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Neighborhood conditions are associated with maternal health behaviors and pregnancy outcomes

L.C. Vinikoor-Imler[a], **L.C. Messer**[b], **K.R. Evenson**[c], and **B.A. Laraia**[d,*]

[a]National Center for Environmental Assessment, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA

[b]Center for Health Policy, Duke Global Health Institute, Durham, NC, USA

[c]Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, NC, USA

[d]Center for Health and Community and Prevention Sciences Group, University of California, San Francisco, CA, USA

Abstract

Women residing in neighborhoods of low socioeconomic status are more likely to experience adverse reproductive outcomes; however, few studies explore which specific neighborhood features are associated with poor maternal health behaviors and pregnancy outcomes. Based upon our conceptual model, directly observed street-level data from four North Carolina US counties were used to create five neighborhood indices: physical incivilities (neighborhood degradation), social spaces (public space for socializing), walkability (walkable neighborhoods), borders (property boundaries), and arterial features (traffic safety). Singleton birth records (2001–2005) were obtained from the North Carolina State Center for Vital Statistics and maternal health behavior information (smoking, inadequate or excessive weight gain) and pregnancy outcomes (pregnancy-induced hypertension/pre-eclampsia, low birthweight, preterm birth) were abstracted. Race-stratified random effect models were used to estimate associations between neighborhood indices and women's reproductive behaviors and outcomes. In adjusted models, higher amounts of physical incivilities were positively associated with maternal smoking and inadequate weight gain, while walkability was associated with lower odds of these maternal health behaviors. Social spaces were also associated with inadequate weight gain during pregnancy. Among pregnancy outcomes, high levels of physical incivilities were consistently associated with all adverse pregnancy outcomes, and high levels of walkability were inversely associated with pregnancy-induced hypertension and preterm birth for Non-Hispanic white women only. None of the indices were associated with adverse birth outcomes for Non-Hispanic black women. In conclusion, certain neighborhood conditions were associated with maternal health behaviors and pregnancy outcomes.

[*]Corresponding author. Tel.: +1 415 476 7655. LaraiaB@chc.ucsf.edu (B.A. Laraia).

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Keywords

Birth outcomes; Maternal health behaviors; Neighborhood conditions; Neighborhood deprivation; USA

Introduction

Research in the United States, which mostly employs census data to define both neighborhood conditions and boundaries, has found consistent modest associations (after adjustment for individual-level variables) between neighborhood deprivation and preterm birth (Holzman et al., 2009; Messer et al., 2008; O'Campo et al., 2008), low birthweight (Nkansah-Amankra, Luchok, Hussey, Watkins, & Liu, 2010; Schempf, Strobino, & O'Campo, 2009), small-for-gestational age (Elo et al., 2009; Farley et al., 2006) and neural tube defects (Grewal, Carmichael, Song, & Shaw, 2009; Wasserman, Shaw, Selvin, Gould, & Syme, 1998). Similar associations have been found in studies across Europe (Agyemang et al., 2009; Gray et al., 2008; Gudmundsson, Bjorgvinsdottir, Molin, Gunnarsson, & Marsal, 1997; Janghorbani, Stenhouse, Millward, & Jones, 2006; Vrijheid et al., 2000).

In addition to understanding the influence of neighborhood characteristics on birth outcomes, there is also interest in identifying neighborhood conditions that influence maternal health behaviors which could be on the causal pathway between neighborhood environments and pregnancy outcomes. Recent studies have shown that neighborhood characteristics may affect birth-weight through the neighborhood's effects on maternal behaviors, such as smoking (Schempf et al., 2009) and inappropriate weight gain (Laraia, Messer, Evenson, & Kaufman, 2007). Explicating the ways through which neighborhoods influence health behaviors and outcomes is important for identifying the policy-relevant, modifiable neighborhood characteristics to which scarce public health resources can be applied.

Estimating a woman's residential environment with aggregated census variables does not necessarily represent the physical and social attributes of a neighborhood. In an effort to capture neighborhood-level attributes besides those possible using census data, a number of investigators have collected directly observed neighborhood characteristics. Because the number of neighborhood attributes available for observation is nearly infinite, we turned to the land use and planning literature as well as crime and safety literature to guide our data collection. From the criminology literature, Perkins, Meeks, and Taylor (1992) hypothesized that physical evidence of neighborhood degradation, including markers of "physical incivilities" (e.g., litter, graffiti, poor housing conditions), would undermine the confidence that residents have in their neighbors and community, thus increasing the fear of crime and associated stress; whereas physical signs of property demarcation through hedges, fences and decorations ("borders") symbolically convey to outsiders that area residents maintain and communicate control over their property. From land use and planning literature, researchers have suggested that providing public space for socializing ("social spaces") and walkable neighborhoods with aesthetic qualities and destinations ("walkability"), that maximize traffic and pedestrian safety ("arterial features") all promote travel and leisure physical activity, which are important for health (Evenson et al., 2009; Frank, Schmid, Sallis, Chapman, & Saelens, 2005).

Prior work conducted by the authors explored preliminary associations between three of these literature-based neighborhood attributes and pregnancy-related health behaviors (but not birth outcomes) within a smaller pregnancy cohort on a limited geographic scale (Laraia et al., 2007). Laraia et al. found that higher levels of physical incivilities were inversely associated with physical activity and higher levels of social spaces were related to lower odds of inappropriate weight gain, but no associations were found between territoriality and health behaviors.

Derived from the cited literature and prior work, the conceptual model underlying this research hypothesized that women are exposed to multiple neighborhood-level health promoting and impairing influences, including incivilities, borders, social spaces, walkability and arterial features. We further anticipated these variables would differ in their magnitude and direction of association with adverse health behaviors and birth outcomes. Our conceptual model posited higher levels of physical incivilities and arterial features would be associated with worse pregnancy-related health behaviors and outcomes whereas borders, social spaces and walkability indicators would be associated with better health behaviors and outcomes. We believe that exposure to indicators of physical incivilities would result in increased psychosocial stress and may be associated with both individual- and neighborhood-level poverty, which has been associated with adverse pregnancy-related behaviors and outcomes. Access to increased social spaces may encourage healthy behaviors, increase the likelihood of neighborhood-level social interactions during pregnancy and increase perceived social support among expectant women. The presence of borders is thought to be associated with favorable maternal health behaviors and birth outcomes through its hypothesized influence on a woman's feeling of security through defined personal space and ownership. Neighborhood walkability should facilitate positive maternal health behaviors by providing a safe space within which healthy behaviors may occur. However, arterial features relate to heavy vehicular traffic and less pedestrian-friendly attributes of a neighborhood. Areas with paved roads, bus traffic, and streets made up of multiple lanes, with the need for crosswalks and other pedestrian-friendly markings due to the traffic volume, are hypothesized to be negatively related to pregnancy-related behaviors and outcomes due to high traffic volume being associated with greater risk of accidents and stress.

