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Neighborhood deprivation and maternal smoking and drinking during pregnancy: an analysis of the Georgia PRAMS survey, 2009 – 2011

By

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MPH

Epidemiology

_____

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Committee Chair

# Neighborhood deprivation and maternal smoking and drinking during pregnancy: an analysis of the Georgia PRAMS survey, 2009 – 2011

By

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Bachelor of Science

Northeastern University

2015

Thesis Committee Chair: Michael Kramer, PhD

An abstract of

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## Abstract

Neighborhood deprivation and maternal smoking and drinking during pregnancy: an analysis of the Georgia PRAMS survey, 2009 – 2011

By Emma Kaiser

**Background:** Many studies have indicated that living in a deprived neighborhood may increase the risk of smoking or drinking during pregnancy, when these two behaviors are examined separately. This study investigated the effect of neighborhood deprivation on smoking and drinking during pregnancy as separate outcomes, and also examined the effect of neighborhood on both smoking and drinking during pregnancy.

**Methods:** Georgia Pregnancy Risk Assessment Monitoring System Phase 6 survey data from 2009 – 2011 was linked to birth certificate information from these same years, and this dataset was then linked to a dataset containing neighborhood deprivation information. Logistic regression was performed using SAS complex survey design procedures.

**Results:** The final analysis dataset contained 3,325 observations, and in the study population 264 women smoked during pregnancy, 143 drank during pregnancy, and 34 women smoked and drank during pregnancy. The association between NDI and drinking or smoking during pregnancy was modified by several individual level characteristics. The association between a 1 standard deviation increase in NDI and drinking during pregnancy among women enrolled in Medicaid was 0.97 (95% CI: 0.61, 1.53), and the association among those not enrolled in Medicaid was 0.63 (95% CI: 0.40, 0.98). Among women of non-Hispanic black race, the association between a one standard deviation increase in NDI and smoking during pregnancy was 1.66 (95% CI: 1.08, 2.55), however, among women of non-Hispanic white race, the association between a one standard deviation increase in NDI and smoking during pregnancy was 0.95 (95% CI: 0.69, 1.32). The association between a one standard deviation increase in NDI and smoking and drinking during pregnancy was 1.36 (95% CI: 0.65, 2.87).

**Conclusion:** High neighborhood deprivation is associated with higher odds of smoking during pregnancy among women of non-Hispanic black race, and with lower odds of drinking during pregnancy among women not enrolled in Medicaid. Low neighborhood deprivation is associated with lower odds of smoking and drinking during pregnancy. Interventions aimed at reducing smoking and drinking during pregnancy should consider the level of neighborhood deprivation when targeting women of certain races.

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# Literature Review

*Summary*

Individual attributes explain only a portion of the variation in health in populations. Characteristics of residential neighborhood and other contextual environments may also affect individual health and produce geographic variation in population health. Results of a number of studies show that where a person lives can have a profound effect on health and harmful health behaviors, and the effect persists even after controlling for individual-level factors (30, 37, 49).

Neighborhood deprivation, a measure of the material and social resources of a residential neighborhood, has been shown to be associated with an increased risk of adverse health and birth outcomes, including low birth weight (infant <2500 grams at birth), and preterm birth (infant born <37 weeks gestation) (30, 32). Some studies provide evidence that neighborhood deprivation also increases the risk of smoking tobacco and drinking alcohol during pregnancy, although few examine the effect of neighborhood deprivation on engaging in both behaviors (30). Smoking during pregnancy is a significant public health concern. Findings from studies associate smoking during pregnancy with health problems such as low birth weight, fetal mortality, and sudden infant death syndrome (11, 23, 29)

While engaging in either smoking or drinking during pregnancy can increase the risk of adverse health and birth outcomes, the harmful effect of both behaviors combined is greater than the effect of each individually (23). There are many interventions available that aim to reduce drinking and smoking during pregnancy, and examining the association between neighborhood and smoking and drinking during pregnancy may help determine where interventions are most needed.

## Neighborhood Socioeconomic Deprivation

*Neighborhood Studies and Measuring Neighborhood Deprivation*

Researchers frequently measure neighborhood deprivation using a neighborhood deprivation index (NDI), which is a composite of census-level variables (13). The NDI can be used to measure the overall socioeconomic environment of an area. The degree of neighborhood deprivation can affect health through the association with the distribution of positive (e.g. health care services) and negative (e.g. built environment constraints on physical activity) exposures and opportunities (13).

The NDI used in studies is often created by performing principal components analysis (PCA) on a number of different single-indicator measures that can represent overall deprivation, such as poverty, unemployment, and education. PCA is a data reduction technique that involves analyzing the total variance between single level measures. The correlation between individual variables suggests that a smaller number of principal components may be used to quantify a single latent construct. In this study, PCA is used to quantify the NDI as the weighted average of many different variables, with the weights of the variables determined by loading values. The analysis results in loading values that represent the correlation between the variable and the component (30).

Measuring neighborhood deprivation using an NDI is advantageous, as it allows the exposure to include a number of different variables. However, researchers may use a variety of different individual variables to estimate neighborhood deprivation, and often obtain these variables from U.S. Census data (30). Income, composition of races/ethnicities in the area, education, employment or unemployment, and occupation are very frequently used as measures of neighborhood deprivation (30).

Researchers have used a number of different study design strategies to estimate the association of neighborhood deprivation with health. In the past, researchers used ecologic study designs as a method of estimating the effect of neighborhood deprivation on health. Ecologic studies are useful for determining differences in morbidity and mortality across neighborhoods, but are only able to measure average health inequalities between neighborhoods. As a result, they

cannot be used to determine if the differences in health between areas are due to neighborhood-level effects, or are the result of individual differences between residents in the different neighborhoods (10).

Contextual and multilevel analyses can be used to control for individual differences between residents in the neighborhoods, and in this way determine if the area truly has an effect on the health of residents. Multilevel analyses link census-level data to individual data obtained through surveys, other studies, or vital statistics. These studies are useful to determine neighborhood and individual-level effects on health, as well as how neighborhood and individual variables can interact jointly to affect health (10).

Multilevel studies also allow the variability within neighborhoods and between different neighborhoods to be examined, and allow researchers to take into account variability that is explained by individual level factors. The confounding effect of individual-level variables on health outcomes can be controlled using stratification or multivariable adjustment. It is possible for individual-level variables to be mediators instead of confounders, and their classification as mediators or confounders can change depending on the study question (10).

*Standardized Neighborhood Deprivation Index*

Messer and colleagues have outlined a process for creating a standardized NDI that measures neighborhood deprivation using U.S. Census variables (30). In order to determine which variables would be used in the principal components analysis, the researchers identified broad socioeconomic and demographic domains that were often used to measure deprivation: poverty, housing, occupation, employment, education, residential stability, and racial composition. Within these domains, Messer and colleagues identified 20 U.S. Census variables from the year 2000 that were frequently used to measure deprivation in studies. The researchers used PCA to determine which variables should be included in the final index measure, and considered variables with a loading value of 0.25 to be included in the final index measure. The

researchers also examined the 95% confidence interval for the loading to determine which variables should be considered for inclusion in the final index measure. The final NDI included eight out of the 20 variables included in the PCA: percent of males in management and professional occupations, percent of crowded housing, percent of households in poverty, percent of female headed households with dependents, percent of households on public assistance and households earning less than $30,000 per year, percent earning less than a high school education, and percent unemployed (30). The process outlined by Messer and colleagues provides a method of creating a measure of neighborhood that has been tested in different cities (30, 32, 38).

*Effects of neighborhood deprivation on health*

There is evidence in the literature that an inverse relationship exists between individual-level socioeconomic status and unhealthy behaviors such as tobacco use and inactivity (34). This association may be due to increased stress or social network norms around substance use among people with lower socioeconomic status. However, some harmful health behaviors that are common in groups with low socioeconomic status, such as smoking, are expensive and therefore contradict this explanation of the association between low socioeconomic status and poor health (34). The geographic environment of an area has also been considered as a factor that explains this association, as low-income neighborhoods have been found to have fewer services that promote good health, such as exercise facilities (40).

Over the past few decades, social epidemiologists have increasingly studied neighborhood-level factors as potentially effecting health, and as possible determinants of the health disparities that exist between geographical areas (10). Social epidemiologists often associate living in a neighborhood characterized as having a high level of economic disadvantage with many adverse health behaviors, such as an increased risk of alcohol and substance abuse. In addition, residents living in deprived neighborhoods have a higher risk of partner violence, homicide, cardiovascular disease, breast cancer, and overall excess mortality (30).

Evidence in the literature supports the effect of neighborhood on health above and beyond that explained by individual-level risk factors (45). In order to further examine the relationship between individual-level and neighborhood-level risk factors, Stafford and colleagues conducted a study on the interaction between individual and neighborhood risk factors. The aim of this research was to determine whether contextual effect of neighborhood deprivation on depression, self-rated general health, and waist-to-hip ratio differed by individual attributes, including poverty. The results of their study suggest that the adverse effects of living in a deprived neighborhood were more pronounced for poorer individuals (45). The researchers concluded that living in a deprived area might exacerbate the effect of individual-level deprivation, or that poorer individuals are more dependent on neighborhood-level resources. These findings illustrate the importance of including individual-level variables in neighborhood studies, and indicate that poorer individuals living in deprived neighborhoods may benefit the most from interventions aimed at improving health (45).

