

Is Neighborhood Deprivation Independently Associated with Maternal and Infant Health? Evidence from Florida and Washington

Catherine Cubbin · Kristen Marchi · Michael Lin · Thomas Bell · Helen Marshall · Curt Miller · Paula Braveman

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Abstract

Objectives To determine whether a widely used measure of neighborhood-level socioeconomic deprivation was associated with unintended pregnancy, delayed/no prenatal care, low birth weight (LBW), and not breastfeeding, after adjusting for a more comprehensive set of individual-level socioeconomic factors than previously reported.

Methods Data from CDC's Pregnancy Risk Assessment Monitoring System (PRAMS) in Washington and Florida (1997–1998) were linked with census tract-level data (2000) based on birth certificate addresses. For each state, logistic regression models were estimated for associations between neighborhood deprivation measured by the Townsend Index and each dependent variable, unadjusted and then adjusting for maternal age, parity, racial/ethnic group, and education; paternal education; and family income. Similar models were estimated for each racial/ethnic group separately.

Results Despite significant unadjusted associations between neighborhood deprivation and all dependent variables except LBW in Washington, few statistically

significant associations were found in the adjusted models overall. In stratified models, African American women in low-deprivation Florida neighborhoods had *higher* odds of delayed/no prenatal care compared with their moderate-deprivation counterparts, and only among European American women were high-deprivation neighborhoods associated with increased odds of delayed/no prenatal care. **Conclusions** These results, which may not be generalizable beyond Florida and Washington or to other health indicators, suggest that some previously reported associations between neighborhood characteristics and the selected health indicators may reflect residual confounding by individual-level socioeconomic status/position. Until methodological and conceptual challenges regarding mediation (“over-controlling”) and measurement of neighborhood exposure are overcome, conclusions regarding independent neighborhood associations should be made with caution.

Keywords Neighborhood · Socioeconomic status · Race/ethnicity · Deprivation · PRAMS

C. Cubbin (✉) · K. Marchi · P. Braveman
Department of Family and Community Medicine, University of California, 500 Parnassus Avenue, MU-3E, Box 0900, San Francisco, CA 94143–0900, USA
e-mail: cubbinc@fcm.ucsf.edu

M. Lin
School of Public Health, University of Pittsburgh, Pittsburgh, PA, USA

T. Bell
Washington Department of Health, Olympia, WA, USA

H. Marshall · C. Miller
Florida Department of Health, Tallahassee, FL, USA

Introduction

The relationship between neighborhood-level socioeconomic context (NSC) and individual-level health, including reproductive health [1], has been receiving increasing attention [2–6]. Neighborhood effects on health could have major policy implications, given the possibility of designing interventions that could potentially affect the health of entire communities. A causal relationship between NSC and health is plausible. Neighborhoods that share socioeconomic characteristics also tend to share physical (e.g., pollution, nutritious food availability), social (e.g., crime,

behavioral norms), and service (e.g., transportation, health care, police protection) environments; these environments could influence health above and beyond the health effects of the socioeconomic characteristics of residents living within them [6, 7].

A large body of “neighborhood effects” literature now exists, with many studies concluding that there are “independent” effects of NSC on diverse health outcomes [2–6] and some concluding the opposite [3, 8–10]. Neighborhood effects studies typically estimate the association between a neighborhood-level characteristic and an individual-/household-level health indicator, after statistically adjusting for one or more indicators of individual-/household-level socioeconomic status/position (SES); the latter are generally viewed as confounders of the relationship between neighborhood characteristics and health. However, this approach can be problematic in so far as indicators of individual-/household-level SES may to some extent mediate the relationship between neighborhood socioeconomic context and health; e.g., growing up in a poor neighborhood without good educational opportunities could determine one’s later educational attainment and income. Thus, adjusting for individual-level SES (e.g., education, income) could be “over-controlling.” However, excluding individual-level SES variables in neighborhood effects studies is problematic because (a) individual-level socioeconomic factors often have important health effects; (b) individual- and neighborhood-level measures of SES are correlated; (c) it is improbable that neighborhood context is the only determinant of individuals’ subsequent SES; and (d) SES is a multidimensional construct [11, 12] that is difficult to measure adequately with one or even two indicators [13, 14]. For all of these reasons, associations between neighborhood socioeconomic context and health could represent unmeasured variation in individual-level SES and not an “independent” neighborhood effect; that is to say, individual-/household-level SES factors could confound observed relationships between neighborhood characteristics and health [1, 4, 15].

There is limited literature regarding neighborhood effects on maternal and infant health. Associations between NSC (in small areas such as census tracts, census block groups, or ZIP codes) and birth weight (BW) or low birth weight (LBW) have been found in several population-based studies, after adjusting for maternal education [16–21], or both maternal education and family income [22]. We identified only one study that found associations between NSC and delayed prenatal care after adjusting for maternal education [23]; no such studies were found that examined unintended pregnancy or breastfeeding as dependent variables. With one exception [22], these studies adjusted for individual-level maternal education only, leaving unanswered the question of whether significant

neighborhood-level associations were observed because of residual confounding by other individual-/household-level SES characteristics, such as income and paternal education. The primary objective of this study was to determine whether NSC was “independently” associated with four important indicators of maternal and infant health, health care, or health behaviors (hereafter referred to as health indicators)—unintended pregnancy, delayed or no prenatal care, LBW, and not breastfeeding—among statewide representative samples of women who gave birth in Florida and Washington, adjusting for a more comprehensive set of individual-/household-level socioeconomic factors (family income, maternal education, and paternal education) than has previously been reported.

Methods

Data

For this study, we used data from the Pregnancy Risk Assessment Monitoring System (PRAMS). A cooperative project between CDC and (currently) 29 states and New York City, PRAMS is an ongoing, population-based surveillance system that collects information on maternal behaviors and experiences. PRAMS was developed in 1987 to supplement data from vital records for planning and assessing perinatal health programs on a state level. The PRAMS questionnaire includes a core portion, with questions asked by all states, and a state-specific portion, with questions developed by the state and/or selected from a set of standard questions developed by the CDC. This standardized format permits the generation of state-specific data and allows comparisons among states. Currently, PRAMS surveillance covers about 62% of all US births.