Based on the published literature, which guided our construct selection, prior work, which suggested interesting associations to pursue within a larger and more geographically diverse sample, and our conceptual model, the objective of this work was to identify the associations between these five neighborhood indices and maternal health behaviors and birth outcomes independent of individual-level characteristics.

Methods

This geographically-defined cohort study combined directly-observed street-level data with five years of birth records data from four counties in North Carolina (NC). Five neighborhood indices were constructed based on previously identified measures (Evenson et al., 2009; Laraia et al., 2007), and associations between these indices and maternal health behaviors and outcomes were estimated. *A priori* we decided to stratify the statistical analyses by race, as neighborhood effects have been differentially associated with white and black women's birth outcomes in the literature (Gorman, 1999; O'Campo et al., 2008; Pickett, Ahern, Selvin, & Abrams, 2002; Savitz et al., 2004). Ethical review was completed at the University of North Carolina.

Population description

Birth records for the four counties in which most of the third Pregnancy, Infection, and Nutrition (PIN3) Study participants resided were obtained from the NC State Center for Vital Statistics for 2001–2005. Over 39,000 singleton births to Non-Hispanic (NH) white and black women with geocodable addresses were included in the study. Infants with improbable gestational ages (less than 22 weeks, greater than 42 weeks), infants with improbable birth-weights (less than 500 g, greater than 6000 g), and infants for whom a stillbirth outcome could not be precluded (infants with a gestational age of 22–25 weeks without birthweight information) were excluded ($n = 167$). The residential address provided on the birth certificate was geocoded and used to assign each woman to a census block group.

Outcome definitions

Information on pregnancy-related behavioral risk factors (smoking and maternal weight gain) and outcomes (pregnancy-induced hypertension/eclampsia, low birthweight, and preterm birth) were obtained from birth certificates. These pregnancy-related behavioral factors and outcomes were chosen, in part, because they have previously been shown to be reliably reported on birth certificates (Vinikoor, Messer, Laraia, & Kaufman, 2010). Other behaviors and outcomes, such as alcohol consumption and anemia, were not considered because the birth certificate data appear unreliable (Vinikoor et al., 2010). The behavior of smoking during pregnancy was categorized as present or absent for each woman. Weight gain was categorized based on the 1990 Institute of Medicine cutpoints for adequate gestational weight gain (Institute of Medicine, 1990). Because pre-pregnancy weight status is not recorded on the birth certificate, we used general cutpoints for inadequate (<15 lbs) and excessive (≥40 lbs) weight gain as these apply to any pre-pregnancy weight. Pregnancy-induced hypertension/eclapmsia (hereafter referred to as PIH) was classified as having either condition present or absent during pregnancy. Gestational age was determined using information on last menstrual period when this information was complete; clinical estimates were used when data elements to calculate gestational age using last menstrual period were missing. Infants born at less than 37 weeks whose reported gestational weight was less than 3888 g were categorized as being preterm. This additional weight restriction was applied based on research of infant birthweight (Alexander, Himes, Kaufman, Mor, & Kogan, 1996). Among infants born at 36 weeks, the 95th percentile of their weight distribution was 3888 g. By applying this weight restriction, infants with birthweights of a full term infant (i.e. at least greater than the 95th percentile of weight for 36 weeks of gestation), will be classified as a term birth. Infants were classified as term low birthweight if they were delivered at term (37–42 weeks) weighing less than 2500 g.

Exposure data source

Street audit data were collected for the areas where most women from the PIN3 Study resided (Evenson et al., 2009). Residential characteristics were observed during the summers of 2005 and 2006 for all streets within a ¼-mile of the PIN3 woman's address. The geographic areas in which these study participants lived was unevenly distributed among the four central NC counties (Alamance, Chatham, Durham and Orange); because more women lived in densely populated areas, more data collection occurred in these areas than in the sparsely populated regions of the counties. Further information on the street audit and evidence for reliability is available elsewhere (Caughy, O'Campo, & Patterson, 2001; Evenson et al., 2009; Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003).

Unit of analysis

For this analysis, we used year 2000 U.S. census block group boundaries to approximate the women's neighborhood environment. Directly observed data were collected on 235 of 317 block groups in the study area. *A priori* the decision was made to include only block groups that had at least 20% of the streets audited (n = 157), which we used in prior research to represent the neighborhood (Laraia et al., 2006). As expected, the block groups with at least 20% of streets audited had greater mean population (1924 versus 1417) and a lower proportion of the population living in rural areas (14% versus 40%), indicative of the sample of block groups being from the urban and suburban sections of the study area.

Geographically-limited sample description

Of the 38,915 women who met the overall study inclusion criteria, 23,304 lived in block groups with ≥20% of the roads audited and were therefore included in the analyses. The included women differed from the excluded women (those living in a block group with <20% of the streets audited) by including a greater proportion of married (68% versus 63%) and NH black women (38% versus 33%) and a smaller proportion of women who smoked while pregnant (9% versus 14%).

Index construction

The neighborhood indices were constructed at the block group level, by assessing all the observed street-level variables used previously to create the following domains—"Physical Incivilities," "Walkability," "Decoration," "Arterial or Thoroughfare" (Evenson et al., 2009), and "Social Spaces" (Laraia et al., 2006). These prior indices were created by factor analyzing street-level data. Here, the street-level data were aggregated, assessed and modified for use at the block group level. Prior to index modification, several criteria for the indices were established: 1) the principal components analysis (PCA) procedure, which would be used to construct the indices, could result in only one or two Eigenvalues greater than 1; 2) the first principal component needed to explain more than 50% of the total variation; and 3) the index that resulted from the first component had a Cronbach's alpha greater than 0.7.

The index modification procedure began with the index-specific variable list previously identified (Evenson et al., 2009; Laraia et al., 2006). Variables based on geographic information system (GIS) information, which are reliant upon GIS skills, were excluded to purposely pursue key directly observable indicators from a check list completed by a trained rater, and that would produce reliably replicable indices. The full list of considered variables is included in the Electronic Appendix [insert link to online content here]. Each item was dichotomized to represent presence or absence at the street level. Next, the dichotomized variable was aggregated to the block group level. This aggregation resulted in a continuous variable that represented the percentage of audited streets in each block group in which the specific feature was observed. For example, audited streets were categorized as having litter present or not. The proportion of audited streets with litter present was then calculated for each block group.