*Effects of neighborhood on birth outcomes*

Living in deprived neighborhoods is associated with a higher risk of adverse birth outcomes, such as preterm birth and low birth weight. In the United States, there are disparities in preterm birth between races, and non-Hispanic black women have a risk of preterm birth that is approximately 50% higher than that for non-Hispanic white women (28). Many studies have been conducted on the relationship between preterm birth and neighborhood factors in an attempt to explain why these disparities exist. Existing research provides evidence that neighborhood income and preterm birth are inversely correlated among non-Hispanic black women, but not for non-Hispanic white women (19).

Other studies in the literature provide contradictory evidence on the relationship between neighborhood deprivation and preterm birth between races, however. In a study conducted on the effect of neighborhood deprivation on preterm birth by race, O'Campo and colleagues found a

weaker association of neighborhood deprivation and preterm birth among black women compared to the association in white women. The researchers did conclude that neighborhood deprivation was associated with preterm birth overall, even after controlling for individual-level factors such as maternal age and education (32).

In addition to preterm birth, a number of different studies associate neighborhood deprivation and low infant birth weight. Many single-indicator measures of neighborhood deprivation, such as neighborhood poverty, unemployment, education, income, and median rent have been shown to be significantly associated with mothers having low birth weight infants (30). Neighborhood index measures have also been used to further examine this association, and have provided evidence of the association between deprivation and low birth weight. In these studies, mothers living in an area with high levels of deprivation were shown to be more likely to give birth to infants that were low birth weight (30).

A number of possible explanations for the mechanism by which neighborhood affects birth outcomes have been investigated, and some researchers consider stress a possible mediating variable. A study conducted by Clemens and colleagues examined the effect of neighborhood crime rates on adverse birth outcomes in order to investigate the mechanisms by which neighborhoods might have an effect on health. The researchers aimed to determine the effect of stress on health outcomes. The exposure of interest was neighborhood crime rates, and the researchers assumed stress was the mediating variable between crime rates and birth outcomes. Pregnant women living in neighborhoods with the highest crime rates had a higher risk of adverse birth outcomes. The researchers hypothesized that high neighborhood crime rates may increase individual stress levels, which can increase a woman's risk of having an adverse birth outcome (6).

## Smoking during Pregnancy

### *Prevalence and measurement*

Smoking during pregnancy is associated with a few adverse birth outcomes, such as miscarriage, low birth weight, premature birth, congenital birth defects, and Sudden Infant Death Syndrome (47). As a result, the CDC recommends women who are pregnant or who are trying to become pregnant to quit smoking (44, 47). In addition, pregnant women should also avoid e-cigarettes and secondhand smoke throughout the duration of her pregnancy (47).

Measuring smoking during pregnancy accurately can be very difficult, as smoking is often self-reported. Measures of the overall prevalence of smoking during pregnancy are often subject to social desirability bias, as women may under report their smoking during pregnancy (7). Cotinine, a primary metabolite of nicotine, can be measured in women's blood plasma to avoid the social desirability bias that is often present in studies that require women to self-report their smoking status (4, 18). One study conducted by Caraballo et al. quantified the discrepancies between self-reported smoking status and smoking status as determined by plasma cotinine levels. The researchers found that 1.4% of those who reported themselves as non-smokers had plasma cotinine levels that indicated the respondents were current smokers. These discrepancies were higher in respondents who were over the age 65, had 0-8 years of education, and who were black (4). The American College of Obstetricians and Gynecologists reported that the rate of overall reported smoking during pregnancy among women in the U.S. was 13.2% in 2006 (44).

*Adverse health outcomes for smoking during pregnancy*

There are a number of adverse birth outcomes associated with smoking during pregnancy. One study that investigated the effect of smoking during pregnancy among pregnant women in Romania found a significant association between smoking and low birth weight. The researchers also found that women who smoked more cigarettes during their pregnancy had a higher risk of giving birth to a low birth weight infant than women who smoked fewer cigarettes. Women who continued to smoke throughout their pregnancies were also at an increased risk for having a small for gestational age infant. Women who quit smoking early in their pregnancy had

risks of adverse birth outcomes similar to women who did not smoke, demonstrating the importance of quitting cessation during pregnancy (29).

In addition to low birth weight and small gestational age infants, smoking during pregnancy is significantly associated with preterm birth, stillbirth, and ectopic pregnancies (7). The adverse effects of smoking during pregnancy can also affect the health of children long-term. In the KOALA birth cohort study, researchers Timmermans et al. investigated the effect of maternal smoking during pregnancy on both birth outcomes, as well as on the child's BMI. The researchers found that maternal smoking during pregnancy was associated with an increased risk of children exceeding the 85$^{th}$ percentile of BMI and waist circumference by the time the children were 6 and 7 years old (46).

*Individual risk factors for smoking during pregnancy*

Many studies provide evidence that women with greater individual-level deprivation have a higher likelihood of smoking and continuing to smoke during their pregnancies. While rates of maternal smoking during pregnancy have declined over the past few decades, this decline has not been consistent among all levels of socioeconomic status. Women who continue to smoke during their pregnancies are often without a partner, have low levels of social support, or have high parity. Globally, women living in low- to middle-income countries are more likely to smoke than women living in high-income countries, indicating that individual social or material deprivation is an important risk factor for maternal smoking during pregnancy (25). While the United States has an overall lower prevalence of smoking during pregnancy than lower-income countries, the rates of smoking during pregnancy are different between socioeconomic groups. The increased prevalence of smoking during pregnancy contributes to the health disparities that exist between socioeconomic groups. Some researchers even cite smoking during pregnancy as a main source of health inequality between high and low-income individuals (25).

Some of the individual-level risk factors for smoking during pregnancy include low levels of educational attainment, low income, and substance abuse problems. Ellingson and colleagues conducted a study to further examine the relationship between smoking during pregnancy and a number of other risk factors that are often present in women who smoke during pregnancy. Using a sample of full- and half- sister pairs, the researchers found an association between smoking during pregnancy and having more co-occurring risk factors (11). Ellingson and colleagues discovered that 55% of the variance associated with maternal smoking during pregnancy is attributable to environmental factors, such as low educational attainment and non-cohabitation (11). Their research shows that individual-level measures of deprivation are highly associated with smoking during pregnancy, even when genetic risk factors are controlled for by using matched sibling pairs. Because individual deprivation measures are so highly associated with maternal smoking during pregnancy, neighborhood level deprivation has also been studied to determine its effect on smoking during pregnancy.

*Neighborhood deprivation and smoking during pregnancy*

Evidence in the literature suggests that there is an association between neighborhood-level deprivation characteristics and maternal smoking during pregnancy, even after controlling for individual-level risk factors. In a study conducted on births in Finland between the years 2005 and 2010, Raisanen et al. found an association between municipality-level socioeconomic status and an increase in smoking during pregnancy. The researchers used a measure of deprivation containing information on income, education, and unemployment at the municipality level (37). Women living in municipalities that had the highest levels of deprivation were 70% more likely to smoke during pregnancy when individual socioeconomic status was taken into account (37).

Although there are many studies that provide evidence for the association between neighborhood deprivation and smoking during pregnancy, other researchers have observed that the association between neighborhood deprivation and smoking during pregnancy disappears

after controlling for individual risk factors. In the Missouri Adolescent Female Twin Study (MOAFTS), researchers studied the relationship between neighborhood socioeconomic deprivation and smoking during pregnancy. The researchers found an association between socioeconomic deprivation at the neighborhood level and smoking during pregnancy, but this association disappeared after controlling for individual risk factors, including demographic characteristics and alcohol use. Overall geographic variation of smoking during pregnancy still persisted after controlling for individual factors, however (24). The MOAFTS study used a state-specific measure of socioeconomic deprivation created using principal component common factor analysis. Factors included in the neighborhood deprivation measure were: percentage of the population unemployed, percent of households with at least one person per room, percent of female-headed households with dependent children, percent of households with public assistance, percent of households without a car, percent of population below the federal poverty line, and the percent of non-Hispanic African American (24). Because the neighborhood deprivation measure used in the MOAFTS study was specific to the state of Missouri, the results of this study may not be comparable to those of other neighborhood studies.

Researchers Turrell et al. investigated smoking quitting attempts among all residents, male and female, and found that people living in disadvantaged neighborhoods have a lower probability of quitting smoking than residents in more advantaged neighborhoods (49). While the researchers did not limit the population to pregnant women, these findings have implications for smoking during pregnancy, as women who quit smoking before becoming pregnant likely do not smoke while pregnant.

## Drinking during pregnancy

### *Prevalence and measurement*

Drinking alcohol during pregnancy can cause a number of adverse birth outcomes, and can have long-term health consequences for children whose mothers drank during pregnancy. As

a result, CDC recommends that pregnant women should stop drinking before becoming pregnant, and should abstain from alcohol throughout the entirety of their pregnancy (3). In 2015, CDC reported that 10.2% of pregnant women living in the United States reported drinking alcohol in the past 30 days, and 3.1% of pregnant women reported binge drinking, which is defined as having 4 or more drinks on one occasion (5).