Each month, PRAMS surveys a random sample of mothers who gave birth to a live infant 2–6 months earlier. To do so, PRAMS uses stratified, systematic sampling of the birth certificates of infants born to state residents. Mothers are mailed a questionnaire, and follow-up mailings are sent to nonresponding mothers. Further attempts to contact nonresponding mothers are made by telephone. Most states oversample mothers of low birth weight infants, and several states oversample women of selected racial or ethnic groups or by population density. Mothers who have died, are mentally incapacitated, adopted their child, gave birth to four or more babies, or are not state residents are excluded from the PRAMS eligible population. If a mother’s last name is missing from the birth certificate, she is excluded, as are out-of-state births to state residents. Finally, birth certificates that are processed more than 6 months after the date of birth are excluded. Statistical weights are applied to account for sampling

probability, nonresponse, and sampling frame coverage in each state. PRAMS data are linked to birth certificate data and weighted so that results from the PRAMS sample of mothers can be generalized to the state's entire population of live births [24]. PRAMS methods have previously been published [25–31].

This study used PRAMS data from two states, Florida ($N = 4,696$) and Washington ($N = 4,433$), 1997–1998. For Florida, response rates were 78.2% in 1997 and 78.6% in 1998; for Washington, the corresponding rates were 69.4% and 71.3%. For this study, PRAMS data also are linked with 2000 census tract data. Each state geocoded the PRAMS respondents' address; census tract data were then linked to PRAMS data through geographic identifiers (state, county, and tract codes). Respondents whose addresses could not be accurately geocoded ($N = 224$ or 4.8% in Florida, $N = 546$ or 12.3% in Washington) were excluded, resulting in a final analytic sample of 4,472 births in Florida and 3,887 in Washington. Respondents with missing geocodes in Florida were more likely to report an unintended birth or to have had only one birth compared with respondents with geocodes (chi-square p values < 0.05). Respondents with missing geocodes in Washington were more likely to report lower income, to have lower maternal and paternal education on the birth certificate, and to be Latina or Native American compared with respondents with geocodes (chi-square p values < 0.05). Analyses of low birth weight included singleton births only (representing over 94% of births in Florida and over 98% in Washington).

Dependent variables

Unintended pregnancy was defined based on responses to the question, “Thinking back to *just before* you got pregnant, how did you feel about becoming pregnant?” Pregnancies among postpartum women who responded, “I wanted to be pregnant later”, “I didn't want to be pregnant then or at any time in the future”, or “I don't know” were categorized as unintended, compared to unambiguously intended pregnancies (women who responded “I wanted to be pregnant sooner” or “I wanted to be pregnant then”). “Unintended pregnancies” here refer only to pregnancies among women who gave birth. *Delayed/no prenatal care* was defined (from birth certificate data) based on when women initiated prenatal care (excluding visits only for pregnancy testing or for Women, Infants, and Children's Nutrition Program); women beginning care after the first trimester or those with no prenatal care were classified as having delayed/no prenatal care. *LBW* was defined as birth weight under 2,500 g, based on birth certificate data. *Not breastfeeding* was defined as not ever initiating breastfeeding.

Independent variables

We examined three individual-level socioeconomic factors: poverty status (before-tax annual household income in dollars from all sources for the 12 months preceding delivery in percentage increments of the federal poverty level [FPL] based on family size), and maternal and paternal education (from birth certificates; number of completed years, grouped into categories corresponding to earned credentials). Spearman correlations between the three variables ranged from 0.43 to 0.69. Race/ethnicity was conceptualized as indicating the large geographic region of a woman's family origin and/or skin color, which could reflect her life experiences. It was categorized into six mutually exclusive groups: African American, Asian/Pacific Islander, Latina, Native American, European American, and “other” or “unknown” race/ethnicity. Hispanic African Americans are included with the African American group; other Hispanic women are included with the Latina group. Marital status at the time of birth was defined as married versus unmarried; maternal age was grouped as 17 or younger, 18–19, 20–34, or 35 years or older at the time of birth; and parity was defined as first birth, 2–4 births, or 5 or more births including the index birth. Race/ethnicity, marital status, age, and parity information were obtained from birth certificates. Racial/ethnic groups that did not comprise at least 5% of the total sample (unweighted estimates) were excluded from multivariate models.

Neighborhood-level socioeconomic variable

There is no gold standard for using census-based variables to measure neighborhood socioeconomic context. However, because we wanted a measure that was comparable across studies and that has been used in previous research, we chose to use the Townsend material deprivation index at the census tract level (on average, 5,100 people/tract in Florida and 4,500 people/tract in Washington) as a measure of NSC, which has been done in previous research and shown to be associated with health [32–37]. The Townsend index, calculated for all tracts in each state, is composed of four census variables reflecting the proportion of crowded occupied housing units, unemployed persons in the civilian labor force, renter-occupied housing units, and occupied housing units without a motor vehicle available. Following Townsend et al.'s methodology [32], unemployment and crowded housing were first log transformed, each variable was standardized, and the four variables were then summed with equal weights. Higher numbers indicate higher levels of deprivation (mean 0, range –6.9 to 14.4 in Florida and –8.4 to 16.0 in Washington). Neighborhood effects are thought to be nonlinear; [38, 39] thus, we categorized the

deprivation index into three groups based on the statewide distribution of all tracts: low deprivation (lowest quartile), high deprivation (highest quartile), and moderate deprivation (middle two quartiles). Moderate deprivation was used as the reference group in multivariate models estimating both protective and harmful effects.

Analytic approach

First, we used SAS (version 8, SAS Institute, Cary, NC) to describe the sample. Second, we constructed logistic regression models for associations between neighborhood deprivation and each dependent variable, unadjusted and then adjusting for all the individual-/household-level variables. Third, to examine associations between neighborhood deprivation and the dependent variables among specific racial/ethnic groups, we constructed similar models for each racial/ethnic group with adequate sample sizes (defined as comprising at least 5% of the total sample). Fourth, we repeated all of the models classifying the deprivation variable into quartiles with the lowest deprivation quartile as the reference group to determine whether the choice of reference group (i.e., middle 50% versus lowest quartile) influenced the results for women living in high deprivation neighborhoods. Because PRAMS is a complex multistage probability sample that yields clustered observations, we used SUDAAN (version 7.5.6, Research Triangle Institute, Research Triangle Park, NC) to account for the survey design effects and to produce valid variance estimates in our regression models [40]. SUDAAN also alleviates difficulties with statistical inference introduced by hierarchical research designs [41, 42]. Explicit hierarchical linear modeling techniques [43, 44] were not used in this analysis because, while the number of census tracts (or neighborhoods) is large for each group, there were insufficient numbers of women living within the same tract (i.e., low clustering) to allow more formal hierarchical modeling techniques. In Florida, PRAMS respondents lived in 64% of the tracts statewide (2,009 out of a total of 3,154 statewide), with an average of 2.2 respondents per tract (median 2, range 1–10). In Washington, PRAMS respondents lived in 80% of the tracts (1,059 out of a total of 1,318 statewide), with an average of 3.7 respondents per tract (median 3, range 1–28). Previous studies have employed a similar analytic approach [45–49].

