire an STD throughout her pregnancy. Although the risk of the acquisition of STDs decreases with increasing gestation as the frequency of sexual intercourse decreases, a nontrivial number of pregnant women (i.e., 28 to 40 percent) are at continued of the acquisition of STD even during the later stages of their pregnancy (5). Together, these reasons demonstrate the need for more systematic research to promote screening and prevention of STDs for women throughout pregnancy.

Previous studies on the acquisition of STD have used two approaches: an *individual-centered approach* that focuses on individual-level factors, and an *ecological approach* looking at contextual-level STD rates (6). These studies have contributed to our understanding of various social determinants of STDs at multiple levels. Prior research using the first approach has found that various individual sociodemographic and behavioral factors contribute to the acquisition of STD: race/ethnicity (particularly a membership in ethnic minority groups), lower education, poverty, a higher number of sexual partners, and delinquency behaviors (6, 7). In addition, prior ecological studies have found that several contextual characteristics, such as racial/ethnic composition and social disorganization, are associated with STD rates at the aggregated level (6, 8-10). While these studies contribute to our understanding of social determinants of STDs, scholars and policy makers have started to move beyond these approaches by developing a multilevel research framework in which they simultaneously consider individuals and their neighborhoods (11-13). The multilevel approach can offer unique insights and notable contributions to the literature on social determinants of STDs as the acquisition of STDs is *concurrently* influenced by complex factors at multiple levels (14, 15).

Drawing from previous studies on neighborhood contexts and STDs (6, 12), we specifically examine whether the black-white disparity in the acquisition of STDs during pregnancy could be explained by racial segregation and income inequality—two critical contextual determinants of STDs in the multilevel framework (3). Building upon previous ecological studies that found that contextual-level STD rates are associated with residential segregation

(2, 16) and income inequality (16, 17), this study investigates how residential racial segregation and income inequality are associated with the acquisition of STDs during pregnancy above and beyond mothers' individual characteristics. To the best of our knowledge, this study is the first to investigate how individual and neighborhood characteristics are concurrently associated with the acquisition of STDs during pregnancy using a multilevel approach. The current study contributes to the literature in three ways. First, we focus on STD acquisition during pregnancy as our main outcome, which has not been examined using the multilevel approach. Second, we apply the multilevel approach to the population data. Third, we use the residential segregation measures rather than simplistic racial/ethnic composition measures.

Materials and Methods

We obtained approval to conduct the research from the human subjects review board at the Pennsylvania State University. Data for this study come from two sources. The individual-level data are from the Commonwealth of Pennsylvania Department of Health Bureau of Health Statistics and Research—Master File Birth Extract. This dataset is based on the total population of women who had a live birth in Pennsylvania during 2012 calendar year, and it includes detailed information on women's prenatal health, birth experience, and birth outcomes. The contextual-level data are from five-year estimates of the 2009–2013 American Community Survey. We use the census tract as a proxy for individuals' neighborhoods, which is a common practice in health research (18). Our analytic sample includes mothers who self-identified as non-Hispanic white ($N = 79,271$) or non-Hispanic black ($N = 17,669$). Defining neighborhoods with Census tracts, we had 96,940 respondents residing in 3,154 neighborhoods for our analysis.

Individual-level Variables

The dependent variable used in this analysis, *the acquisition of STDs during pregnancy*, is measured as a dichotomous variable; women who acquired any of several STDs (i.e., gonorrhea, chlamydia, syphilis, herpes simplex virus, or hepatitis B or C) during pregnancy are coded as 1. The presence of any of STDs is reported by doctors and/or hospital personnel who filled out the birth certificates.

Drawing from the literature, we include several individual-level sociodemographic factors. *Maternal race* is a dichotomous variable indicating whether a woman reported their race as non-Hispanic black (coded 1 if black). Maternal age at the time of infant's birth is measured as the continuous variables *age* and *age squared*. If women were married at the time of infant's birth, their *marital status* is coded as 1 and 0 if they were not married or in other marital statuses. A set of three dummy variables are created to measure *maternal education*: less than high school, high school diploma or equivalent degree, some college, and bachelor's degree or higher. We use whether mothers received the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) as a proxy of *maternal poverty status*. We also include two pregnancy-related individual-level factors: (1) the *total number of prenatal visits*, a count variable indicating how many times women received prenatal care during their pregnancies; and (2) a set of three dummy variables measuring women's

insurance status to indicate the method of payment for their delivery—namely, private insurance, Medicated, self-pay, and other.