Surveys are often used to measure alcohol use during pregnancy. CDC's BRFSS and Pregnancy Risk Assessment Monitoring System (PRAMS) surveys both include questions on alcohol use during pregnancy, as well as questions on binge drinking during pregnancy. The BRFSS is a telephone-based survey on risk behaviors, and PRAMS contacts women who recently gave birth by mailed questionnaires and by telephone. Alcohol use during pregnancy may be subject to social desirability bias or recall bias, which can result in under-reporting alcohol use. A validation study in Ireland conducted on a survey created based on the US PRAMS survey methodology found that the prevalence of drinking during pregnancy calculated using PRAMS survey questions was similar to the national prevalence, which was determined using population based postal surveys in the Irish general population. This finding indicates that PRAMS is a valid method of collecting information on drinking during pregnancy (20).

*Adverse health outcomes for drinking during pregnancy*

There is a great deal of evidence in the literature that drinking alcohol during pregnancy may increase the risk of adverse pregnancy complications and adverse health outcomes for children. There is a causal relationship between maternal alcohol consumption during pregnancy and Fetal Alcohol Spectrum Disorders, which are a group of different physical and cognitive conditions that affect children throughout their lifetime (12). FASD can result in a number of long-term adverse health effects, such as small head size and low BMI. In addition, children with FASD perform poorly on verbal IQ tests, working memory tasks, and have more behavioral problems than children that do not have FASD. Mothers who use alcohol during the first three

months of pregnancy are more likely to give birth to children with FASD than mothers who did not use alcohol during the first few months of pregnancy (27).

While there is evidence that using alcohol during pregnancy increases the risk of FASD, some of the literature provides conflicting information on the risks associated with drinking during pregnancy. In these studies, researchers discovered that low amounts of alcohol during pregnancy may not increase the risk of adverse birth outcomes. In addition, studies that do find an effect of alcohol on adverse birth outcomes often have inconsistent findings (15, 16). Despite the conflicting evidence of the effect of drinking during pregnancy on birth outcomes, it is still recommended that women abstain from using alcohol throughout pregnancy to reduce the risk of FASD and other adverse health outcomes for the child.

*Individual risk factors for drinking during pregnancy*

There are a number of individual risk factors that are often cited in the literature as risks for alcohol use during pregnancy, such as age, marital status, parity, educational status, and occupation. In one study, researchers in Sweden investigated a number of individual factors to determine their association with drinking during pregnancy. The researchers found that higher age, living in large cities, and using tobacco increase the risk of drinking during pregnancy (43). In addition, women who drank less frequently before their pregnancy and women with high social support had a decreased risk of drinking during pregnancy (43). The researchers' findings indicate that socio-economic factors are important risk factors for using alcohol during pregnancy, and highlight the frequent co-occurrence of smoking and drinking during pregnancy.

An association also exists between many of the same risk factors for overall drinking during pregnancy and binge drinking. Living in a major city, using tobacco, and using alcohol frequently before pregnancy, may increase the risk of using alcohol or binge drinking during pregnancy. In addition to these factors, women who binge drink during pregnancy are more often single than women who moderately consume alcohol during pregnancy (42). In order to further

examine risk factors for drinking during pregnancy, researchers conducted a literature search on predictors of alcohol use during pregnancy. They reviewed studies published in a number of different countries and regions, including the United States. In the studies, the researchers found that anxiety, depression, and previous abuse or violence increased the women's risk of drinking during pregnancy (41).

There are clear individual risk factors for drinking during pregnancy, including social support, anxiety, depression, and living in an area with high levels of violence. Information from the literature also indicates that there may be contextual or environmental risk factors for drinking during pregnancy that may be independent of or in addition to these individual risk factors. In many studies, tobacco use during pregnancy has been found to be a significant risk factor for drinking during pregnancy, emphasizing the importance of considering both behaviors when determining possible interventions to reduce alcohol use during pregnancy.

*Neighborhood deprivation and drinking during pregnancy*

Evidence in the literature shows an association between neighborhood-level factors and drinking during pregnancy, and women that live in neighborhoods that are perceived to have a higher level of disorder are more likely to drink during their pregnancy (17). Hill et al. found that neighborhoods with more disorder, which includes assaults, drug dealings, burglaries, teen pregnancy, and high unemployment, increase a woman's risk of drinking during pregnancy. Anxiety and depression mediate this relationship, as women under more psychological stress due to neighborhood are more likely to drink during their pregnancy (17).

Although there is evidence of neighborhood-level deprivation having an effect on alcohol drinking during pregnancy, there are few studies that examine the relationship between drinking and neighborhood without also taking into account smoking during pregnancy, as smoking and drinking behaviors are often found to occur together.

**Smoking and drinking co-occurrence**

Smoking and alcohol use during pregnancy co-occur frequently, and women who drink alcohol during their pregnancy are 5.5 times as likely to also smoke during their pregnancy (23). Smoking and drinking during pregnancy have a negative synergistic effect on preterm labor, low birth weight, and grown restrictions. This finding means that the risk of these adverse birth outcomes is greater than the sum or product of the risk associated with each behavior independently (23). Mateja and colleagues used PRAMS data to investigate the synergistic effect of smoking and binge drinking in the 3 months prior to pregnancy. The researchers found that those who binge drank before pregnancy were 2.99 times more likely to have a baby with a congenital heart defect than women who didn't binge drink (26). Smoking in the 3 months before pregnancy appeared to be surprisingly protective in the researchers' final model (OR = 0.40) (26). There was an interaction between binge drinking and smoking, and the researchers found that women who reported both smoking and binge drinking before pregnancy had a risk 12.65 times higher of having a baby with congenital heart defects than women who reported smoking but not binge drinking before pregnancy (26). The risk factors for both behaviors are similar, and another study that examined the co-occurrence of smoking and drinking during pregnancy among Canadian women found that unemployment and low income predicted both smoking and drinking during pregnancy (23).

Currently, there are few studies documenting the relationship of neighborhood deprivation on both smoking and drinking behaviors among pregnant women. One study examined pregnant women living in a number of different neighborhoods in Brazil, and aimed to identify the effect of both neighborhood social cohesion and individual socioeconomic status on smoking, drinking, and having a poor diet during pregnancy. The exposure of interest was neighborhood social capital, which included information on social trust, social control, and neighborhood security. The researchers stated that while neighborhood social capital did not have any effect on health-compromising behaviors during pregnancy, individual social deprivation did

have an effect (48). The findings of this study are somewhat contradictory to those of other studies that examine the effect of neighborhood on alcohol use or smoking during pregnancy separately, as these studies often provide evidence that an association exists between neighborhood and these behaviors. The contradictory findings may be a result of different contextual constructs used in this study, as Tofani et al. used social cohesion as the neighborhood exposure of interest instead of neighborhood material deprivation. In addition, the researchers conducted this study in Brazil, and there may be different results in future studies conducted in the United States.

*Neighborhood deprivation on smoking and drinking during pregnancy in Georgia*

This study aims to examine the effect of neighborhood deprivation on smoking and drinking individually, as well as together, during pregnancy among women living in Georgia. While studies in the literature provide evidence of an association between deprivation and smoking during pregnancy, fewer studies have focused on deprivation and drinking. Even fewer studies have focused on the association between neighborhood deprivation and the joint use of tobacco and alcohol during pregnancy, which is a risk profile associated with poor health outcomes. In addition, Georgia is a unique state as it has a large black population with great socioeconomic diversity, as there is a relatively large middle-class black population, as well as rural and urban diversity, with a reasonably large rural black population. As a result, studying the relationship between neighborhood deprivation and adverse health behaviors during pregnancy in this population is particularly important.

*Study objectives*

Given the relationship between neighborhood deprivation and smoking or drinking during pregnancy and the strong evidence that smoking and drinking often co-occur, the effect of neighborhood on both of these behaviors should be investigated. The objective of this study is to

estimate the association between neighborhood deprivation and smoking and drinking during pregnancy. This study will aim to fill this gap in the literature by estimating the association between NDI and a woman's likelihood of smoking, drinking, or both smoking and drinking during pregnancy among women in Georgia.

## Introduction

Although a number of individual attributes, such as socioeconomic status, can affect a person's health, these attributes do not fully explain the variation of health in populations. Neighborhood characteristics can have a profound effect on health, and a number of studies provide evidence that neighborhood effects on health persist even after controlling for individual attributes (30, 37, 49). Results of some studies indicate that neighborhood deprivation can increase the risk of low birth weight and preterm birth, both of which can have detrimental long-term effects on a child's health (32, 28). Low birth weight and preterm birth are closely associated with drinking and smoking during pregnancy, leading many researchers to investigate the direct impact of neighborhood deprivation on these behaviors.

An association exists between drinking and smoking during pregnancy and living in a socioeconomically deprived area (23). In addition, while each of these individual behaviors is a risk factor for adverse birth outcomes, the harmful effect of both behaviors combined is greater than the effect of each individually (23). There are many interventions available that aim to reduce drinking and smoking during pregnancy, but women living in the most deprived neighborhoods may not have access to these interventions. Determining whether or not an association exists between neighborhood deprivation and these harmful health behaviors may help determine where interventions are most needed.