Block group indices were constructed by including the continuous proportion variables for each neighborhood characteristic in a PCA, which is a data reduction technique for which each variable loading represents the correlation between the specific variable and the overall component. We used PCA to help identify the variables that were most closely related to domains they were chosen to represent. Following the first PCA run for each index, we identified individual variables that did not correlate well with the overall index and that, if removed, would result in a Cronbach's alpha that met or was closer to our original criteria. Each such variable was then removed, and the PCA was re-run (without the eliminated variable) and the index was reassessed according to the above criteria. We continued in this manner until the criteria were met. The first component of the PCA was utilized for each index because the first component accounts for the largest proportion of the total variance (Messer et al., 2006). Quartiles of each of the final indices were constructed at the block group level prior to merging these data with the birth record outcomes.

The final indices were comprised of between three and seven variables (Table 1). Three of the indices (physical incivilities, walkability, and borders) had over 60% of the total variance explained by the first principal component. The lowest percent of the total variance explained by the first principal component was 50% for arterial features. Principal component variable loadings were generally quite high; and the index alphas ranged from 0.72 for arterial features to 0.86 for physical incivilities.

In addition, we recreated the Neighborhood Deprivation Index (NDI), which has previously been used to estimate area level deprivation using the following census variables: % households in poverty, % female-headed households with dependents, % households with income <$30,000, % households on public assistance, % males in management/professional occupations, % living in crowded housing, % unemployed, and % without a high school education (Messer et al., 2006). The first component for NDI explained 52% of the variance and had a Cronbach's alpha of 0.86. The NDI was then correlated with the neighborhood indices to assess the extent of overlap between the directly observed neighborhood indices and the more typically-used census-based sociodemographic measures.

Statistical analysis

All analyses were performed using Stata v.10 (StataCorp, 2007). Counts and percentages of the individual- and neighborhood-level characteristics were calculated. Spearman correlations were used to examine the relatedness of the five block group-level indices. Fixed slope random intercept multilevel logistic models were used to estimate the associations between the neighborhood level exposure variables and the pregnancy-related health behaviors and outcomes. Race-stratified crude and adjusted models were estimated including only women with complete information in each analysis. Adjusted models included maternal age (continuous), maternal education (high school or greater than high school compared to less than high school), marital status (married compared to not married) and previous pregnancies (one or two previous pregnancies or three or more previous pregnancies compared to no previous pregnancy). These variables were included because they are thought to be potential confounders of the association between neighborhood and pregnancy-related behaviors and outcomes. They have been demonstrated to be associated with some of the outcomes under study (Berkowitz & Papiernik, 1993; Bibby & Stewart, 2004; Goldenberg, Culhane, Iams, & Romero, 2008). In addition, when tested in our dataset, these variables met the definition of confounders (not on the causal pathway between 'exposure' variables of interest and outcomes, associated with the exposure variables of interest in the source population, and associated with the outcomes). The models were also run including a quadratic term for age to allow for flexible adjustment of maternal age. No differences were observed when the quadratic age term was included; therefore no quadratic terms were retained in the final models. A two-tailed *z*-test for linear trend was performed for the adjusted analyses to examine the change in association across the four quartiles of each index.

Results

Index correlations

Walkability was modestly correlated ($r \geq 0.47$) with all indices (Table 2). Social spaces was inversely related to walkability (−0.64) and arterial features (−0.74) and positively associated with borders (0.74). Physical incivilities was a relatively independent construct that was moderately inversely correlated with walkability (−0.51) but weakly correlated with the other indices ($r < 0.20$). The NDI was moderately correlated with physical incivilities ($r = 0.70$) but weakly correlated with the other indices ($r < 0.30$).

Demographic characteristics

Approximately 38% of the women included in the analyses were NH black (Table 3), and more NH black women delivered at younger ages. A greater percentage of the NH white women had more than a high school education, reported being married, and were primiparous, compared to the NH black women. The smoking prevalence was generally low among women of both races. Comparable proportions of both NH white and black women gained more than 40 pounds during pregnancy and experienced PIH. NH black women delivered almost three times as many term low birthweight term infants and almost twice as many preterm infants, compared to their NH white counterparts.

A considerably larger proportion of NH white women resided in block groups with low amounts of physical incivilities; by contrast far more NH black women lived in block groups with the highest level of observed physical incivilities. NH white and NH black women were comparably distributed across the quartiles of social spaces. While more NH white women resided in more walkable block groups, compared to less walkable block groups, NH black women were about equally distributed across walkable block groups. Most NH white and NH black women lived in block groups with moderate amounts of borders, but more NH black women lived in block groups with the most arterial features compared to NH white women.

Associations with pregnancy-related behaviors and outcomes among NH white women

In unadjusted models for NH white women (Table 4a), maternal residence in block groups characterized by greater physical incivilities was associated with higher odds of adverse pregnancy-related behaviors and outcomes. High levels of physical incivilities were associated with maternal smoking and inadequate and excessive weight gain. High levels of physical incivilities were also associated with all three pregnancy-related outcomes. Residence in block groups with high amounts of social spaces was also associated with higher odds of maternal smoking and inadequate weight gain, but only residence in block groups with the highest levels of social spaces were associated with excessive weight gain and preterm birth. In block groups with greater walkability, the odds of adverse pregnancy behaviors were lower, as were the odds for preterm birth and PIH. Higher levels of arterial features were associated with lower odds of smoking and inadequate weight gain. Block groups with more arterial features were not associated with any pregnancy outcomes. The amount of borders present was not associated with any maternal behavior or outcome.

Following adjustment for maternal covariates, the patterns of association between block group indices and pregnancy-related behaviors and outcomes remain fairly consistent for NH white women (Table 4b), but the point estimates were uniformly attenuated. Residence in block groups with high amounts of physical incivility was associated with greater odds of maternal smoking, inadequate or excessive weight gain, and PIH. Only exposure to the highest quartile of physical incivilities was associated with greater odds of term low birthweight and preterm birth. Higher quartiles of social spaces were associated with greater odds of smoking and inadequate gestational weight gain, but not with pregnancy outcomes. Higher walkability continued to be associated with lower odds of maternal smoking, inappropriate weight gain, and PIH; importantly, walkable neighborhood also remained associated with an approximately 20% lower odds of preterm birth. There was still no association between borders and pregnancy-related behaviors and outcomes. Moderate to high levels of arterial features remained associated with reduced odds of maternal smoking.