Results

Table 1 presents key sociodemographic characteristics of the PRAMS sample for both states, as well as prevalences of the four dependent variables among women in each sociodemographic subgroup. In both states, postpartum

women appeared more likely to be living in neighborhoods characterized by high deprivation (32%) compared with the overall population statewide (25%). Florida had a lower proportion of high SES women than Washington, based on income, maternal education, and paternal education. The racial/ethnic distributions seemed markedly different between the two states, with Florida having higher proportions of African Americans and Latinas, and Washington having higher proportions of the other groups. Florida had a higher proportion of unmarried women (36%) than Washington (27%). The age and parity distributions of the states appeared similar.

As shown in Table 1, the rates of unintended pregnancy, low birth weight, and not breastfeeding generally appeared higher in Florida versus Washington overall and among most subgroups defined by individual-level variables, while rates of delayed/no prenatal care appeared similar or slightly lower in Florida versus Washington overall and among subgroups. In both states, rates of each dependent variable appeared to decrease with decreasing neighborhood deprivation and increasing individual-/household-level socioeconomic status (indicated by income, maternal education, and paternal education). Rates of each dependent variable varied according to race/ethnicity, but were generally highest for African American women and lowest for European American women. Rates also appeared lower for married compared with unmarried women, for adult women compared with teenagers, and for women with lower parity compared with those with five or more births.

To illustrate the neighborhood characteristics captured by the Townsend material deprivation index, Figure 1 displays percentages of each of the four components of the index in Washington for the three neighborhood deprivation groups: lowest quartile (least deprived), middle 50%, and highest quartile (most deprived). For each of the four component neighborhood characteristics, high deprivation neighborhoods reflected a percentage that was 3.5 to 6.3 times greater than the percentage for that component in low deprivation neighborhoods. For example, the percent of rented housing in a high deprivation area was on average 59% compared with 16% in a low deprivation area. A similar pattern was observed in Florida (not shown, available on request).

Figure 2 presents the median values and 25th to 75th percentile ranges of the Townsend neighborhood material deprivation index for (a) all census tracts in Florida, (b) census tracts with at least one PRAMS respondent, and (c) tracts with respondents stratified by income or by racial/ethnic group. Compared with the entire statewide population, PRAMS respondents generally lived in neighborhoods with higher deprivation (75th percentile of the Townsend Index for PRAMS tracts was 2.39 versus 1.71 for all tracts). Not surprisingly, individually poor (0–100% FPL)

Table 1 Weighted characteristics of the sample population, Florida ($N = 4,472$) and Washington ($N = 3,887$) PRAMS (1997–1998) linked to Census tract data (2000)^a

	Distribution (%)		% Unintended pregnancy		% Delayed/no prenatal care		% LBW ^b		% Never breastfed	
	Florida 100.0	Washington 100.0	Florida 45.8	Washington 37.0	Florida 15.1	Washington 16.4	Florida 6.5	Washington 4.4	Florida 30.4	Washington 12.6
<i>Neighborhood-level deprivation^c</i>										
Low	17.4	17.1	32.8	28.7	7.6	9.6	4.9	3.9	22.5	11.2
Moderate	50.4	50.5	42.7	34.9	13.0	14.0	6.0	4.2	30.3	11.5
High	32.2	32.4	57.7	44.7	22.4	23.8	7.9	5.1	35.1	15.2
<i>Income^d</i>										
Missing	10.4	6.8	47.8	46.2	25.6	29.3	7.6	5.2	37.4	18.0
0–100%	35.0	29.0	57.6	53.8	23.5	26.7	7.9	6.2	35.7	18.3
101–200%	21.4	24.2	48.9	38.2	11.6	14.2	5.9	3.0	30.3	13.6
201+%	33.2	40.1	31.2	23.6	5.2	8.4	4.9	3.8	23.0	7.2
<i>Maternal education</i>										
Less than high school	20.5	16.6	58.8	52.9	29.9	28.6	8.4	7.8	46.1	22.8
High school/GED	36.1	33.3	48.2	40.8	16.1	19.9	6.5	2.8	36.1	16.7
Some college	23.7	24.6	46.8	36.4	11.2	11.8	5.9	3.5	24.0	9.0
College graduate	19.7	25.5	27.2	19.8	2.6	7.9	4.9	3.3	11.9	4.1
<i>Paternal education</i>										
Missing	17.1	22.2	73.2	52.8	34.1	28.0	10.6	7.2	49.2	17.8
Less than high school	13.6	10.5	51.0	46.0	28.7	25.6	6.5	4.1	39.8	13.5
High school/GED	30.9	26.4	45.1	37.0	10.3	14.0	6.4	3.4	33.7	17.0
Some college	18.1	18.1	40.9	30.9	9.7	13.4	5.1	3.3	22.0	9.2
College graduate	20.3	22.9	25.8	23.1	2.7	8.1	4.3	4.0	11.7	5.2
<i>Race/ethnicity</i>										
Other/missing	0.2	4.3	65.6	33.3	3.0	24.0	6.0	13.3	11.5	15.8
African American	22.4	3.9	72.0	58.0	26.9	22.2	10.6	8.2	44.9	20.1
Asian/Pacific Islander	2.1	6.8	42.1	38.1	12.7	20.2	7.2	4.4	22.7	15.3
Latina	19.8	11.9	40.6	40.0	16.2	28.2	5.0	4.5	19.3	13.8
Native American	0.3	2.0	39.4	50.7	7.5	23.0	9.2	7.0	24.0	20.6
European American	55.3	71.2	37.2	35.0	10.2	13.4	5.3	3.6	29.0	11.4
<i>Marital status</i>										
Unmarried	35.7	26.9	69.5	65.4	26.4	28.6	8.8	6.6	42.6	19.7
Married	64.3	73.1	33.2	27.0	8.9	12.1	5.2	3.6	23.8	10.1
<i>Age (years)</i>										
<17	5.0	3.5	72.8	78.1	34.8	38.5	9.9	10.4	45.3	20.8
18–19	8.4	6.7	71.9	64.4	32.2	33.6	8.4	11.1	47.5	24.6
20–34	72.9	76.2	43.1	35.3	13.1	14.1	5.9	3.3	28.8	12.0
35+	13.6	13.6	34.1	21.5	8.0	14.4	6.9	5.0	23.3	8.9
<i>Parity</i>										
First birth	40.9	41.5	44.4	37.3	12.4	14.3	7.8	6.3	26.6	10.6
2–4 births	55.6	54.3	45.4	36.2	16.2	17.0	5.4	2.2	32.9	13.6
5+ births	3.5	4.2	70.2	38.5	30.2	26.6	8.0	7.0	36.2	15.0