Neighborhood-level: Residential Segregation and Income Inequality

Although racial segregation can be measured with five dimensions (19), we focus on exposure and concentration because they are identified as the most relevant dimensions for infectious diseases (20). Exposure measures the degree of potential contact between groups within neighborhoods (19), and we assess this dimension with *the isolation index* measuring “the extent to which minority group members are exposed only to one another” (19). The dimension of concentration measures the relative amount of physical space a minority group occupies in the neighborhood. To measure concentration, we utilize the *delta index*, which indicates the proportion of a minority group that would have to move in order to produce a uniform density across neighborhoods. More detailed information on these measures is available elsewhere (19). In addition to the direct associations between residential segregation and STDs during pregnancy, we include the cross-level interaction terms (individual race $\times$ residential segregation indices) to test the potential moderating associations between residential segregation and STDs during pregnancy.

With respect to income inequality, we use two measures: a *Gini index*, which measures income inequality (relative measure of income distribution), and a *poverty index*, which assesses the absolute deprivation (absolute measure of income distribution). The Gini index is arguably the most common measure of income inequality; it ranges from 0, indicating no income inequality (i.e., everyone has the same income), to 1, representing complete income inequality (i.e., one person has all the income while everyone else has zero income). Following previous research for creating neighborhood-level composite measures (21), we first use principal components analysis to confirm the emergence of one factor for two variables (see Appendix I): percentage of household living below the poverty line (factor loading = 0.92) and percentage unemployed (0.923). Then, we use the regression-weighted method to create the poverty index. Finally, we follow previous research (22) in transforming the Gini index and poverty index into quintiles, because quintiles imply that the effects of Gini or poverty indices on STDs during pregnancy may be nonlinear. In our data, while d have missing values, to avoid potential selection bias, we adopt the missing data imputation approach to generate robust results. Specifically, we use multiple imputation methods (i.e., *mi* command) to create 25 datasets in Stata to take the uncertainty of imputed values into account. We use a series of hierarchical logistic models.

Results

Descriptive Statistics

Table 1 shows descriptive statistics for all variables included in the models for all women and by race. Overall, about 5.5% of women who had had a live birth in Pennsylvania during 2012 acquired STD during their pregnancies. This is similar to previous research, which estimated that about 1% to 5% of all pregnant women in the United States had chlamydia or gonorrhea (23). However, this percentage varies by race, with the number of mothers who acquired STDs during pregnancy about three times higher for blacks (12.1%) than for whites

(4.1%). Other individual characteristics also vary by race. Whereas 67.6% of white mothers were married at the time of the birth, 20.6% of black mothers were married. Large differences appear in the educational attainment of white and black mothers. In addition, black mothers are more likely to have been impoverished, with 68.3% of black mothers but 28.3% of white mothers receiving WIC benefits.

The characteristics of the mothers' neighborhoods vary considerably. On average, black mothers reside in highly segregated neighborhoods with an isolation index of 0.63, which indicates that black mothers have higher propensity to be exposed only to other blacks in their neighborhoods. In comparison, white mothers reside in less-segregated neighborhoods. Physical spaces occupied by black and white mothers were about equivalent as measured by the concentration index. With respect to income inequality, white mothers were more equally distributed across the five quintiles than were their black counterparts; furthermore, almost 70% of black mothers lived in the two least-equal quintiles of neighborhoods, in contrast to 35% of white mothers in the same quintiles. A similar pattern could be observed for poverty, with approximately 30% of white mothers but 75% of black mothers living in the two poorest quintiles. These racial differences at the neighborhood level suggest that neighborhoods should play a role in the acquisition of STDs during pregnancy.