Associations with pregnancy-related behaviors and outcomes among NH black women

Fewer associations were evident for NH black women compared with NH white women (Table 4c). In unadjusted models, residence in block groups with high physical incivilities was associated with greater odds of maternal smoking and inadequate weight gain, as well as greater odds of preterm birth and term low birthweight. The highest quartile of social spaces and borders were positively associated with inadequate weight gain, whereas the highest quartile of walkability was inversely associated with inadequate weight gain, the odds of smoking during pregnancy, and term low birthweight. None of the indices was associated with excessive weight gain. The only association for arterial features was the fourth quartile being inversely associated with PIH.

Among NH blacks, even fewer block group-level indices were associated with pregnancy behaviors and outcomes following adjustment for maternal covariates (Table 4d). Higher amounts of physical incivilities were associated with greater odds of maternal smoking and inadequate weight gain. The relationships between the highest quartiles of social spaces and borders with greater odds of inadequate weight gain remained similar in magnitude and precision to the unadjusted context. The highest quartile of walkability was still associated with lower odds of maternal smoking and inadequate weight gain. Similar to the unadjusted models, higher levels of arterial features remained associated with lower odds of PIH. No other association between the indices and pregnancy outcomes persisted.

Discussion

In this analysis we created five neighborhood constructs (physical incivilities, social spaces, walkability, arterial features and borders) at the block group level using directly observed street-level data. The neighborhood indices were associated with pregnancy-related behaviors among both NH white and NH black women and with pregnancy-related outcomes among NH white women. This supports previous research using U.S. census data showing that neighborhood environment is not only related to birth outcomes but is also associated with maternal health behaviors that are on the pathway to birth outcomes.

The physical incivilities index had the greatest internal reliability and percent variance explained. It was also the index most consistently associated with maternal health behaviors. For both NH whites and NH blacks, greater physical incivilities were associated with higher odds of smoking and inadequate weight gain. In addition, among NH white women, higher amounts of physical incivilities were associated with excessive weight gain. Our findings are consistent with other published work. A previous study in Sweden showed that smoking during pregnancy was more prevalent in poor neighborhoods and that smoking likely modified the association between neighborhood socioeconomic status and birthweight (Sellstrom, Arnoldsson, Bremberg, & Hjern, 2007). The physical incivilities index was correlated with neighborhood deprivation, and residents of neighborhoods characterized by high physical incivility and high poverty may have less access to supermarkets or stores with healthy food products (Larson, Story, & Nelson, 2009). This could result in less healthy food options and women may not consume enough for adequate weight gain. Conversely, it is possible that women who have less access to healthy food may consume even more unhealthy foods while pregnant, resulting in excessive weight gain. Finally, women dealing with stress and other psychosocial factors have been observed to consume more food during pregnancy (Hurley, Caulfield, Sacco, Costigan, & Dipietro, 2005). Future studies of stress resulting from neighborhood deprivation will provide a more in-depth understanding of these relationships.

Higher physical incivilities were associated with all three birth outcomes for NH white women. No associations were detected among NH black women. Previous studies have shown that neighborhood disorganization is inversely associated with birth-weight (Holland, Kitzman, & Veazie, 2009) and perception of neighborhood security is inversely associated with small-for-gestational age infants (Auger et al., 2008). Although women in our study were not interviewed regarding their perceptions of the neighborhood, it is feasible that characteristics of neighborhoods with high physical incivilities, disorganization, and perceived security may be related to each other and to birth outcomes by their roles as potential maternal stressors. Further research is needed to understand why associations were observed only among NH white women. In the United States, black race is associated with more adverse social exposures than white race. Therefore, it is difficult to tease out the effect of any one social stressor. It can be hard to find associations for a specific exposure given the multiple adverse stressors to which these women are simultaneously exposed.

Walkability was also an internally reliable index that was modestly correlated with the other indices, suggesting that walkable neighborhoods may share some features with the other indices (e.g., incivil neighborhoods may not be very walkable). Walkability was inversely associated with smoking and inadequate weight gain among both NH white and NH black women. Therefore, walkable neighborhoods may be associated with healthy behaviors that decrease smoking during pregnancy and also encourage healthy weight gain. Among NH white women, higher walkability was associated with lower odds of PIH and preterm birth. Thus, positive associations for walkability are present with both maternal health behaviors and birth outcomes among NH white women. Stuebe et al. (Stuebe, Oken, & Gillman, 2009) recently reported that women who walked or performed vigorous physical activity mid-pregnancy had a reduced odds of excessive pregnancy weight gain. Other studies have shown negative associations between walkability and overall hypertension (Mujahid et al., 2008). These are echoed among women in our study; living in neighborhoods with higher walkability was associated with better health behaviors during pregnancy and better pregnancy-related outcomes among NH white women.

The social spaces, arterial features, and borders indices were not as internally consistent as walkability and physical incivilites. The social spaces and arterial features indices did show evidence of associations with maternal health behaviors and birth outcomes. The direction of association for social spaces was opposite to that expected; previous research in a similar study population found a positive association between social spaces and adequate pregnancy weight gain (Laraia et al., 2007). It is possible that social spaces provide residents with a place where social norms are shared, and some norms may be related to unhealthy maternal behaviors. Further research in these areas is necessary to fully understand the relationships with social spaces. The borders index was created to represent the separations of personal space. While there are conceptual reasons to imagine that territoriality, as indicated by the borders index, may be associated with health, other than the association with inadequate weight gain among NH blacks, we observed no associations between borders and maternal health behaviors or birth outcomes among NH white or NH black women.

Among the five indices, the census-constructed index (NDI) was moderately correlated with the physical incivilities index but not the other four indices. The NDI being weakly correlated with the other four indices suggests that the indices are representing aspects of the neighborhood other than deprivation. These new domains should be further investigated as potential areas for public health interventions for pregnancy-related behaviors and outcomes. For example, instead of focusing more generally on impoverished neighborhoods, this study has outlined specific neighborhood characteristics that can be explored, such as improving the walkability of a neighborhood.

For NH white women, the physical incivilities and walkability indices were associated with both pregnancy-related health behaviors and outcomes. It is possible that the health behaviors we considered here are on the pathways between these aspects of neighborhood and pregnancy outcomes. For NH black women, however, physical incivilities and walkability were associated with maternal health behaviors but not with pregnancy-related outcomes. It is possible that there are other factors affecting their pregnancy outcomes and the pathways differ from those of NH white women. Further, the neighborhood indices affecting maternal health behaviors could influence causal pathways leading to other pregnancy outcomes not examined here, such as babies born small-for-gestational age or need for cesarean section. Future research in these areas will support the identification of which maternal health behaviors are on the pathways between neighborhood environments and birth outcomes for both NH white and NH black women.