### Neighborhood deprivation

Different individual level variables, including income, composition of race/ethnicities in the area, education, employment or unemployment, and occupation are often used to create a composite measure of neighborhood deprivation (NDI) (30). In order to create a measure of deprivation that can be used to compare results in many different neighborhood studies, Messer and colleagues outlined the process for creating a standardized NDI that is comprised of eight different U.S. Census variables using Principal Components Analysis (30).

There is evidence in the literature of the effect of neighborhood deprivation on birth outcomes such as preterm birth and low birth weight. Single-indicator measures of deprivation, such as neighborhood poverty, unemployment, education, income, and median rent increase the risk of pregnant women having low birth weight infants (30). In addition to individual-indicator measures of deprivation, index measures of neighborhood deprivation are also associated with adverse birth outcomes. Using an NDI as a measure of neighborhood deprivation, Messer and colleagues found that mothers living in an area with high levels of deprivation were more likely to have low birth weight or preterm infants (30). There is a strong association between having a low birth weight or preterm infant and smoking or drinking during pregnancy, which lead researchers to investigate the effect of neighborhood deprivation on these behaviors as well.

**Smoking and drinking during pregnancy**

There is a consistent association between smoking during pregnancy and having a low birth weight infant (23). There is also an association between smoking during pregnancy and preterm birth, stillbirth, and ectopic pregnancies, and is associated with long-term adverse health outcomes, such as an increased risk of having a childhood BMI exceeding the 85$^{th}$ percentile (7, 46). Many individual characteristics of socioeconomic status, such as income, social support, or educational attainment, are risk factors for smoking during pregnancy (25). Researchers Raisanen and colleagues investigated the association between smoking during pregnancy and neighborhood-level factors using an index measure of deprivation in Finland, and found that women living in municipalities with higher levels of deprivation were 70% more likely to smoke during pregnancy than women living in municipalities with lower deprivation (37). Individuals living in deprived neighborhoods are also less likely to quit smoking than those in more advantaged neighborhoods (49). The number of people who quit smoking before becoming pregnant is an important measure to consider when researching smoking during pregnancy.

Drinking alcohol during pregnancy is another harmful health behavior that can have a number of long-term consequences for the child, and there is an association between drinking alcohol during pregnancy and both individual and neighborhood-level deprivation characteristics (41, 17). Maternal alcohol consumption during pregnancy increases the risk of giving birth to a child with Fetal Alcohol Spectrum Disorders (FASD), which are a group of different physical and cognitive conditions that affect the child throughout life (12). In a study conducted on the relationship between alcohol use during pregnancy and FASD, researchers May and colleagues found that mothers who drank during the first three months of pregnancy had a higher risk of giving birth to a child with FASD (27).

A number of factors have been cited as risks for maternal drinking during pregnancy, including lower social support, living in an urban area, and using tobacco during pregnancy (43). In a study investigating the relationship between neighborhood deprivation and drinking during pregnancy, researchers found that women living in a neighborhood with higher levels of disorder, which includes assaults, drug dealings, burglaries, teen pregnancy, and high unemployment, are more likely to drink during their pregnancies (17). Although there is evidence in the literature that neighborhood deprivation increases the risk of drinking during pregnancy, few studies examine the relationship between drinking and neighborhood without also including smoking during pregnancy in their analyses.

Smoking and alcohol use during pregnancy co-occur frequently, and women who drink alcohol during their pregnancy are 5.5 times more likely to also smoke during their pregnancy (23). Smoking is often considered one of the largest risk factors for drinking alcohol during pregnancy. Smoking and drinking have a synergistic effect on adverse pregnancy outcomes such as preterm birth and low birth weight, meaning that the risk of these adverse outcomes is greater than the sum or product of each factor independently (23). Many risk factors for both behaviors are similar, and include individual-indicator measures of socioeconomic status, such as unemployment and low income (23).

There are few studies that examine the relationship of neighborhood on both smoking and drinking during pregnancy. One study examined the effect of neighborhood social cohesion, which included information on social trust, social control, and neighborhood security, and individual deprivation on smoking, drinking, and having a poor diet among pregnant women living in Brazil. The researchers found that neighborhood social cohesion was not associated with harmful health behaviors during pregnancy, but that individual deprivation increased the risk of these behaviors (48). The results of this study are somewhat contradictory to those of other studies, which support the association between neighborhood deprivation and smoking and drinking during pregnancy (48). The contradictory findings of this study may be a result of a different exposure used in this study, as the researchers used neighborhood social cohesion instead of neighborhood material deprivation, or because this study was conducted in Brazil.

Given the relationship between neighborhood and smoking and drinking during pregnancy, as well as the strong evidence that smoking and drinking often co-occur and are risk factors for each other, in this analysis we will estimate the association between NDI and a woman's likelihood of smoking, drinking, or both smoking and drinking during pregnancy. In addition, the study population will consist of women in Georgia, a state that has many different socioeconomic disparities between counties. The goal of this study is to examine the association between neighborhood and harmful health behaviors, as findings may help determine where interventions are most needed.

# Methods

## Study Design

This study is a cross-sectional multi-level study design nesting individual women's births in the context of their residential neighborhoods in the state of Georgia. Geocoded birth certificate information was linked to Pregnancy Risk Assessment Monitoring System (PRAMS) surveys using Census tract IDs. The exposure under consideration is neighborhood deprivation, measured using the standardized Neighborhood Deprivation Index as proposed by Messer and colleagues (30), and as calculated by current authors for neighborhoods in Georgia. The outcomes are smoking and drinking during pregnancy, measured using PRAMS survey variables. Approval was received from the Georgia Department of Public Health Institutional Review Board, as well as from the Emory University Institutional Review Board.

## Study Population

The study population of interest is women between the ages of 15 and 44 whose pregnancies resulted in a live birth in the state of Georgia between the years 2009 and 2011. This study uses Phase 6 PRAMS surveys to measure the outcome variables of smoking and drinking during pregnancy. The PRAMS survey is a systematic sample of all live births in the state, and is administered by state departments of health with support from CDC. PRAMS provides data for state health officials and CDC to study and monitor changes in maternal and child health indicators, including information on smoking and drinking during pregnancy. The PRAMS questionnaire used in Georgia between the years 2009 and 2011 include questions on smoking and drinking during the first three months of pregnancy, smoking and drinking during the last three months of pregnancy, as well as smoking and drinking ever during pregnancy (36).

The birth certificate files of states are used to select women for the PRAMS sample, and these women are contacted by both mail and telephone. Some high-risk strata of births are over-sampled to ensure enough data are collected from these groups. CDC and states participating in

PRAMS revise the questionnaire to include or change which topics are included every few years. The PRAMS Phase 6 questionnaire that will be used in this study was administered between the years 2009 and 2011 (36).

A dataset containing information on births in Georgia between the years 2009 to 2011 was linked to a dataset containing Georgia PRAMS information between these same years. Then, another dataset containing neighborhood deprivation information was linked to this dataset.

**Measures and Variables**

*Smoking and drinking during pregnancy*

The outcomes of interest are maternal smoking and drinking during pregnancy, and were measured using the Phase 6 PRAMS survey. PRAMS yes/no variables containing information on smoking or drinking during the last 3 months of pregnancy were used to measure the outcome variables. For both of the variables, answers that were recorded as "unknown" were set to missing. The PRAMS variables containing information on smoking and drinking during pregnancy were separated into four different categories: women who smoked during pregnancy, women who used alcohol during pregnancy, and women who both smoked and used alcohol during pregnancy.

*Neighborhood deprivation*

The exposure of interest was neighborhood deprivation, which was measured using a Neighborhood Deprivation Index created using the process outlined by Messer and colleagues (30). The final standardized index is comprised of eight different 2000 U.S. Census variables to measure neighborhood-level deprivation: percent of males in management and professional occupations, percent of crowded housing, percent of households in poverty, percent of female headed households with dependents, percent of households on public assistance and households

earning less than $30,000 per year, percent earning less than a high school education, and percent unemployed (30).

NDI values were standardized so that a value of +1 signifies a neighborhood deprivation score that was one standard deviation higher than the mean score for all tracts in the state of Georgia, and a score of -1 is one standard deviation lower than the mean score.

*Causal Diagrams*

The goal of this study is to estimate the effect of neighborhood deprivation on smoking and drinking during pregnancy. The exposure of interest is neighborhood-level deprivation, and the outcomes are smoking and/or drinking during pregnancy. Individual risk factors may be confounders or intermediate variables of the association between the exposure and outcome. Confounding variables will be controlled in the analysis. There are a number of potential confounding and intermediate covariates that are measured in the birth certificate. Three conceptual DAGs are shown, as some covariates may be confounding variables or intermediate variables. Figure 1 shows a DAG that takes time into consideration. This may be the most complete DAG, as the characteristics of those moving into a neighborhood likely have an effect on the overall NDI, which can in turn affect later socioeconomic status of residents. This DAG takes into consideration the selection into certain neighborhoods based on age, income, and education, and shows that neighborhood deprivation can have an effect on income and education later in life. However, the birth certificate only measures these variables at one point in a woman's life, when she delivers her baby. Figure 1 and Figure 2 are depictions of DAGs with covariates at one time point, and these DAGs will be used to determine which factors may need to be controlled in this analysis.