Multilevel Logistic Regression Results

The results in Table 2 show the associations between neighborhood characteristics and the acquisition of STDs during pregnancy. Prior to the model specifications, we test the intercept-only null models to confirm the appropriateness of using the multilevel models. The results support the use of multilevel models and indicate that a large proportion of the variance in STDs during pregnancy is explained by differences between neighborhood contexts (14.4%). Next, we include the residential segregation measures and cross-level interaction measures (Model 1) and then examine income inequality and poverty index quintiles in Model 2 and Model 3, respectively. In our final model (Model 4), all neighborhood characteristics are included.

Individual-level results are consistent across models; thus, we report the results from the final model (Model 4). *Ceteris paribus*, the odds of acquiring STDs during pregnancy is 60% higher for non-Hispanic black women compared with non-Hispanic white women (OR: 1.60; 95% CI: 1.41–1.80). Maternal age is significantly associated with the odds of acquiring STDs during pregnancy: a one-year increase in maternal age is associated with roughly an 8% decrease in the odds of acquiring STDs during pregnancy ($0.92^{(1)} \times 1.00^{(1) \times (1)} = 0.92$). In addition, the odds of acquiring STDs during pregnancy are lower for married mothers than for unmarried mothers, and lower for mothers with relatively high educational attainment levels. Lastly, indicators for mothers' socioeconomic status are significantly associated with the odds of acquiring STDs during pregnancy. Mothers who receive WIC benefits are about 12% (OR: 1.12; 95% IC: 1.04–1.20) more likely to have acquired STDs during pregnancy compared with mothers not receiving WIC benefits.

With respect to the neighborhood level covariates, our multilevel models show that neighborhood further explains a substantial proportion of individual-level variance in STDDP acquisition. Specifically, neighborhood residential segregation has both direct and

indirect associations with women's odds of acquiring STDs during pregnancy. The exposure dimension of racial segregation (i.e., isolation index) is directly and positively associated with the odds of acquiring STDs during pregnancy. Model 1 shows that the odds of acquiring STDs during pregnancy increase by 2.5 times (OR: 2.47; 95% CI: 1.99–3.08) when isolation index increases by 1 unit. However, the dimension of concentration is not significantly associated with STDs during pregnancy. More importantly, the cross-level interaction between maternal race and isolation suggests that among black mothers, those who live in a more segregated neighborhood are less likely to have acquired STDs during pregnancy (OR: 0.56; 95% CI: 0.43–0.73) (Model 2).

Figure 1 illustrates the predicted probabilities of acquiring STDs during pregnancy for non-Hispanic white and non-Hispanic black mothers were plotted across different levels of neighborhood isolation. Two findings are notable. First, the probability of acquiring STDs during pregnancy is consistently higher among non-Hispanic black mothers than their white counterparts; however, non-Hispanic white mothers were found to be more sensitive to neighborhood segregation. Specifically, when the level of neighborhood isolation increases from 0.1 to 07, the probability of acquiring STDs during pregnancy increases by almost 50 percent for non-Hispanic white mothers but 10 percent for non-Hispanic black mothers. Second, the black-white disparity in acquiring STDs during pregnancy is wider among racially mixed neighborhoods than racially segregated neighborhoods, which suggests that non-Hispanic black mothers may benefit from living with other co-ethnics.

Neighborhood-level income inequality is also significantly associated with the odds of acquiring STDs during pregnancy. In Model 2, comparing with the most equal quintile, the odds of acquiring STDs during pregnancy are 13% (OR: 1.13; 95% CI: 1.01–1.25) and 26% (OR: 1.26; 95% CI: 1.13–1.40) higher for women in the middle quintile and the least-equal quintile, respectively. Similarly, the poverty index shows that the odds of acquiring STDs during pregnancy are 18% (OR: 1.18; 95% CI: 1.05–1.33) and 45% (OR: 1.45; 95% CI: 1.29–1.63) higher for women residing in second-poorest and the poorest quintiles, respectively (Model 3). When we examine racial segregation and income inequality simultaneously (Model 4), both measures are still significantly associated with the odds of acquiring STDs during pregnancy, and patterns are consistent with previous models. However, the associations of structural inequality and absolute deprivation are attenuated. Specially, the association between income inequality and the odds of acquiring STDs during pregnancy are less salient.