^a Excluding inaccurate geocodes ($N = 224$, Florida; $N = 546$, Washington)

^b Singleton births only (over 94% of births in Florida, $N = 4,221$; over 98% of births in Washington, $N = 3,832$)

^c Cutpoints based on statewide distribution of all tracts (3,154 tracts in Florida; 1,318 tracts in Washington)

^d As a percentage of the federal poverty level

Fig. 1 Components of the Townsend material deprivation index for each of the three neighborhood deprivation groups, census tracts, 2000, Washington, *N* = 1,318

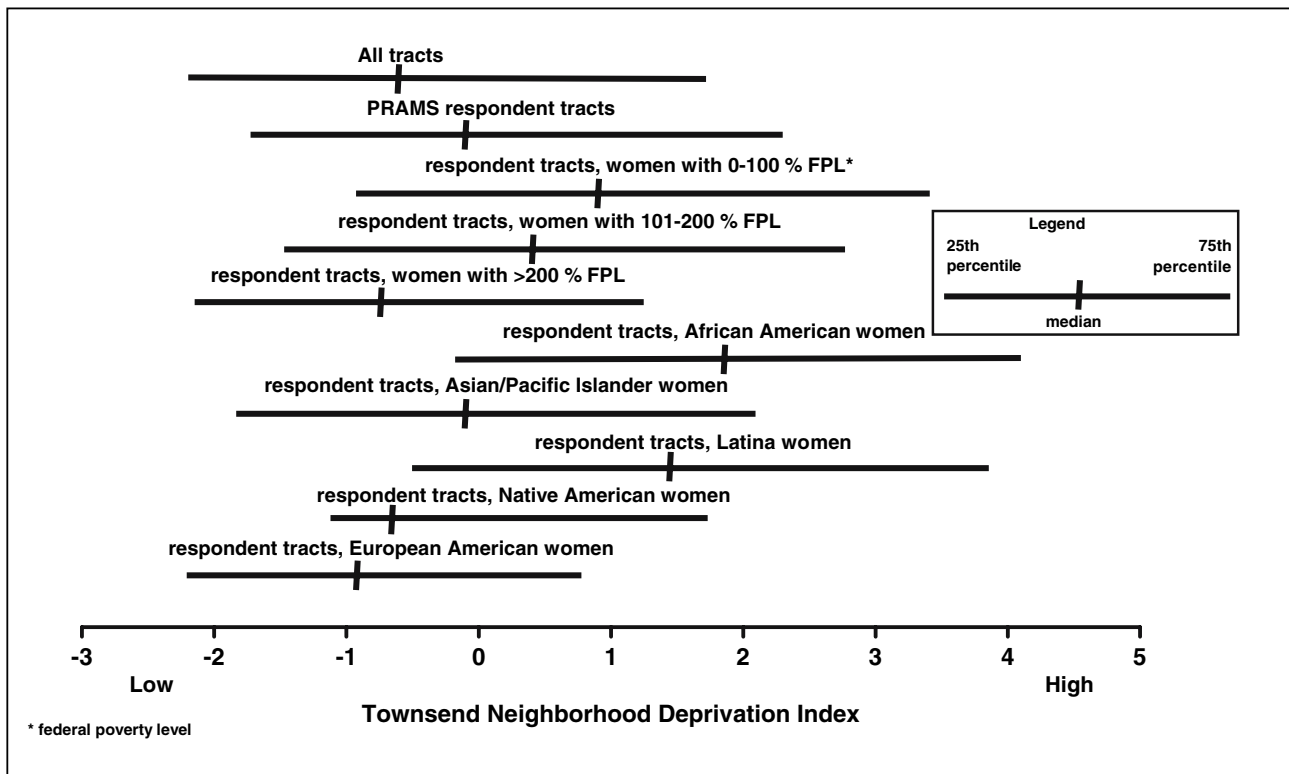
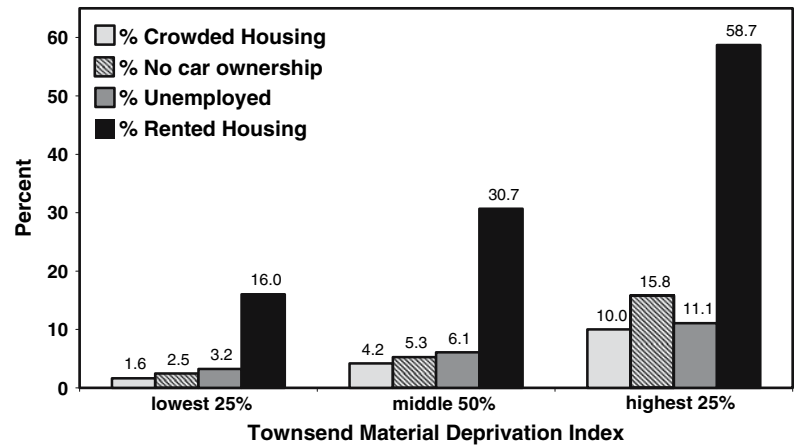


Fig. 2 Medians and interquartile ranges of the Townsend neighborhood deprivation index, Florida PRAMS (1997–1998) linked with Census tract data (2000)

and near-poor (101–200% FPL) respondents had neighborhood deprivation distributions that were skewed toward higher deprivation compared with women with individual/household incomes that were over 200% of the FPL. For example, the median value of the deprivation index for poor women (0.95) was nearly as high as the 75th percentile value for women with incomes that were over 200% of the federal poverty level (1.21), meaning that about half of poor respondents compared with a quarter of higher-income respondents were living in neighborhoods with a similarly high deprivation level. Differences in neighbor-

hood deprivation were seen between racial/ethnic groups as well. African American and Latina women resided in neighborhoods that were far more deprived than Asian/Pacific Islander, Native American, or European American women. Over 75% of African American and Latina women were living in neighborhoods with a deprivation level at least as high as the median level for European American women. Similar patterns were observed in Washington (not shown, available on request).