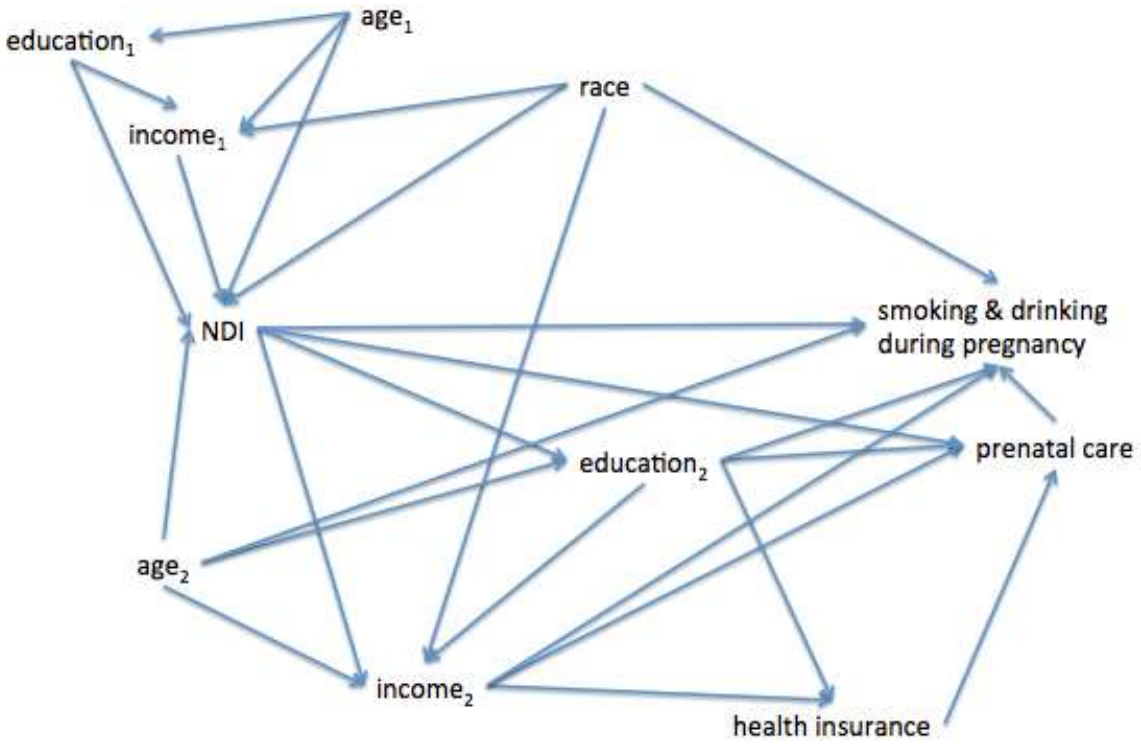


Figure 1. DAG with potential confounders at different time periods. Variables with subscript 1 occurred first and have an effect on the overall deprivation of the neighborhood, while variables with subscript 2 occur at a later time period. In this DAG, $age_1$, age2 and race are confounders and $education_2$ and $income_2$ are intermediates.

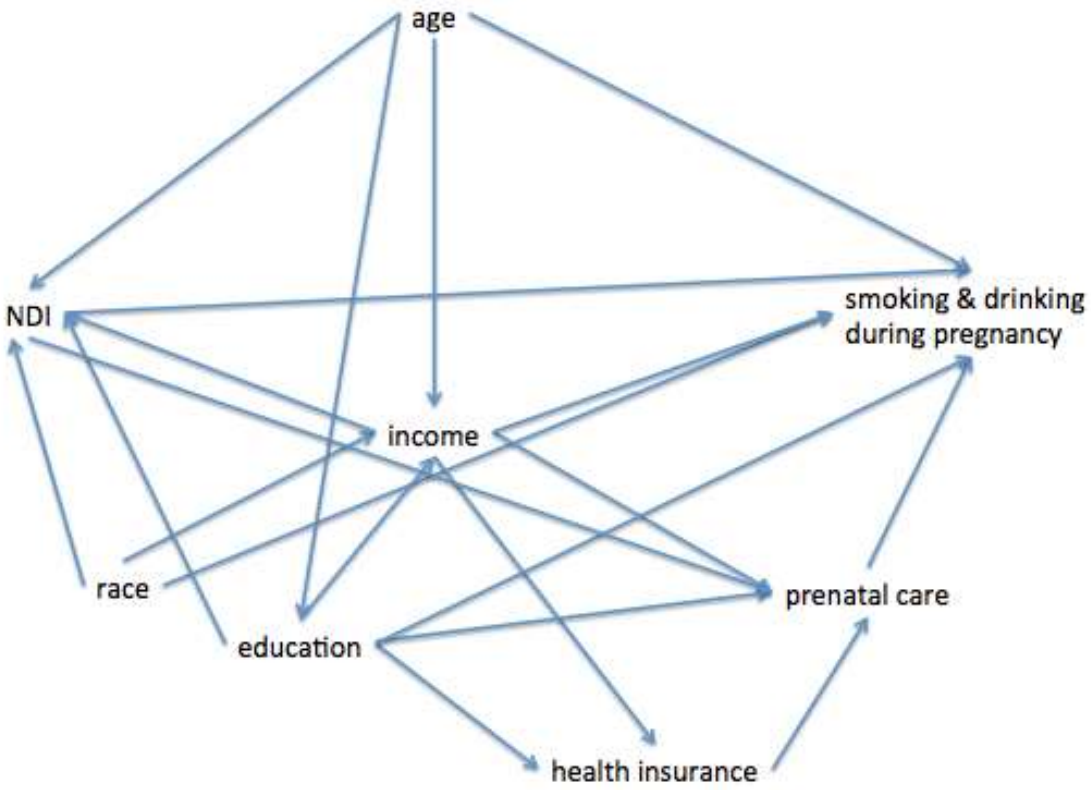


Figure 2. Conceptual Directed Acyclic Graph (DAG) with confounding of the association between neighborhood deprivation and smoking and drinking during pregnancy by race, age, income, and education. Intermediate variables are prenatal care and health insurance.

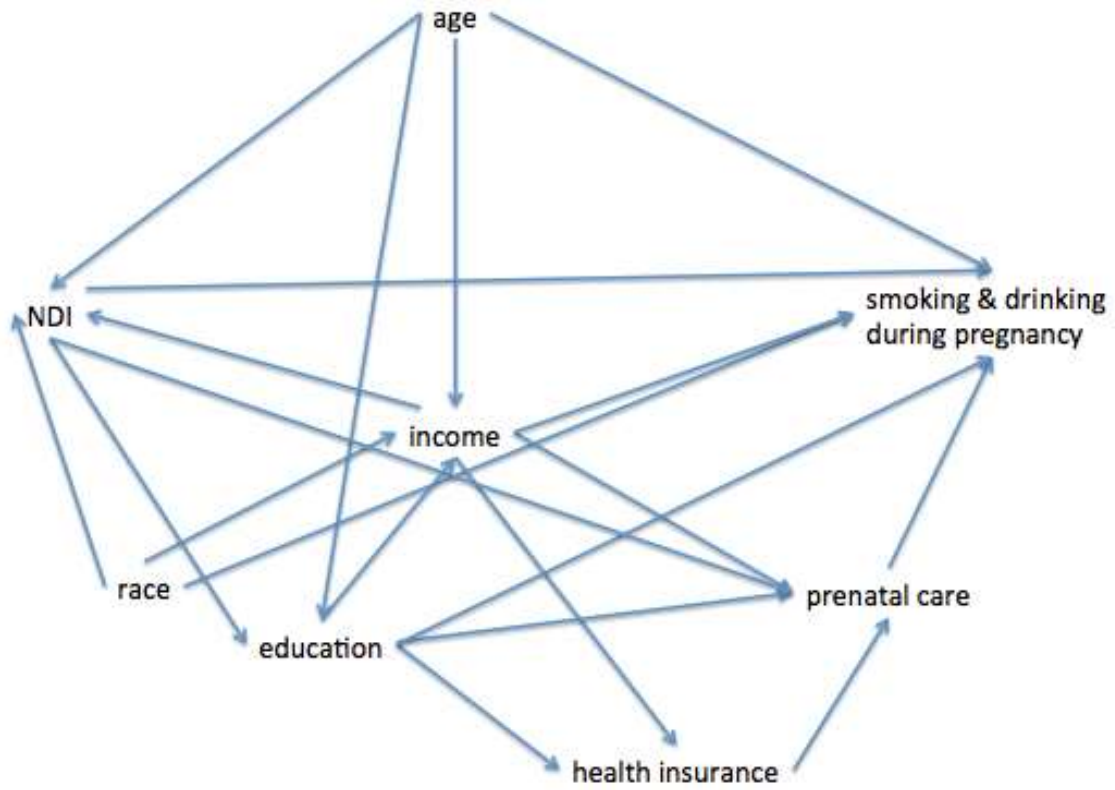


Figure 3. Alternate DAG. In this DAG, income and education are intermediate variables, instead of confounding variables. Insurance and prenatal care remain intermediate variables, and age and race are confounding variables.