Among the strengths of this study, the study population included a large number of women with various health behaviors and birth outcomes. In addition, information was collected by directly observing the neighborhoods where women resided, as opposed to examining information obtained from non-observed sources like census data. This allowed for the examination of new indices based on unique physical and social neighborhood attributes. Instead of more general census variables representing a neighborhood based on overall measures related to employment and poverty, our study was able to examine more detailed neighborhood characteristics, such as litter and presence of porches. This presents a more in-depth assessment of neighborhood characteristics. It is important to begin to understand the influence of these specific physical and social attributes so mechanisms related to neighborhood environments can be understood. Also, although the maternal behavior and birth outcomes information was obtained from birth records, which are dependent on accurate self-report, previous work has shown that the birth records for women included in this study have good reliability for the variables examined (Vinikoor et al., 2010).

One of the limitations of the study is that the audited streets were more likely to be in urban areas and therefore this study is not generalizable to the entire population. Although some rural areas were included, further work needs to be done using block groups in rural areas to see if the indices remain internally consistent and the associations persist. Another limitation is that there were not enough women of other races and ethnicities in the study population to examine the associations between the neighborhood characteristics and maternal health behaviors and birth outcomes among women other than NH white women and NH black women. We do not have information on pre-pregnancy weight or body mass index (BMI), which would have allowed more specific calculations on adequacy or excessiveness of weight gain. In addition, we do not know if the women in the study changed residence while pregnant or if she resided in the same location for the duration of her pregnancy. However, a previous study of pregnant women in Texas revealed that although 32% of mothers changed residence between conception and birth, most remained close to their previous residence (Nuckols, Langlois, Lynberg, & Luben, 2004). In addition, Canfield, Ramadhani, Langlois, and Waller (2006) determined the misclassification associated with residential mobility to be non-differential, therefore affecting cases and non-cases similarly. Preterm birth may have some misclassification due to reliance on last menstrual period when calculating gestational age. In an attempt to correct for the errors in the calculation of gestational age, we added an additional cut-off determined by birthweight at 36 weeks of age, thereby reducing the number of infants incorrectly classified as preterm. Finally, as with all neighborhood work, the degree to which these indices capture salient aspects of neighborhood conditions, particularly as they pertain to pregnancy behaviors and outcomes, is unknown. A research study in which women are asked about their neighborhood experience at the same time as these neighborhoods are being assessed would be required to fully understand these relationships.

In summary, we created five neighborhood indices from directly observed street-level data, characterizing different aspects of neighborhoods, and determined the associations between the indices and pregnancy-related health behaviors and outcomes. This study highlighted the associations between neighborhood environment and maternal health behaviors, illustrating a potential pathway to negative birth outcomes. Moreover, the results presented here can be used to shape future public health interventions; resources might be directed to neighborhood aspects shown to affect pregnancy-related behaviors and outcomes. Future research exploring the pathways between neighborhood characteristics and pregnancy outcomes as affected by maternal health behaviors is warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix. Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.socscimed.2011.08. 012.

Table 1

Factor Loadings and Variance of the Five Neighborhood Indices Examined.

Number of block groups	**157**
Physical incivilities	
Eigenvalue[a]	3.63
# of Eigenvalue >1	1
%variance explained by component 1	0.60
Alpha	0.86
Eigenvector loadings:	
Fair/poor/deteriorated condition of residential units	0.48
Fair/poor condition of resident-kept grounds	0.48
Abandoned/burned/boarded up units	0.41
Litter	0.41
Pedestrian-oriented public lighting	−0.23
No trespassing sign	0.39
Social spaces	
Eigenvalue[a]	2.30
# of Eigenvalue >1	2
% variance explained by component 1	0.58
Alpha	0.74
Eigenvector loadings:	
Porches in at least half of residences	0.57
Sidewalk on at least one side of the street	−0.51
Traditional lawn or landscaped	0.56
Visible adult/child	−0.32
Walkability	
Eigenvalue[a]	2.55
# of Eigenvalue >1	1
% variance explained by component 1	0.64
Alpha	0.81
Eigenvector loadings:	
Neighborhood park/playground	−0.50
Sidewalk in good condition	0.50
Pedestrian oriented lighted	0.48
Neighborhood entrance sign	0.52
Borders	
Eigenvalue[a]	1.96
# of Eigenvalue >1	1
% variance explained by component 1	0.65
Alpha	0.72
Eigenvector loadings:	

Number of block groups	157
Porches in at least half of residences	0.65
Some form of decoration on at least half of residences	0.61
Border on at least half of residences	0.45
Arterial features	
Eigenvalue[a]	3.53
# of Eigenvalue >1	2
%variance explained by component 1	0.50
Alpha	0.82
Eigenvector loadings:	
Nonresidential commercial land use	0.38
Sidewalk in good condition	0.33
Bus stop/facilities	0.37
More than two lanes to cross the street	0.44
Paved roads	0.18
Pavement markings/crosswalk	0.47
Yield to pedestrian signs/paddles/signals	0.41

[a]Eigenvalues are a measure of the variance of all the variables accounted for by the factor. The higher the eigenvalue, the greater amount of variance that has been explained.

Table 2

Spearman's correlations between the indices and the Neighborhood Deprivation Index (NDI).

	Physical incivilities	Social spaces	Walkability	Borders	Arterial features
Physical incivilities	1.00				
Social spaces	0.16	1.00			
Walkability	−0.51	−0.64	1.00		
Borders	0.02	0.74	−0.47	1.00	
Arterial features	−0.07	−0.73	0.47	−0.41	1.00
NDI	0.70	−0.18	−0.19	−0.22	0.29

Table 3

Demographic, health behavior, pregnancy outcome and neighborhood characteristics of women by racial group.[a]

	Non-Hispanic whites N (%) n = 14531	Non-Hispanic blacks N (%) n = 8773
Individual-level		
Maternal age		
<20	679 (4.7)	1272 (14.5)
20–24	1844 (12.7)	2541 (29.0)
25–29	3834 (26.4)	2335 (26.6)
30–34	5242 (36.1)	1700 (19.4)
35+	2932 (20.2)	925 (10.5)
Maternal education		
<High school	1101 (7.6)	1982 (22.7)
High school	2056 (14.2)	2574 (29.4)
>High school	11,347 (78.2)	4193 (47.9)
Marital Status		
Married	12,510 (86.1)	3378 (38.5)
Number of previous pregnancies		
0	5643 (38.9)	2615 (29.9)
1–2	6987 (48.2)	4094 (46.8)
3+	1876 (12.9)	2031 (23.2)
Smoker		
Yes	1192 (8.2)	884 (10.1)
Weight gain during pregnancy		
<15 lbs	713 (5.0)	1040 (12.2)
15–39 lbs	9676 (67.7)	5300 (62.2)
40 + lbs	3894 (27.3)	2178 (25.6)
Pregnancy-induced hypertension		
Yes	712 (4.9)	492 (5.6)
Term low birthweight		
Yes	191 (1.4)	321 (4.2)
Preterm birth		
Yes	1036 (7.1)	1166 (13.3)
Neighborhood level		
Number of block groups	156	156
Physical incivilities		
Mean (SD)	−0.62 (1.3)	0.57 (2.3)
Quartile 1	4924 (33.9)	1732 (19.7)
Quartile 2	4334 (29.8)	2031 (23.2)
Quartile 3	3582 (24.7)	1668 (19.0)
Quartile 4	1691 (11.6)	3342 (38.1)
Social Spaces		