Odds ratios (OR) and 95% confidence intervals (CI) for unintended pregnancy are displayed in Table 2 for both

Table 2 Odds ratios (OR) and 95% confidence intervals (CI) for unintended pregnancy, Florida and Washington PRAMS (1997–1998) linked to Census tract data (2000)

	Florida						Washington					
	Unadjusted			Adjusted ^a			Unadjusted			Adjusted		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
<i>Neighborhood-level deprivation^b</i>												
Low	0.65	0.49	0.87	0.95	0.69	1.31	0.75	0.54	1.04	0.81	0.56	1.19
Moderate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
High	1.83	1.49	2.25	1.09	0.84	1.42	1.51	1.20	1.90	1.22	0.91	1.62
<i>Income^c</i>												
Missing	2.02	1.44	2.83	1.05	0.70	1.60	2.78	1.82	4.24	1.43	0.87	2.34
0–100%	3.00	2.36	3.81	1.37	1.00	1.87	3.77	2.89	4.92	1.83	1.25	2.67
101–200%	2.11	1.61	2.77	1.45	1.05	1.99	2.00	1.49	2.68	1.35	0.96	1.90
201+%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Maternal education</i>												
Less than high school	3.83	2.78	5.28	0.83	0.51	1.35	4.56	3.17	6.55	1.40	0.79	2.48
High school/GED	2.49	1.87	3.32	1.00	0.68	1.48	2.79	2.00	3.89	1.62	1.03	2.54
Some college	2.36	1.73	3.22	1.47	1.02	2.12	2.32	1.62	3.30	1.67	1.09	2.55
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Paternal education</i>												
Missing	7.85	5.59	11.01	1.68	1.04	2.71	3.73	2.66	5.24	0.94	0.56	1.57
Less than high school	2.99	2.08	4.29	1.39	0.85	2.25	2.85	1.94	4.17	0.72	0.41	1.28
High school/GED	2.36	1.75	3.18	1.32	0.90	1.93	1.95	1.40	2.72	0.78	0.50	1.22
Some college	1.99	1.42	2.79	1.31	0.89	1.92	1.49	1.03	2.16	0.80	0.51	1.24
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Race/ethnicity</i>												
African American	4.33	3.56	5.25	2.25	1.74	2.90	2.56	2.07	3.16	1.47	1.12	1.93
Asian/Pacific Islander							1.14	0.93	1.40	1.42	1.11	1.81
Latina	1.15	0.88	1.52	0.89	0.64	1.23	1.24	1.01	1.52	0.82	0.59	1.13
Native American							1.90	1.56	2.32	0.89	0.67	1.18
European American	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Marital status</i>												
Unmarried	4.59	3.73	5.64	2.67	2.01	3.55	5.10	4.01	6.50	3.01	2.16	4.20
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Age (years)</i>												
<17	5.17	3.24	8.24	3.10	1.72	5.59	12.96	6.26	26.84	5.20	2.10	12.87
18–19	4.95	3.40	7.21	3.31	2.03	5.42	6.59	3.91	11.10	2.92	1.57	5.45
20–34	1.46	1.08	1.98	1.37	0.96	1.95	1.99	1.40	2.83	1.72	1.14	2.58
35+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Parity</i>												
First birth	0.96	0.79	1.16	0.74	0.58	0.94	1.05	0.84	1.31	0.76	0.58	1.00
2–4 births	2.83	1.54	5.21	2.29	1.19	4.42	1.10	0.66	1.86	0.96	0.50	1.84
5+ births	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

^a Adjusted for neighborhood-level deprivation, income, maternal education, paternal education, race/ethnicity, marital status, age, parity

^b Based on statewide cutpoints

^c As a percentage of the federal poverty level

Florida and Washington. Generally similar results were found in each state. In the unadjusted models, low neighborhood deprivation was associated with lower odds (OR

0.7, CI 0.5–0.9 and OR 0.8, CI 0.5–1.0 for Florida and Washington, respectively, not statistically significant in Washington), and high deprivation was associated with

significantly higher odds (OR 1.8, CI 1.5–2.3 and OR 1.5, CI 1.2–1.9 for Florida and Washington, respectively) of unintended pregnancy, compared with women living in moderately deprived neighborhoods (middle 50%). However, these results became nonsignificant after adjustment for individual/household-level variables. In both Florida and Washington, significant associations remained in the adjusted models for individual-/household-level income (lower income generally corresponded to higher odds of unintended pregnancy), maternal education (high school and/or some college education = higher odds), African American women (OR 2.3, CI 1.7–2.9 and OR 1.5, CI 1.1–1.9 for Florida and Washington, respectively), unmarried women (OR 2.7, CI 2.0–3.6 and OR 3.0, CI 2.2–4.2, respectively), and age (lower age = higher odds), compared with their respective reference groups. In addition, lower odds of unintended pregnancy were found for women with first births in both states (OR 0.7, CI 0.6–0.9 and OR 0.8, CI 0.6–1.0), and higher odds were found for women with 2–4 births in Florida (OR 2.3, CI 1.2–4.4) and for Asian/Pacific Islander women in Washington (OR 1.4, CI 1.1–1.8), compared with their reference groups.