*Covariates*

Age, number of prenatal care visits, education, and race/ethnicity were included as potential effect modifiers or confounders based on information in the literature. Medicaid enrollment was used as a proxy measure for income. In Georgia, pregnant women are eligible for Medicaid coverage if they fall below 220% of the federal poverty level (9). All covariates are recorded on the birth certificate, and are self-reported. The Georgia birth certificate has payment categories of: Medicaid managed care, Champis, Medicaid, private insurance, other government assistance, self-pay/uninsured, and unknown. Unknown payment observations were set to missing and payment options were simplified into non-Medicaid or Medicaid, with Medicaid including

women who paid using Medicaid or Medicaid managed care. Payment information was missing for 8.4% (n = 280) of the sample.

Maternal age is recorded on the birth certificate as a continuous variable. Maternal age was separated into six categories for Tables 1 and 2: 18 – 19, 20 – 24, 25 – 29, 30 – 34, 35 – 39, and 40+. Maternal age was used as a continuous variable in the logistic regression models. Age information was missing for 6.4% (n = 214) of the sample.

Prenatal care adequacy is measured on the birth certificate using the Kotelchuck Index, which is calculated based on the gestational age when prenatal care began and on the gestational age at delivery. The Kotelchuck Index is based on the assumption that the earlier prenatal care begins the better, and the index has four different levels: inadequate (received less than 50% of expected prenatal visits), intermediate (50% - 79%), adequate (80% - 109%), and adequate plus (110% or more) (22). Unknown prenatal care information was set to missing. Prenatal care information was missing for 28.1% (n = 935) of the sample.

Maternal education is self-reported as the mother's highest grade completed at the time of birth. Unknown education information was set to missing, and education was divided into four categories: less than 9$^{th}$ grade, 9$^{th}$ through 11$^{th}$ grade, High School/GED, and some college or higher. Education information was missing for 3.4% (n = 113) of the sample.

Maternal race is recorded on the birth certificate as six categories: American Indian or Alaska native, Asian, black or African-American, multiracial, native Hawaiian or other, and white. Maternal ethnicity is recorded as Hispanic or non-Hispanic. For the purposes of this study, race and ethnicity were combined into a single variable with four categories: Hispanic, Non-Hispanic white, Non-Hispanic black, and Non-Hispanic other. Any unknown race or ethnicity information was set to missing. Maternal race/ethnicity was missing for 7.7% (n = 256) of the sample.

*Potential Interactions*

Three interaction terms between covariates and neighborhood deprivation were hypothesized based on information in the literature. Interactions between the NDI and age, race, and income were considered. In the literature, living in a deprived neighborhood has been shown to have a larger detrimental effect on poor individuals than on wealthier individuals (44). Other studies in the literature have suggested that there may be an interaction between deprivation and race, and deprivation and age on various birth outcomes (10).

In addition to interactions between covariates and neighborhood deprivation, two interaction terms between covariates were determined based on the DAGs and the research question. An interaction term between income and education was considered, as women with a low educational attainment and low individual income may be more likely to drink and smoke during pregnancy than women with higher income and education. The interaction between prenatal care and income was also evaluated to determine its significance. Information in the literature has shown that individuals with lower income may be more likely to use alcohol and smoke during pregnancy, and this effect may be more pronounced for those who do not have adequate prenatal care during pregnancy (41).

**Statistical Analysis**

Logistic regression was used to perform the analysis using complex survey design SAS procedures. Three potential outcomes were considered: drinking during pregnancy (women who only drank during pregnancy = 1), smoking during pregnancy (women who only smoked during pregnancy = 1), and both drinking and smoking during pregnancy (women who both smoked and drank during pregnancy = 1). For each of the potential outcomes, the best fitting model was determined by first evaluating collinearity of the terms, then assessing the interaction terms for significance, followed by a confounding and precision assessment.

Collinearity occurs when variables in the model are highly correlated with one another. Collinearity was assessed by fitting a model with all covariates and interaction terms and

calculating condition indices (CIs) and variance decomposition proportions (VDPs). Variables that had CIs greater than 30 with VDPs greater than 0.5 were assessed for collinearity. Interaction terms with collinearity were dropped from the model before covariates. After dropping one variable with collinearity, the model was re-run and remaining variables were re-assessed for collinearity.

After the collinearity assessment, interaction terms were assessed for their significance to the model. In order to determine which interaction terms should be included in each of the models, backwards elimination was conducted using maximum likelihood estimation. Interaction terms that had an insignificant likelihood ratio test were dropped from the model.

After interaction assessment, any covariates that were not involved in the remaining interaction terms were assessed for confounding. The odds ratios of all possible subsets of covariates were compared to the fully adjusted odds ratio. Covariates were removed if the model odds ratio had a change of less than 10% from that of the fully adjusted model. Removing these covariates increases the model parsimony. In addition, confidence interval widths and ratios were compared to determine which subsets of covariates resulted in the most precise odds ratio estimates.

After confounding assessment, the model fit was assessed by comparing the final model to the intercept-only model. The Likelihood Ratio test was used to test the global null hypothesis and to determine whether the final model fits the data well.

## Results

*Descriptive Statistics*

The dataset containing information on births in Georgia between the years 2009 to 2011 had 407,237 observations, and the dataset containing Georgia PRAMS information had 3,584 observations. After linking the two dataset and only retaining those observations that linked, the dataset was reduced to 3,584 observations. The dataset containing neighborhood deprivation information was then linked to this dataset. This reduced the final study population to 3,325 women, because neighborhood geocode information was missing for some of the women. In the unweighted study sample, 264 women smoked during pregnancy, 143 drank during pregnancy, and 34 women smoked and drank during pregnancy [Table 1].

Among women living in the least deprived neighborhoods, 5.7% smoked during pregnancy, 8.0% drank during pregnancy, and 0.6% smoked and drank during pregnancy. The average age among women living in the least deprived neighborhoods was 29.2, and the largest age category was 30 – 34 (29.6%). Most women in the least deprived neighborhoods were non-Hispanic white (71.7%), had some college education or higher (72.0%), and did not use Medicaid to pay for their births (68.6%). Almost half of the women had adequate prenatal care (48.8%) [Table 1].

In the second quartile of neighborhood deprivation (low to middle deprivation 7.9% of women smoked during their pregnancy, 4.4% drank during their pregnancy, and 1.1% smoked and drank during their pregnancy. The average age was 26.3 years old, and the largest age category was 25 – 29 (31.1%). More than half of the women in this NDI quartile were non-Hispanic white (57.7%), and almost half of the women had some college education or higher (45.5%). A little over half used Medicaid to pay for their birth (51.5%), and 39.3% had an adequate number of prenatal care visits [Table 1].

Among women living in neighborhoods with middle to high deprivation, 8.7% smoked during pregnancy, 3.7% drank during pregnancy, and 0.3% smoked and drank during pregnancy.

The average age in this NDI quartile was 25.4, and the largest age group was 25 – 29 (33.3%). Almost half of the women in this NDI quartile were non-Hispanic white (47.4%) and nearly half had a high school education (45.0%). Over half of the women were enrolled in Medicaid (59.4%) and 40.1% of women had adequate prenatal care [Table 1].

In the fourth quartile of neighborhood deprivation (most deprived), 8.6% of women smoked during their pregnancy, 3.2% of women drank during their pregnancy, and 1.3% of women smoked and drank during their pregnancy. The average maternal age was 25.4 years old, and the largest age category was 20 - 24 (35.4%). A majority of women in this NDI quartile were non-Hispanic black (68.7%), and 39.49% of women had a high school education. The majority of women were enrolled in Medicaid (69.5%) and 37.5% of women in this NDI quartile had inadequate prenatal care [Table 1].

The average NDI value among women who smoked during pregnancy was 0.26 (SE = 0.10), the average NDI among women who drank during repugnancy was -0.46 (SE = 0.12), and the average NDI among women who both smoked and drank during pregnancy was 0.42 (SE = 0.39). Of the women who smoked during pregnancy, 26.8% lived in a neighborhood with the lowest levels of deprivation and 23.0% lived in a neighborhood with the highest levels of deprivation. About half (52.8%) of women who drank during pregnancy lived in a neighborhood with the lowest levels of deprivation, and 11.9% lived in a neighborhood with the highest levels of deprivation. A majority of women who smoked and drank during their pregnancy lived in neighborhoods with low levels of deprivation, with 26.1% living in a neighborhood with an NDI in the first quartile, and 37.1% living in a neighborhood with an NDI in the second quartile. About a third of women who smoked and drank during pregnancy lived in a neighborhood in the highest quartile of deprivation (30.2%) [Table 2].

Most women in the study population were between the ages of 20 - 24 (n = 825) and 25 – 29 (n = 800). Almost half of the women who smoked during pregnancy were 20 – 24 (45.7%) with an average age of 24.7 years old, and the largest proportion of women who drank during

pregnancy was 25 – 29 (29.6%) with an average age of 31.4 years old. The largest proportion of women who smoked and drank during pregnancy were 25 – 29 (37.6%) and had an average age of 26.6 years old [Table 2].

A majority of women were non-Hispanic white, and this was consistent through all outcome categories. Non-Hispanic white women comprised 74.4% of the women who smoked during pregnancy and 71.7% of women who drank during pregnancy. In the outcome category that only included women who smoked and drank during their pregnancy, 54.1% of the women were non-Hispanic white and 43.8% were non-Hispanic black [Table 2].