	Non-Hispanic whites N (%) *n* = 14531	Non-Hispanic blacks N (%) *n* = 8773
Mean (SD)	0.17 (1.2)	−0.02 (1.2)
Quartile 1	3043 (20.9)	2038 (23.2)
Quartile 2	4539 (31.2)	2571 (29.3)
Quartile 3	3431 (23.6)	2698 (30.8)
Quartile 4	3518 (24.2)	1466 (16.7)
Walkability		
Mean (SD)	0.25 (1.5)	0.17 (1.8)
Quartile 1	2621 (18.0)	1880 (21.4)
Quartile 2	2869 (19.7)	2299 (26.2)
Quartile 3	4743 (32.6)	2227 (25.4)
Quartile 4	4298 (29.6)	2367 (27.0)
Borders		
Mean (SD)	0.10 (1.1)	−0.22 (1.3)
Quartile 1	2704 (18.6)	2448 (27.9)
Quartile 2	5375 (37.0)	2787 (31.8)
Quartile 3	3179 (21.9)	2067 (23.6)
Quartile 4	3273 (22.5)	1471 (16.8)
Arterial features		
Mean (SD)	−0.39 (1.2)	−0.10 (1.2)
Quartile 1	4024 (27.7)	1578 (18.0)
Quartile 2	4513 (31.1)	2472 (28.2)
Quartile 3	3532 (24.3)	2736 (31.2)
Quartile 4	2462 (16.9)	1987 (22.7)

[a]Information was missing for the following variables: maternal education (*n* = 51), marital status (*n* = 1), number of previous pregnancies (*n* = 58), smoking status (*n* = 77), weight gained during pregnancy (*n* = 503), pih/eclampsia (*n* = 1), low birthweight (*n* = 15), preterm birth (*n* = 9).

Table 4a

Unadjusted Odds Ratios (95% Confidence intervals) for the association between neighborhood indices and pregnancy-related behaviors and outcomes among Non-Hispanic white women.

	Quartiles	Smoking	Weight gained during pregnancy <15 lbs	Weight gained during pregnancy ≥ 40 lbs	Pregnancy-induced hypertension/eclampsia	Term low birthweight[a]	Preterm birth
Physical incivilities	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.50 (0.98, 2.31)	1.14 (0.89, 1.44)	1.08 (0.96, 1.20)	1.26 (1.02, 1.55)	1.44 (0.92, 2.25)	1.05 (0.89, 1.24)
	3	3.39 (2.23, 5.13)	1.93 (1.53, 2.43)	1.28 (1.14, 1.43)	1.38 (1.11, 1.71)	1.43 (0.90, 2.27)	1.23 (1.04, 1.46)
	4	7.09 (4.64, 10.83)	2.78 (2.15, 3.60)	1.42 (1.23, 1.63)	1.57 (1.22, 2.02)	2.90 (1.79, 4.69)	1.67 (1.37, 2.03)
Social spaces	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.32 (0.76, 2.28)	1.07 (0.78, 1.46)	0.99 (0.86, 1.13)	0.96 (0.75, 1.24)	1.12 (0.66, 1.90)	0.96 (0.80, 1.16)
	3	2.01 (1.17, 3.48)	1.52 (1.12, 2.07)	1.07 (0.93, 1.24)	1.00 (0.78, 1.30)	1.62 (0.96, 2.74)	1.12 (0.93, 1.37)
	4	2.46 (1.43, 4.22)	1.75 (1.30, 2.38)	1.16 (1.01, 1.33)	1.20 (0.93, 1.54)	1.48 (0.87, 2.51)	1.22 (1.01, 1.48)
Walkability	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.68 (0.41, 1.14)	0.65 (0.48, 0.88)	0.83 (0.72, 0.96)	0.85 (0.65, 1.10)	0.82 (0.48, 1.40)	0.75 (0.62, 0.91)
	3	0.42 (0.25, 0.70)	0.60 (0.45, 0.80)	0.79 (0.69, 0.90)	0.85 (0.67, 1.08)	0.79 (0.48, 1.30)	0.75 (0.63, 0.89)
	4	0.34 (0.20, 0.57)	0.57 (0.42, 0.76)	0.83 (0.73, 0.95)	0.79 (0.62, 1.00)	0.77 (0.47, 1.27)	0.69 (0.57, 0.82)
Borders	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.67 (0.39, 1.15)	0.99 (0.72, 1.36)	0.96 (0.84, 1.10)	0.93 (0.73, 1.19)	1.07 (0.65, 1.77)	0.88 (0.73, 1.06)
	3	1.26 (0.73, 2.17)	1.19 (0.86, 1.66)	1.02 (0.88, 1.18)	1.00 (0.76, 1.30)	0.98 (0.57, 1.69)	0.88 (0.71, 1.08)
	4	0.70 (0.40, 1.22)	0.99 (0.71, 1.38)	1.03 (0.89, 1.19)	1.00 (0.77, 1.30)	0.96 (0.56, 1.66)	0.96 (0.79, 1.17)
Arterial features	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.59 (0.35, 0.98)	0.89 (0.67, 1.19)	0.94 (0.83, 1.07)	0.92 (0.73, 1.15)	1.12 (0.70, 1.79)	0.87 (0.74, 1.02)
	3	0.50 (0.30, 0.85)	0.69 (0.51, 0.93)	0.96 (0.84, 1.10)	0.94 (0.74, 1.19)	0.68 (0.40, 1.14)	0.76 (0.64, 0.91)
	4	0.43 (0.25, 0.75)	0.67 (0.48, 0.93)	0.88 (0.76, 1.02)	0.89 (0.68, 1.16)	1.04 (0.61, 1.77)	0.91 (0.75, 1.09)

[a] Among only term births.

Table 4b

Adjusted[a] odds ratios (95% confidence intervals) for the association between neighborhood indices and pregnancy-related behaviors and outcomes among Non-Hispanic white women.