The results for delayed/no prenatal care in Florida and Washington differed from those for unintended pregnancy (Table 3). Although significant odds of delayed/no care associated with neighborhood deprivation were found in Florida in the unadjusted model for women living in both the lowest (OR 0.6, CI 0.4–0.9) and highest (OR 1.9, CI 1.5–2.5) deprivation neighborhoods compared with those in moderately deprived neighborhoods, these results were statistically insignificant in the adjusted model. In contrast, the results remained significant for women in Washington living in the most deprived neighborhoods (OR 1.5, CI 1.0–2.1). Significant increased odds of delayed or no prenatal care were found in the adjusted models for poor women in both states compared with women with incomes over 200% of the federal poverty level; however, only in Florida were higher odds found after adjustment among women with lower education (or among those whose infants' fathers had lower education) compared with college graduates. Compared with European American women, African American women had higher odds (OR 1.5, CI 1.1–2.1) of delayed/no prenatal care in Florida, while Latina (OR 1.8, CI 1.3–2.4) and Native American (OR 1.5, CI 1.0–2.1) women had higher odds in Washington. Teens had higher odds of delayed/no prenatal care in Florida, but not in Washington, compared with older mothers, and women delivering their first birth had lower odds in both states, compared with women who had five or more births.

No significant neighborhood deprivation effects were found in either state in the adjusted models for low birth weight (Table 4). The rest of the findings for LBW were quite different in the two states. In Florida, increased odds

of having a low birth weight baby were found for women who were poor (OR 1.3, CI 1.1–1.6), African American (OR 1.8, CI 1.5–2.0), or who had their first birth (OR 1.6, CI 1.4–1.9), and also for women whose partners had no more schooling than a high school education (OR 1.4, CI 1.1–1.7), or for women whose partner's education was missing (OR 1.7, CI 1.3–2.2), compared to their reference groups. Women younger than age 35 were at significantly decreased risk of having a low birth weight baby (ORs 0.6–0.7, CIs 0.4–0.8). Few statistically significant results were found in Washington, however: Asian/Pacific Islander women (OR 1.9, CI 1.0–3.7) or women who had their first birth (OR 3.2, CI 1.8–5.8) had higher odds of having a low birth weight baby than their respective reference groups.

As with low birth weight, no significant associations with neighborhood deprivation were found for not breastfeeding among women in the adjusted models and more individual-level characteristics were significantly associated with this outcome in Florida compared with Washington (Table 5, adjusted models). In Florida, poor women were *less* likely to have not breastfed compared with higher-income women (OR 0.7, CI 0.5–1.0). In contrast, large differences were seen in the odds of not breastfeeding for both maternal and paternal education. For example, women without a high school degree were four times more likely not to have breastfed compared with college graduates. African American women in Florida had higher odds of not breastfeeding (OR 1.3, CI 1.0–1.7), and Latinas had lower odds (OR 0.4, CI 0.3–0.6), compared with European American women. Women aged 18–19 were marginally more likely not to have breastfed compared with women aged 35 and over, and those who had delivered their first birth were less likely to have never breastfed compared with women with five or more births. As in Florida, women with a high school degree or less in Washington had higher odds of never having breastfed compared with college graduates, and those who had delivered their first birth had lower odds compared with women who had five or more births.

We found very few differences between the findings on neighborhood deprivation in the adjusted models for each racial/ethnic group compared with the full sample models (data not shown, available upon request). In Florida, we found that African American women living in the *least* deprived neighborhoods had *higher* odds of delayed/no prenatal care compared with their counterparts living in moderately deprived neighborhoods. The significant increased odds of delayed/no prenatal care for women living in high-deprivation neighborhoods in Washington was found only among European American women (the odds ratio was also elevated for Asian/Pacific Islander women, but not significantly). No other differences were found. We repeated the models with the least deprived quartile of

Table 3 Odds ratios (OR) and 95% confidence intervals (CI) for delayed/no prenatal care, Florida and Washington PRAMS (1997–1998) linked to Census tract data (2000)

	Florida						Washington					
	Unadjusted			Adjusted ^a			Unadjusted			Adjusted		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
<i>Neighborhood-level deprivation^b</i>												
Low	0.55	0.35	0.86	0.89	0.54	1.44	0.65	0.40	1.07	0.72	0.40	1.28
Moderate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
High	1.93	1.51	2.47	1.06	0.77	1.46	1.92	1.43	2.57	1.46	1.03	2.07
<i>Income^c</i>												
Missing	6.27	3.98	9.89	2.58	1.59	4.17	4.53	2.69	7.64	2.68	1.47	4.89
0–100%	5.62	3.84	8.21	1.88	1.22	2.90	3.97	2.73	5.80	1.90	1.17	3.08
101–200%	2.40	1.53	3.75	1.30	0.82	2.05	1.80	1.16	2.81	1.23	0.75	2.03
201+%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Maternal education</i>												
Less than high school	15.98	8.44	30.24	2.94	1.37	6.30	4.67	2.86	7.64	1.11	0.55	2.25
High school/GED	7.18	3.82	13.48	2.81	1.35	5.86	2.91	1.79	4.72	1.55	0.84	2.84
Some college	4.70	2.41	9.17	2.82	1.33	5.99	1.56	0.90	2.70	1.04	0.55	1.94
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Paternal education</i>												
Missing	18.72	10.06	34.82	3.95	1.83	8.51	4.43	2.73	7.20	1.89	0.94	3.81
Less than high school	14.61	7.59	28.12	3.89	1.79	8.43	3.92	2.36	6.52	1.27	0.62	2.61
High school/GED	4.16	2.20	7.87	1.55	0.74	3.27	1.85	1.12	3.04	0.93	0.50	1.74
Some college	3.88	1.91	7.87	1.95	0.92	4.17	1.76	1.01	3.06	1.31	0.69	2.46
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Race/ethnicity</i>												
African American	3.25	2.55	4.15	1.47	1.05	2.06	1.92	1.48	2.50	0.92	0.66	1.29
Asian/Pacific Islander							1.83	1.37	2.45	0.90	0.62	1.31
Latina	1.71	1.17	2.48	0.94	0.62	1.43	1.63	1.24	2.16	1.77	1.28	2.43
Native American							2.53	1.94	3.30	1.47	1.01	2.14
European American	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Marital status</i>												
Unmarried	3.66	2.85	4.70	1.23	0.88	1.72	2.92	2.19	3.89	1.48	0.98	2.24
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Age (years)</i>												
<17	6.12	3.63	10.32	3.12	1.59	6.12	3.72	1.87	7.39	2.12	0.89	5.07
18–19	5.43	3.33	8.84	3.47	1.93	6.25	3.00	1.68	5.35	1.55	0.77	3.11
20–34	1.73	1.10	2.73	1.54	0.93	2.55	0.97	0.64	1.49	0.75	0.46	1.23
35+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Parity</i>												
First birth	0.73	0.58	0.93	0.52	0.38	0.71	0.81	0.61	1.09	0.55	0.39	0.79
2–4 births	2.25	1.30	3.88	1.60	0.88	2.90	1.76	1.03	3.02	1.26	0.70	2.27
5+ births	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