The largest proportion of women who smoked during pregnancy had a $9^{th}$ – $11^{th}$ grade education (40.9%), and most women who drank during pregnancy had some college education or higher (73.6%). Most women who both smoked and drank during pregnancy had a high school education (58.5%) [Table 2].

Most women who smoked during pregnancy were enrolled in Medicaid at the time they gave birth (75.6%), and most women who drank during pregnancy were not enrolled in Medicaid (73.7%). Among women who both smoked and drank during pregnancy 51.4% were not enrolled in Medicaid [Table 2].

Most of the women in all outcome categories had adequate prenatal care. Among the women who smoked during pregnancy, 38.2% of women had adequate prenatal care, and 36.7% of women who drank during their pregnancy had adequate prenatal care. Over half (57.9%) of women who smoked and drank during pregnancy had adequate prenatal care [Table 2].

*Model Results*

The crude model for the relationship between NDI and drinking during pregnancy showed neighborhood deprivation as having a protective effect (OR = 0.53, 95% CI: 0.37, 0.75) [Table 3]. Backwards elimination of the interaction terms in the model describing the effect of NDI on drinking during pregnancy resulted in only the interaction between NDI and payment

being retained in the model. After the interaction assessment, confounding assessment was conducted and age and payment were retained in the final model. Among women enrolled in Medicaid, a one standard deviation increase in neighborhood deprivation was associated with an odds of drinking during pregnancy of 0.97 (95% CI: 0.61, 1.53) [Table 4]. Among women not enrolled in Medicaid, a one standard deviation increase in neighborhood deprivation had an association of 0.62 (95% CI: 0.40, 0.98) [Table 4].

The crude model of the association between NDI and smoking during pregnancy resulted in an odds ratio of 1.26 (95% CI: 1.05, 1.52). The final model for the relationship between NDI and smoking during pregnancy controlled for age, payment, race/ethnicity, and education. The variable for Kotelchuck Index was dropped from the final model, in order to satisfy the convergence criterion of the model. There was also significant interaction between NDI and age, and NDI and race [Table 3]. The effect of neighborhood deprivation on smoking differed by race and ethnicity [Figure 4]. Among non-Hispanic women of other race, the association between a one standard deviation increase in NDI and smoking during pregnancy was 0.56 (95% CI: 0.29, 1.10), and among Hispanic women, a one standard deviation increase in NDI had an association of 0.60 (95% CI: 0.19, 1.87) [Table 4]. Among non-Hispanic white women, the association between a one standard deviation increase in NDI and smoking during pregnancy was 0.95 (95% CI: 0.69, 1.32) [Table 4]. In contrast to women of other races and ethnicities, non-Hispanic black women had higher odds of smoking during pregnancy in more deprived neighborhoods (OR = 1.66; 95% CI: 1.08, 2.55) [Table 4]. There was also significant interaction between NDI and age in this model. ORs were obtained for women with ages in the $10^{th}$ and $90^{th}$ percentiles of the study population ($10^{th}$ percentile = 18; $90^{th}$ percentile = 35). The OR's were obtained contrasting women living in a more deprived neighborhood (NDI = 1) as compared to women living in a neighborhood with average deprivation (NDI = 0). Women who lived in more deprived neighborhoods were overall less likely to smoke during pregnancy, and this decrease in the odds of smoking during pregnancy was most pronounced among younger women [Figure 5]. The

association between a one standard deviation increase in NDI and smoking during pregnancy among women who were 18 years old was 0.30 (95% CI: 0.06, 1.44), and among women who were 35 a one standard deviation increase in NDI had an odds ratio of 0.63 (95% CI: 0.29, 1.38) [Table 4].

The crude OR between NDI and smoking and drinking during pregnancy was insignificant (OR = 1.40, 95% CI: 0.82, 2.40) [Table 3]. The final model for the outcome of drinking and smoking during pregnancy controlled for age, race/ethnicity, and payment. The outcome of smoking and drinking during pregnancy was relatively rare [Figure 6]. As a result, the variables education and Kotelchuck were dropped to satisfy the convergence criterion. The association between a one standard deviation increase in NDI and both smoking and drinking during pregnancy was 1.36 (95% CI: 0.65, 2.87) [Table 4].

*Model Fit*

The fit of the final models for each of the outcomes was assessed using Likelihood Ratio test statistics, which tested the null hypothesis that the beta values of each of the covariates is equal to zero. The model of the association between neighborhood deprivation and drinking during pregnancy resulted in a significant Likelihood Ratio test, indication that the final model had good fit when controlling for age and payment, and when including the interaction term NDI*Payment (LR = 2975.37; $p < 0.0001$). Separate models for the association between neighborhood deprivation and smoking during pregnancy were used to assess the effect of each of the interaction terms separately. The model for the outcome smoking during pregnancy had good fit when controlling for age, race/ethnicity, education, and payment, and when including the interaction term NDI*Age (LR = 2429.71; $p < 0.0001$). In addition, the model for the outcome smoking during pregnancy that controlled for these same variables but included the interaction term NDI*Race also had good fit (LR = 2064.73; $p < 0.0001$). The model for the association

between neighborhood deprivation and smoking and drinking during pregnancy had also had good fit when controlling for age, race/ethnicity, and payment ($LR = 63.29$; $p < 0.0001$).

## Discussion

Living in a neighborhood with higher levels of deprivation was associated with a lower odds of drinking during pregnancy. In addition, higher levels of deprivation were associated with lower odds of smoking during pregnancy for Hispanic women and women of non-Hispanic other race, and higher levels of deprivation did not have an effect on smoking during pregnancy among non-Hispanic white women. Higher levels of neighborhood deprivation were associated with a higher odds of smoking during pregnancy among non-Hispanic black women, and higher deprivation also was associated with an increased odds of both smoking and drinking during pregnancy.

These results are consistent with evidence from the literature, as middle-class women are more likely to drink during pregnancy than low-income women. Although the odds of smoking was found to be higher in less deprived neighborhoods for many of the race categories examined, non-Hispanic black women were found to have a higher odds of smoking during pregnancy in more deprived neighborhoods. This finding was statistically significant, and is consistent with evidence from the literature that indicates that higher deprivation is associated with an increase in smoking during pregnancy. The difference in the effect of neighborhood deprivation on smoking during pregnancy among non-Hispanic black women compared to women of other races and ethnicities is notable, however. It is possible that non-Hispanic black women may have higher stress levels in more in deprived neighborhoods, and as a result may be more likely to use smoking as a coping mechanism. This finding may also indicate that non-Hispanic black women are not being reached by smoking cessation programs in more deprived neighborhoods. It is possible that non-Hispanic black women living in more deprived neighborhoods may not receive adequate education on the risks associated with smoking during pregnancy during prenatal care visits. The overall association between neighborhood deprivation and smoking and drinking during pregnancy also indicated that women living in more deprived neighborhoods were more likely to drink and smoke during pregnancy. These results were not surprising, as women living

in more deprived neighborhoods often have a more substance abusing profile than women living n less deprived neighborhoods. In addition, these women are at especially high risk for poor birth outcomes.

*Strengths and Limitations*

One of the main strengths of this study is due to the PRAMS weighting process, which adjusts for missing data in order to make the survey more generalizable to the entire state population. Women with certain demographic characteristics, such as being unmarried or with lower educational attainment, are more likely to not respond to the survey. Some missing data may be clustered within certain hospitals, counties, or times of the year, and the PRAMS weighting process also adjusts for this uneven distribution of missing data. This weighting process reduces the sampling bias that would be present otherwise. In addition to generalizability, another strength of this analysis is its ability to be re-created in different states. The PRAMS survey is implemented in almost every state in the U.S., as well as in a number of territories. The exposure variable of neighborhood deprivation was created using methods outlined by Messer at al., which can also be replicated in different states and geographic areas using U.S. Census data.

Despite the strengths, this analysis has a number of limitations as well. Overall small sample sizes resulted in low statistical power and very wide confidence intervals for the odds ratios. This low statistical power was most pronounced in the outcome group of both smoking and drinking during pregnancy, which only had a sample size of 34 women. In addition, covariates were dropped from the models for smoking during pregnancy and smoking and drinking during pregnancy due to the small sample size. This analysis also uses Medicaid enrollment as a proxy measure for income, which is a limitation as it is likely that not all low-income women were enrolled in Medicaid. Medicaid enrollment also has a strict income cutoff point, as only women who make less than 220% of the federal poverty line may enroll in Medicaid. This means that in this analysis women who made a small amount of money over this cutoff were categorized as not

having a low income, even though their income is still relatively low. Another weakness of this study is due to the cross-sectional study design, which only considers the exposure and outcome variables at one point in time. Certain characteristics may make some women more likely to move into more deprived neighborhoods, and this neighborhood deprivation can then affect individual-level factors and the outcome behaviors later in life.

*Public Health Impact and Future Research*

This analysis indicates that the characteristics of women most at risk for smoking and drinking during pregnancy may differ between neighborhood deprivation groups. When creating interventions to reduce smoking and drinking during pregnancy, it is important to consider the level of neighborhood deprivation when focusing smoking cessation efforts to women of certain races and ethnicities. In more deprived neighborhoods, non-Hispanic black women may benefit the most from programs aimed at helping women stop smoking during pregnancy.