	Quartiles	Smoking	Weight gained during pregnancy <15 lbs	Weight gained during pregnancy ≥ 40 lbs	Pregnancy-induced hypertension/eclampsia	Term Low Birthweight[b]	Preterm Birth
Physical incivilities	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.28 (0.92, 1.80)	1.11 (0.88, 1.39)	1.04 (0.94, 1.15)	1.24 (1.00, 1.52)	1.33 (0.86, 2.07)	1.04 (0.88, 1.23)
	3	1.76 (1.27, 2.45)	1.57 (1.25, 1.96)	1.14 (1.02, 1.27)	1.37 (1.10, 1.71)	1.07 (0.67, 1.73)	1.12 (0.94, 1.34)
	4	2.13 (1.51, 2.99)	1.92 (1.47, 2.50)	1.15 (1.00, 1.32)	1.55 (1.18, 2.04)	1.78 (1.06, 2.98)	1.38 (1.12, 1.72)
	Test of trend	<0.001	<0.001	0.010	0.001	0.093	0.006
	p-value						
Social spaces	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.14 (0.79, 1.62)	1.00 (0.78, 1.30)	0.98 (0.87, 1.10)	1.01 (0.79, 1.29)	1.17 (0.71, 1.95)	0.94 (0.78, 1.13)
	3	1.39 (0.97, 1.98)	1.32 (1.02, 1.70)	1.03 (0.91, 1.16)	1.05 (0.81, 1.35)	1.46 (0.89, 2.42)	1.07 (0.88, 1.29)
	4	1.82 (1.28, 2.59)	1.40 (1.09, 1.81)	1.08 (0.95, 1.22)	1.26 (0.98, 1.63)	1.30 (0.78, 2.17)	1.13 (0.94, 1.37)
	Test of trend	<0.001	0.001	0.149	0.055	0.236	0.076
	p-value						
Walkability	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.79 (0.56, 1.12)	0.73 (0.56, 0.95)	0.88 (0.77, 1.00)	0.84 (0.65, 1.10)	0.93 (0.56, 1.54)	0.79 (0.65, 0.96)
	3	0.68 (0.48, 0.95)	0.74 (0.58, 0.94)	0.86 (0.77, 0.97)	0.85 (0.67, 1.07)	0.96 (0.60, 1.54)	0.82 (0.68, 0.98)
	4	0.60 (0.43, 0.85)	0.71 (0.55, 0.91)	0.90 (0.80, 1.02)	0.77 (0.60, 0.98)	0.97 (0.60, 1.57)	0.77 (0.63, 0.92)
	Test of trend	0.002	0.013	0.135	0.050	0.938	0.014
	p-value						
Borders	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.89 (0.63, 1.25)	1.00 (0.78, 1.29)	1.03 (0.92, 1.15)	0.97 (0.76, 1.24)	1.27 (0.79, 2.02)	0.92 (0.77, 1.10)
	3	1.34 (0.95, 1.91)	1.17 (0.90, 1.52)	1.04 (0.92, 1.18)	1.03 (0.80, 1.34)	1.06 (0.63, 1.76)	0.85 (0.70, 1.04)
	4	0.87 (0.61, 1.25)	1.01 (0.77, 1.32)	1.08 (0.95, 1.22)	1.05 (0.81, 1.37)	1.09 (0.65, 1.82)	0.98 (0.81, 1.19)
	Test of trend	0.930	0.664	0.224	0.552	0.954	0.785
	p-value						
Arterial features	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.65 (0.48, 0.89)	0.98 (0.79, 1.22)	0.98 (0.88, 1.09)	0.91 (0.73, 1.14)	1.21 (0.79, 1.86)	0.92 (0.78, 1.09)

	Quartiles	Smoking	Weight gained during pregnancy <15 lbs	Weight gained during pregnancy ≥ 40 lbs	Pregnancy-induced hypertension/eclampsia	Term Low Birthweight[b]	Preterm Birth
	3	0.61 (0.44, 0.84)	0.79 (0.62, 1.01)	0.98 (0.87, 1.10)	0.92 (0.72, 1.16)	0.75 (0.46, 1.22)	0.80 (0.67, 0.96)
	4	0.50 (0.35, 0.71)	0.78 (0.60, 1.03)	0.93 (0.82, 1.06)	0.84 (0.65, 1.09)	1.14 (0.69, 1.88)	0.96 (0.79, 1.17)
	Test of trend *p*-value	<0.001	0.022	0.327	0.215	0.797	0.246

[a] Adjusted for maternal age, education, marital status, and number of pregnancies.

[b] Among only term births.

Table 4c

Unadjusted odds ratios (95% confidence intervals) for the association between neighborhood indices and pregnancy-related behaviors and outcomes among Non-Hispanic black women.