^a Adjusted for neighborhood-level deprivation, income, maternal education, paternal education, race/ethnicity, marital status, age, parity

^b Based on statewide cutpoints

^c As a percentage of the federal poverty level

Table 4 Odds ratios (OR) and 95% confidence intervals (CI) for low birth weight,^a Florida and Washington PRAMS (1997–1998) linked to Census tract data (2000)

	Florida						Washington					
	Unadjusted			Adjusted ^b			Unadjusted			Adjusted		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
<i>Neighborhood-level deprivation^c</i>												
Low	0.81	0.66	0.98	0.94	0.76	1.16	0.94	0.44	2.01	0.95	0.38	2.36
Moderate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
High	1.34	1.17	1.54	0.99	0.85	1.17	1.22	0.72	2.08	1.21	0.61	2.40
<i>Income^d</i>												
Missing	1.59	1.27	2.00	1.20	0.94	1.55	1.40	0.56	3.50	1.38	0.48	3.93
0–100%	1.65	1.40	1.93	1.30	1.07	1.58	1.66	0.92	2.99	2.10	0.83	5.35
101–200%	1.20	0.99	1.46	1.06	0.86	1.31	0.77	0.37	1.61	1.33	0.56	3.14
201+%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Maternal education</i>												
Less than high school	1.81	1.47	2.23	1.16	0.86	1.56	2.49	1.12	5.54	1.97	0.67	5.83
High school/GED	1.35	1.11	1.64	0.96	0.76	1.22	0.84	0.36	1.96	0.82	0.34	1.97
Some college	1.23	0.99	1.52	1.01	0.80	1.27	1.07	0.45	2.55	1.53	0.62	3.75
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Paternal education</i>												
Missing	2.65	2.16	3.25	1.67	1.26	2.23	1.89	0.92	3.87	0.54	0.18	1.60
Less than high school	1.55	1.21	1.99	1.34	0.99	1.82	1.03	0.44	2.42	0.37	0.11	1.27
High school/GED	1.53	1.25	1.88	1.35	1.06	1.71	0.86	0.39	1.89	0.64	0.24	1.72
Some college	1.20	0.95	1.52	1.17	0.91	1.51	0.83	0.33	2.09	0.56	0.22	1.42
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Race/ethnicity</i>												
African American	2.11	1.96	2.28	1.77	1.54	2.03	1.99	1.26	3.14	1.57	0.83	2.97
Asian/Pacific Islander							2.39	1.51	3.79	1.94	1.03	3.66
Latina	0.94	0.77	1.14	0.87	0.69	1.08	1.23	0.74	2.04	1.00	0.54	1.86
Native American							1.24	0.74	2.08	0.80	0.38	1.69
European American	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Marital status</i>												
Unmarried	1.77	1.56	2.00	1.10	0.92	1.32	1.89	1.14	3.15	0.77	0.31	1.95
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Age (years)</i>												
<17	1.48	1.12	1.95	0.56	0.39	0.80	2.20	0.73	6.59	1.46	0.31	6.97
18–19	1.24	0.98	1.56	0.61	0.46	0.81	2.37	0.96	5.84	2.35	0.62	8.90
20–34	0.85	0.69	1.03	0.68	0.55	0.83	0.65	0.33	1.29	0.63	0.23	1.72
35+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Parity</i>												
First birth	1.48	1.29	1.69	1.63	1.40	1.90	2.94	1.68	5.15	3.18	1.75	5.77
2–4 births	1.52	1.06	2.18	1.01	0.71	1.45	3.32	1.26	8.75	3.19	0.77	13.16
5+ births	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

^a Singleton births only^b Adjusted for neighborhood-level deprivation, income, maternal education, paternal education, race/ethnicity, marital status, age, parity^c Based on statewide cutpoints^d As a percentage of the federal poverty level

Table 5 Odds ratios (OR) and 95% confidence intervals (CI) for never breastfed, Florida and Washington PRAMS (1997–1998) linked to Census tract data (2000)

	Florida						Washington					
	Unadjusted			Adjusted ^a			Unadjusted			Adjusted		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
<i>Neighborhood-level deprivation^b</i>												
Low	0.67	0.49	0.91	0.97	0.69	1.38	0.97	0.60	1.57	1.07	0.61	1.90
Moderate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
High	1.25	1.01	1.53	0.92	0.72	1.18	1.38	1.00	1.89	1.04	0.71	1.53
<i>Income^c</i>												
Missing	2.00	1.41	2.84	0.92	0.61	1.39	2.85	1.62	5.00	1.73	0.90	3.33
0–100%	1.86	1.45	2.38	0.73	0.53	0.99	2.91	1.97	4.30	1.29	0.76	2.19
101–200%	1.45	1.09	1.94	0.83	0.60	1.14	2.03	1.31	3.16	1.23	0.74	2.03
201+%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Maternal education</i>												
Less than high school	6.36	4.34	9.31	4.01	2.40	6.70	6.85	3.63	12.95	5.20	2.26	12.01
High school/GED	4.19	2.92	6.01	2.66	1.71	4.14	4.65	2.50	8.62	3.63	1.71	7.71
Some college	2.35	1.59	3.48	1.84	1.20	2.81	2.28	1.16	4.49	1.80	0.85	3.82
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Paternal education</i>												
Missing	7.30	5.03	10.60	3.21	1.96	5.26	3.98	2.26	7.01	1.50	0.69	3.27
Less than high school	4.99	3.29	7.57	2.60	1.55	4.35	2.88	1.53	5.40	0.81	0.36	1.85
High school/GED	3.84	2.66	5.53	2.13	1.38	3.29	3.76	2.14	6.60	1.45	0.72	2.91
Some college	2.13	1.39	3.26	1.60	1.03	2.51	1.87	0.98	3.56	1.13	0.53	2.38
College graduate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Race/ethnicity</i>												
African American	2.00	1.65	2.41	1.32	1.03	1.71	2.02	1.54	2.64	1.21	0.85	1.72
Asian/Pacific Islander							1.95	1.46	2.62	1.39	0.96	2.02
Latina	0.59	0.42	0.82	0.42	0.29	0.61	1.41	1.05	1.88	1.33	0.95	1.87
Native American							1.24	0.92	1.67	0.85	0.56	1.29
European American	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Marital status</i>												
Unmarried	2.37	1.95	2.89	1.18	0.89	1.55	2.18	1.61	2.97	1.13	0.72	1.77
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Age (years)</i>												
<17	2.72	1.78	4.16	1.08	0.62	1.90	2.69	1.23	5.85	0.77	0.27	2.19
18–19	2.98	2.04	4.34	1.59	1.00	2.51	3.33	1.75	6.33	1.44	0.66	3.13
20–34	1.33	0.96	1.84	1.13	0.79	1.61	1.39	0.87	2.21	0.95	0.56	1.61
35+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Parity</i>												
First birth	0.74	0.61	0.90	0.65	0.51	0.83	0.75	0.54	1.04	0.68	0.46	0.99
2–4 births	1.16	0.68	1.98	0.81	0.46	1.45	1.12	0.58	2.15	0.75	0.37	1.52
5+ births	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