Discussion

The results of this study not only demonstrate the importance of accounting for neighborhood-level factors but also unveil the intertwined relationship between race/ethnicity and the acquisition of STDs during pregnancy. Segregation and income inequality are significantly associated with mothers' STDs during pregnancy acquisition above and beyond mothers' individual characteristics. Our results are consistent with the places stratification hypothesis which posits that negative neighborhood conditions generated by individual and institutional discrimination against minority groups (24) can adversely affect individuals' health (25-27). Residing in segregated neighborhood is associated with higher

odds of STDs during pregnancy acquisition through the direct pathway. However, the significant cross-level interaction terms further advance our understanding of how and why segregation matters. Our findings indicate that white mothers are more sensitive to neighborhood segregation than black mothers and that black mothers may in fact benefit from living with co-ethnics. These patterns are consistent with previous research finding that residing in segregated neighborhood is associated with lower probability of maternal smoking during pregnancy for black mothers than for white mothers (27).

For income inequality, we found that mothers who reside in neighborhoods with a high level of income inequality (relative measure of income distribution) and a high level of absolute deprivation (absolute measure of income distribution) have higher odds of acquiring STDs during pregnancy compared with mothers residing in more-equal and less-deprived neighborhoods. These results echo the previous research, which found that school-level structural inequality and absolute deprivation are associated with higher level of STD acquisition for adolescents (22). In the final model, which accounted for residential segregation and income inequality jointly, we found that although the association of residential segregation remained salient, the associations of income inequality were attenuated. This finding is also consistent with previous ecological research finding that the effect of residential segregation on community-level gonorrhea rates was stronger than the effect of income inequality (16).

This study has four limitations. First, because the data used in this study are cross-sectional, we cannot establish a causal relationship. To rule out the possibility of selection bias, future research should use longitudinal data to establish the causal relationship between neighborhood-level characteristics and the racial disparity in STDs during pregnancy acquisition. Second, several individual-level measures that may be associated with the racial disparity in STDs during pregnancy were not included because of data constraints, such as paternal information and maternal social connections. Third, our study focuses on black and white mothers in Pennsylvania, and it remains unclear whether our findings will be generalizable to other areas in the United States. It is plausible that residential segregation and income inequality may be associated differently in other places with different racial histories (e.g., South). Finally, the influence of neighborhoods may vary depending on how *neighborhood* is operationalized. Although using a census tract to define a neighborhood is a common practice in health research (18), future studies should be cautious of the modifiable areal unit problem (MAUP) (28), which refers to the possibility of producing different results when different scales or zones are used (29, 30).

The results of this study have important policy implications and lead to suggestions for future research. Our results demonstrate the importance of accounting for neighborhood-level factors, which we found to be significantly associated with STDs during pregnancy acquisition beyond mothers' individual characteristics. This finding suggests that health policy makers aiming to prevent and reduce the prevalence of STDs during pregnancy and reduce the racial disparity in STDs during pregnancy should explicitly and carefully incorporate the notion of place in their policy design. Specifically, targeting neighborhoods with a high level of residential segregation may be beneficial in reaching more women at risk. In addition, targeting the most socioeconomically disadvantaged may yield most

effectiveness in terms of reaching women at risk. Future studies should investigate the specific mechanisms by which neighborhood-level segregation and income inequality may influence STDs during pregnancy acquisition and the mechanisms by which racial disparity is generated (e.g., lack of health infrastructure/resources and social disorganization). Elucidating the specific mechanisms will be crucial to designing more effective policy aimed at reducing the racial gap in STDs during pregnancy acquisition. In sum, eliminating racial health disparities in the United States is an important public health concern reflected by *Healthy People 2020* (1). To reduce the racial disparity in STDs during pregnancy, future research should take a more-nuanced approach by examining risk factors at multiple levels.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Predicted probability of acquiring sexually transmitted diseases during pregnancy by race/ethnicity across the interaction index values.