	Quartiles	Smoking	Weight gained during pregnancy <15 lbs	Weight gained during pregnancy ≥ 40 lbs	Pregnancy-induced hypertension/eclampsia	Term low birthweight[a]	Preterm Birth
Physical incivilities	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.68 (0.41, 1.13)	0.96 (0.76, 1.21)	1.01 (0.86, 1.18)	1.04 (0.78, 1.39)	0.77 (0.53, 1.13)	1.00 (0.82, 1.22)
	3	2.33 (1.46, 3.71)	1.28 (1.01, 1.62)	1.06 (0.90, 1.25)	1.07 (0.79, 1.44)	1.16 (0.81, 1.67)	0.94 (0.76, 1.15)
	4	2.88 (1.84, 4.51)	1.39 (1.13, 1.71)	1.03 (0.89, 1.19)	0.84 (0.63, 1.11)	1.36 (1.00, 1.86)	1.31 (1.10, 1.56)
Social spaces	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.05 (0.62, 1.78)	1.09 (0.86, 1.37)	0.92 (0.79, 1.06)	0.96 (0.72, 1.28)	1.16 (0.84, 1.59)	0.88 (0.72, 1.07)
	3	0.88 (0.52, 1.50)	1.13 (0.90, 1.42)	0.94 (0.82, 1.09)	1.06 (0.80, 1.41)	1.31 (0.96, 1.79)	0.87 (0.72, 1.06)
	4	1.15 (0.68, 1.97)	1.29 (1.01, 1.66)	1.04 (0.89, 1.23)	1.11 (0.81, 1.52)	0.99 (0.67, 1.45)	0.90 (0.72, 1.12)
Walkability	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.02 (0.63, 1.65)	1.06 (0.86, 1.30)	0.96 (0.82, 1.11)	1.23 (0.91, 1.66)	0.90 (0.66, 1.22)	1.06 (0.86, 1.30)
	3	0.68 (0.41, 1.11)	0.89 (0.73, 1.09)	0.92 (0.79, 1.07)	1.36 (1.01, 1.83)	0.89 (0.65, 1.22)	0.91 (0.74, 1.12)
	4	0.44 (0.27, 0.73)	0.72 (0.58, 0.89)	0.94 (0.81, 1.10)	1.26 (0.94, 1.70)	0.67 (0.48, 0.93)	1.02 (0.83, 1.25)
Borders	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.74 (0.44, 1.24)	0.91 (0.73, 1.12)	0.92 (0.80, 1.05)	1.02 (0.78, 1.33)	0.92 (0.68, 1.24)	0.90 (0.75, 1.09)
	3	0.99 (0.59, 1.66)	1.09 (0.88, 1.36)	1.05 (0.91, 1.21)	0.79 (0.58, 1.08)	1.05 (0.77, 1.43)	0.89 (0.73, 1.08)
	4	0.79 (0.46, 1.34)	1.30 (1.03, 1.63)	1.05 (0.89, 1.22)	1.10 (0.81, 1.49)	0.91 (0.64, 1.30)	0.89 (0.72, 1.11)
Arterial features	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.66 (0.40, 1.10)	0.92 (0.73, 1.17)	0.88 (0.75, 1.02)	0.78 (0.58, 1.03)	1.01 (0.72, 1.42)	0.78 (0.63, 0.96)
	3	0.64 (0.38, 1.06)	0.85 (0.67, 1.09)	1.04 (0.90, 1.20)	0.76 (0.58, 1.02)	0.86 (0.62, 1.21)	0.92 (0.75, 1.12)
	4	0.80 (0.47, 1.36)	0.85 (0.66, 1.10)	1.05 (0.90, 1.23)	0.73 (0.54, 0.99)	0.93 (0.65, 1.33)	0.96 (0.78, 1.18)

[a] Among only term births.

Table 4d

Adjusted[a] odds ratios (95% Confidence Intervals) for the association between neighborhood indices and pregnancy-related behaviors and outcomes among Non-Hispanic black women.

	Quartiles	Smoking	Weight gained during pregnancy <15 lbs	Weight gained during pregnancy ≥ 40 lbs	Pregnancy-induced hypertension/eclampsia	Term Low Birthweight[b]	Preterm Birth
Physical incivilities	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.80 (0.51, 1.25)	0.97 (0.77, 1.22)	1.00 (0.86, 1.16)	1.02 (0.76, 1.36)	0.78 (0.54, 1.14)	1.02 (0.83, 1.24)
	3	1.80 (1.19, 2.71)	1.30 (1.03, 1.64)	1.06 (0.90, 1.24)	1.16 (0.86, 1.58)	1.03 (0.71, 1.50)	0.87 (0.70, 1.08)
	4	1.65 (1.11, 2.44)	1.41 (1.14, 1.74)	1.05 (0.91, 1.22)	0.98 (0.73, 1.31)	1.07 (0.77, 1.49)	1.13 (0.93, 1.36)
	Test of trend *p*-value	0.001	<0.001	0.427	0.987	0.349	0.278
Social spaces	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.96 (0.64, 1.44)	1.07 (0.85, 1.33)	0.93 (0.81, 1.07)	0.96 (0.73, 1.27)	1.15 (0.83, 1.59)	0.85 (0.71, 1.02)
	3	0.96 (0.64, 1.44)	1.13 (0.90, 1.40)	0.95 (0.83, 1.10)	1.05 (0.81, 1.37)	1.35 (0.98, 1.85)	0.89 (0.74, 1.07)
	4	1.30 (0.86, 1.97)	1.26 (0.99, 1.61)	1.07 (0.91, 1.25)	1.12 (0.83, 1.52)	1.04 (0.70, 1.52)	0.89 (0.73, 1.10)
	Test of trend *p*-value	0.233	0.050	0.497	0.361	0.418	0.358
Walkability	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.97 (0.67, 1.41)	1.04 (0.86, 1.27)	0.97 (0.84, 1.13)	1.25 (0.93, 1.68)	0.88 (0.64, 1.20)	1.06 (0.87, 1.29)
	3	0.86 (0.59, 1.27)	0.90 (0.74, 1.10)	0.90 (0.78, 1.05)	1.27 (0.94, 1.70)	1.05 (0.76, 1.44)	1.01 (0.83, 1.23)
	4	0.56 (0.37, 0.83)	0.74 (0.60, 0.91)	0.92 (0.79, 1.07)	1.18 (0.88, 1.58)	0.78 (0.56, 1.09)	1.12 (0.92, 1.36)
	Test of trend *p*-value	0.005	0.003	0.197	0.339	0.295	0.352
Borders	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.93 (0.62, 1.38)	0.91 (0.75, 1.12)	0.92 (0.80, 1.05)	0.97 (0.75, 1.25)	1.00 (0.75, 1.35)	0.94 (0.79, 1.12)
	3	1.06 (0.71, 1.57)	1.09 (0.88, 1.34)	1.06 (0.92, 1.22)	0.81 (0.60, 1.08)	1.08 (0.79, 1.47)	0.90 (0.75, 1.08)
	4	0.97 (0.64, 1.46)	1.28 (1.03, 1.60)	1.06 (0.91, 1.24)	1.09 (0.82, 1.46)	0.97 (0.68, 1.38)	0.91 (0.75, 1.12)
	Test of trend *p*-value	0.963	0.012	0.218	0.982	0.925	0.289
Arterial features	1	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.69 (0.47, 1.02)	0.95 (0.75, 1.19)	0.86 (0.74, 1.00)	0.75 (0.57, 0.98)	1.06 (0.76, 1.48)	0.80 (0.66, 0.97)

Quartiles	Smoking	Weight gained during pregnancy <15 lbs	Weight gained during pregnancy ≥ 40 lbs	Pregnancy-induced hypertension/eclampsia	Term Low Birthweight[b]	Preterm Birth
3	0.62 (0.42, 0.92)	0.89 (0.71, 1.12)	1.01 (0.87, 1.18)	0.74 (0.57, 0.97)	0.89 (0.64, 1.25)	0.95 (0.79, 1.15)
4	0.71 (0.48, 1.07)	0.88 (0.69, 1.12)	1.02 (0.87, 1.19)	0.73 (0.55, 0.97)	0.91 (0.64, 1.30)	0.95 (0.78, 1.16)
Test of trend *p*-value	0.087	0.248	0.230	0.048	0.351	0.713

[a] Adjusted for maternal age, education, marital status, and number of pregnancies.

[b] Among only term births.