^a Adjusted for neighborhood-level deprivation, income, maternal education, paternal education, race/ethnicity, marital status, age, parity

^b Based on statewide cutpoints

^c As a percentage of the federal poverty level

neighborhoods as the reference group and no appreciable differences were found, overall or within racial/ethnic group.

Discussion

This study's findings suggest the possibility that associations between neighborhood-level deprivation and unintended pregnancy, delayed/no prenatal care, LBW, and breastfeeding initiation may largely reflect residual confounding by individual-level SES. These findings are in contrast to previous studies that found statistically significant associations between NSC, or perceptions of neighborhoods, and both delayed/no prenatal care and LBW [16–23, 50]. These previous studies had more limited adjustment for individual-level socioeconomic factors compared with the current study, suggesting that previous "neighborhood effects" findings ought to be interpreted with more caution.

These findings do not, however, establish definitively the absence of neighborhood effects on the selected outcomes. First, direct comparisons with previous studies are difficult to make because of the variability in measures of NSC. Previous research found that conclusions regarding neighborhood effects could depend upon how NSC was measured [22, 51, 52]. In addition, similarly to previous studies, we used cross-sectional data; therefore, it is difficult to determine to what extent individual/household-level measures of SES (as well as other variables included in the models) may be on pathways between neighborhood context and the dependent variables, i.e., mediators, rather than acting as confounders. While it is very plausible that NSC mediates/determines an individual's socioeconomic attainment at least in part (e.g., living in a poor neighborhood influences one's quality of schooling which in turn influences job opportunities and thus income), NSC is only one of many determinants of socioeconomic status/position (e.g., other obvious determinants include one's parents' socioeconomic status/position and one's own race/ethnicity). Based on the accumulated weight of the literature on multiple health outcomes [2–6], neighborhood environments are likely to exert important influences on maternal and infant health; however, alternative analytic approaches may be required to adequately document these effects, given the limitations of standard approaches such as those used here and in previous studies. In the absence of such evidence, it may be best to consider the magnitude of an observed neighborhood effect as representing a range, with the true value lying somewhere between the crude and adjusted association [53].

Because deeply rooted institutional discrimination has resulted in people of color being far more likely than

European Americans to live in more deprived neighborhood environments, we hypothesized that interactions might exist between neighborhood deprivation and racial/ethnic group. We found some evidence of this. European American women—but not women of color—in Washington living in the most deprived neighborhoods had higher odds of delayed/no prenatal care compared with women living in moderately deprived neighborhoods. One might speculate about issues related to health care access, such as the location of neighborhood health centers and/or Medicaid enrollment sites, urban/rural differences which were not accounted for in the analyses, and/or if differential barriers to Medicaid exist for White women compared with other women. Furthermore, contrary to expectations, we found that African American women living in the *least* deprived neighborhoods in Florida had *higher* odds of delayed/no prenatal care; we can only speculate about potential explanations, including problems with access to acceptable prenatal care sites related to living in areas where fewer African American women reside.

Strengths of this study include its use of population-based data sources with more socioeconomic measures than included in previous studies, and with sufficient numbers to examine racial/ethnic groups separately. An important limitation is that the measures of neighborhood deprivation are simply a snapshot. We have no information on how neighborhoods were changing nor on how long women were exposed to them. This is particularly challenging in perinatal health studies, because women often move during pregnancy [54]; we based neighborhood deprivation on the women's address at the time they gave birth. Women may move to less or more deprived neighborhood environments depending on their individual/household circumstances and resources, and this may not be random, potentially biasing results. In addition, PRAMS data lack information on the birthplace of the mother; this may have influenced our findings since women born outside the U.S. generally have more favorable pregnancy outcomes and health-related behaviors compared with their U.S.-born counterparts of comparable or better socioeconomic circumstances [55–59]. Furthermore, women with missing geocodes in Washington were more likely to be of lower SES, or to be Latina or Native American, compared with women whose geographic information was known, also possibly biasing results toward the null. Finally, multiple tests were being performed, possibly leading to significant findings by chance alone.

In conclusion, while neighborhood environments may have important influences on maternal and infant health—and individual-/household-level factors continue to be important—this study's results illustrate that neighborhood-effects research without adequate adjustment for potential confounding by individual/household-level SES

should be interpreted with caution, particularly regarding conclusions of “independent” neighborhood effects. At the same time, it should be kept in mind that adjusting for individual-level socioeconomic factors may be controlling for key mediators of neighborhood contextual effects. Future efforts investigating the roles of neighborhood environments in maternal and infant health should consider analytic approaches to address the limitations noted here; such approaches may include longitudinal designs, collection of residential histories, and both surveys and qualitative methods to elicit perceptions of neighborhoods and how those might influence health.

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