Table 1
Descriptive statistics of variables at both the individual level and the contextual level

	All	Non-Hispanic White	Non-Hispanic Black
Individual-level measures (N = 96,940)	100%	81.8%	18.2%
Acquisition of STDDP	5.5%	4.1%	12.1%
Maternal age			
Age	28.4	28.9	26.0
Age squared	838.8	866.8	713.1
Marital status			
Married	59.0%	67.6%	20.6%
Maternal education			
Less than high school	10.4%	8.6%	18.9%
High school diploma/GED	24.7%	22.2%	36.1%
Some college	28.5%	27.4%	33.0%
Bachelor's degree or higher	36.4%	41.8%	12.0%
Prenatal visits			
Total number of visits	10.9	11.2	9.4
Poverty status			
WIC Food	35.6%	28.3%	68.3%
Payment for delivery			
Private insurance	64.1%	71.3%	32.5%
Medicaid	31.0%	24.1%	61.5%
Self-pay	2.6%	2.7%	2.1%
Other	2.3%	1.9%	3.9%
Tract-level measures (N = 3,154)			
Residential segregation			
NHB:NHW isolation index	0.18	0.08	0.63
NHB:NHW concentration index	0.03	0.04	0.03
Income inequality (Gini index)			
Most-equal quintile	20.0%	22.8%	7.4%
2nd-most equal quintile	20.0%	22.2%	10.1%
Middle quintile	20.0%	21.2%	15.7%
2nd-least equal quintile	20.0%	18.6%	25.1%
Least-equal quintile	20.0%	15.1%	41.7%
Poverty index			
Richest quintile	20.0%	23.6%	4.0%
2nd-richest quintile	20.0%	23.4%	4.8%
Middle quintile	20.0%	23.0%	6.6%
2nd-poorest quintile	20.0%	20.1%	19.7%
Poorest quintile	20.0%	9.9%	64.9%

Note: Based on 25 imputed datasets.

Table 2
Multilevel logistic regression models predicting the acquisition of STDDP

	Model 1	Model 2	Model 3	Model 4
Individual-level measures (N = 96,940)				
Race/Ethnicity (ref: Non-Hispanic white)				
Non-Hispanic black	1.64 ***	1.68 ***	1.55 ***	1.60 ***
Maternal age				
Age	0.92 ***	0.92 ***	0.92 ***	0.92 ***
Age squared	1.00 ***	1.00 ***	1.00 ***	1.00 ***
Marital status				
Married	0.48 ***	0.47 ***	0.48 ***	0.49 ***
Maternal education (ref: Less than high school)				
High school diploma/GED	0.92 ⁺	0.91 *	0.92 ⁺	0.92 ⁺
Some college	0.81 ***	0.80 ***	0.82 ***	0.82 ***
Bachelor's degree or higher	0.61 ***	0.60 ***	0.63 ***	0.62 ***
Prenatal visits				
Total number of visits	1.00	0.99	0.99	1.00
Poverty status				
WIC benefits	1.13 ***	1.14 ***	1.12 **	1.12 **
Payment for delivery (ref: Private insurance)				
Medicaid	1.47 ***	1.46 ***	1.44 ***	1.44 ***
Self-pay	0.71 **	0.70 **	0.70 **	0.70 **
Other	1.04	1.05	1.02	1.03
Tract-level measures (N = 3,154)				
Residential segregation (direct associations)				
NHB:NHW isolation index	2.47 ***			2.03 ***
NHB:NHW concentration index	1.13			1.14
Residential segregation (moderating associations)				
Black × NHB:NHW isolation index	0.56 ***			0.59 ***
Black × NHB:NHW concentration index	0.98			1.00
Income inequality (Gini index)				
Most-equal quintile (reference)		1.00		1.00
2nd-most equal quintile		1.02		1.01
Middle quintile		1.13 *		1.08
2nd-least equal quintile		1.09		1.00
Least-equal quintile		1.26 ***		1.10 ⁺
Poverty index				
Richest quintile (reference)			1.00	1.00
2nd-richest quintile			1.08	1.08
Middle quintile			1.05	1.03

	Model 1	Model 2	Model 3	Model 4
2nd-poorest quintile			1.18 **	1.11 ⁺
Poorest quintile			1.45 ***	1.21 **
<i>Variance Components</i>				
Intercept	0.19 ***	0.18 ***	0.18 ***	0.18 ***

Note: Results are reported in odds ratios.

⁺ $p < 0.10$;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$