It would be useful for future studies to measure the effect of neighborhood deprivation on smoking and drinking during pregnancy using individual-level factors at different periods of time, to control for the selection into certain neighborhoods. In addition, future studies may focus on studying the effect of neighborhood deprivation on women of different races, as these findings indicate that neighborhood deprivation does not affect women of all races and ethnicities equally. Future studies may also use a larger sample size in order to increase statistical power, which will result in narrower confidence intervals and possibly more statistically significant associations. Larger sample sizes can be obtained by using PRAMS data from multiple years, after ensuring the sampling methodology has not changed significantly between the different Phases of the PRAMS survey.

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## Tables

Table 1. Demographic characteristics of study sample and prevalence of outcome behaviors by Neighborhood Deprivation Index Quantiles

| | | **Lowest NDI (Q1) – Least Deprived** | | **Low-Mid NDI (Q2)** | | **Mid-High NDI (Q3)** | | **Highest NDI (Q4) – Most Deprived** | |
|---|---|---|---|---|---|---|---|---|---|
| *Individual Characteristics* | *N* | *%, Mean* | *SE* | *%, Mean* | *SE* | *%, Mean* | *SE* | *%, Mean* | *SE* |
| Outcome | | | | | | | | | |
| Smoked | 264 | 5.66 | 1.11 | 7.92 | 1.47 | 8.67 | 1.97 | 8.62 | 1.85 |
| Drank | 143 | 7.97 | 1.24 | 4.35 | 1.10 | 3.71 | 1.27 | 3.19 | 1.15 |
| Smoked and drank | 34 | 0.63 | 0.35 | 1.12 | 0.56 | 0.32 | 0.13 | 1.28 | 0.69 |
| Maternal age continuous | 3325 | 29.19 | 0.29 | 26.34 | 0.31 | 25.41 | 0.37 | 25.40 | 0.35 |
| Maternal age groups | | | | | | | | | |
| 18 - 19 | 495 | 4.69 | 0.91 | 9.61 | 1.43 | 12.01 | 2.11 | 12.10 | 1.91 |
| 20 - 24 | 825 | 18.79 | 2.00 | 27.49 | 2.52 | 31.87 | 3.30 | 35.42 | 3.19 |
| 25 - 29 | 800 | 26.03 | 2.08 | 31.06 | 2.54 | 33.27 | 3.31 | 28.51 | 3.01 |
| 30 - 34 | 625 | 29.55 | 2.12 | 22.05 | 2.30 | 14.65 | 2.38 | 16.45 | 2.39 |
| 35 - 39 | 299 | 16.86 | 1.73 | 9.08 | 1.53 | 7.61 | 1.88 | 7.05 | 1.66 |
| 40 + | 67 | 4.08 | 0.92 | 0.72 | 0.37 | 0.60 | 0.41 | 0.47 | 0.35 |
| Maternal race/ethnicity | | | | | | | | | |
| Non-Hispanic black | 1386 | 19.80 | 1.97 | 32.25 | 2.63 | 41.46 | 3.53 | 68.72 | 3.26 |
| Non-Hispanic white | 1450 | 71.70 | 2.21 | 57.69 | 2.79 | 47.40 | 3.60 | 21.66 | 2.91 |
| Hispanic | 114 | 2.91 | 0.88 | 6.02 | 1.41 | 7.75 | 2.01 | 6.35 | 1.78 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Non-Hispanic other | 119 | 5.58 | 1.04 | 4.05 | 1.08 | 3.38 | 1.23 | 3.26 | 1.20 |
| Maternal Education | | | | | | | | | |
| < 9th grade | 110 | 2.21 | 0.68 | 4.43 | 1.21 | 5.40 | 1.66 | 3.49 | 1.21 |
| 9th – 11th grade | 586 | 5.95 | 1.13 | 14.24 | 1.92 | 16.57 | 2.50 | 30.07 | 3.01 |
| High school | 1067 | 19.82 | 1.98 | 35.85 | 2.63 | 45.00 | 3.47 | 39.49 | 3.19 |
| Some college or higher | 1449 | 72.02 | 2.19 | 45.48 | 2.71 | 33.03 | 3.26 | 26.95 | 2.82 |
| Method of payment for birth | | | | | | | | | |
| Medicaid | 1745 | 31.45 | 2.38 | 51.47 | 2.80 | 59.35 | 3.53 | 69.47 | 3.10 |
| Non-Medicaid | 1300 | 68.55 | 2.38 | 48.53 | 2.80 | 40.65 | 3.53 | 30.53 | 3.10 |
| Prenatal Care Adequacy | | | | | | | | | |
| Inadequate | 604 | 21.33 | 2.34 | 32.17 | 2.95 | 29.25 | 3.64 | 37.48 | 3.88 |
| Intermediate | 202 | 7.06 | 1.39 | 6.95 | 1.53 | 8.01 | 2.05 | 3.62 | 1.30 |
| Adequate | 885 | 48.80 | 2.83 | 39.23 | 3.02 | 40.10 | 3.97 | 33.63 | 3.75 |
| Adequate Plus | 699 | 22.81 | 2.25 | 21.65 | 2.44 | 22.64 | 3.21 | 25.27 | 3.18 |

*all numbers are weighted to population

Table 2. Demographic characteristics of study sample and distribution by smoking and drinking during pregnancy

| | | Smoked during pregnancy | | Drank during pregnancy | | Smoked and drank during pregnancy | |
|---|---|---|---|---|---|---|---|
| *Individual Characteristics* | *N* | *%, Mean* | *SE* | *%, Mean* | *SE* | *%, Mean* | *SE* |
| NDI Continuous | | 0.26 | 0.10 | -0.46 | 0.12 | 0.42 | 0.39 |
| NDI Quantiles | | | | | | | |
| Q1 – least deprived | 832 | 26.81 | 4.67 | 52.82 | 6.05 | 26.07 | 12.58 |
| Q2 | 831 | 29.84 | 4.86 | 22.95 | 5.18 | 37.11 | 14.31 |
| Q3 | 793 | 20.40 | 4.33 | 12.29 | 4.00 | 6.61 | 3.09 |
| Q4 – most deprived | 869 | 22.95 | 4.51 | 11.94 | 4.07 | 30.21 | 13.54 |
| Maternal age continuous | | 24.73 | 0.51 | 31.38 | 0.69 | 26.61 | 1.29 |
| Maternal age groups | | | | | | | |
| 18 - 19 | 495 | 10.36 | 2.78 | 1.98 | 1.60 | 2.19 | 1.61 |
| 20 - 24 | 825 | 47.64 | 5.41 | 9.01 | 3.32 | 29.74 | 12.99 |
| 25 - 29 | 800 | 19.83 | 4.29 | 29.57 | 5.60 | 37.59 | 14.15 |
| 30 - 34 | 625 | 18.78 | 4.10 | 25.17 | 5.19 | 27.98 | 13.54 |
| 35 - 39 | 299 | 3.15 | 1.63 | 29.75 | 5.57 | 2.46 | 1.80 |
| 40 + | 67 | 0.24 | 0.17 | 4.53 | 2.42 | 0.05 | 0.05 |
| Maternal race/ethnicity | | | | | | | |
| Non-Hispanic black | 1386 | 22.25 | 4.48 | 13.00 | 4.16 | 43.78 | 14.91 |
| Non-Hispanic white | 1450 | 74.36 | 4.71 | 74.66 | 5.53 | 54.10 | 14.90 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Hispanic | 144 | 3.12 | 1.95 | 6.68 | 3.64 | 0.89 | 0.91 |
| Non-Hispanic other | 119 | 0.27 | 0.18 | 5.66 | 2.71 | 1.23 | 1.27 |
| Maternal Education | | | | | | | |
| < 9th grade | 110 | 1.20 | 1.15 | 2.16 | 2.02 | 0.06 | 0.06 |
| 9th – 11th grade | 586 | 40.88 | 5.32 | 4.14 | 2.31 | 21.54 | 12.64 |
| High school | 1067 | 31.21 | 4.90 | 20.13 | 5.16 | 58.47 | 14.83 |
| Some college or higher | 1449 | 26.71 | 4.69 | 73.57 | 5.60 | 19.94 | 10.88 |
| Method of payment for birth | | | | | | | |
| Medicaid | 1745 | 75.62 | 4.53 | 26.33 | 5.89 | 48.63 | 16.78 |
| Non-Medicaid | 1300 | 24.38 | 4.53 | 73.67 | 5.89 | 51.37 | 16.78 |
| Prenatal Care Adequacy | | | | | | | |
| Inadequate | 604 | 30.99 | 5.72 | 34.14 | 6.71 | 21.63 | 14.39 |
| Intermediate | 202 | 6.19 | 2.93 | 4.53 | 2.67 | 16.82 | 14.21 |
| Adequate | 885 | 38.19 | 6.03 | 36.70 | 6.48 | 57.91 | 17.79 |
| Adequate Plus | 699 | 24.62 | 5.17 | 24.63 | 5.69 | 3.64 | 2.67 |

*all numbers are weighted to population

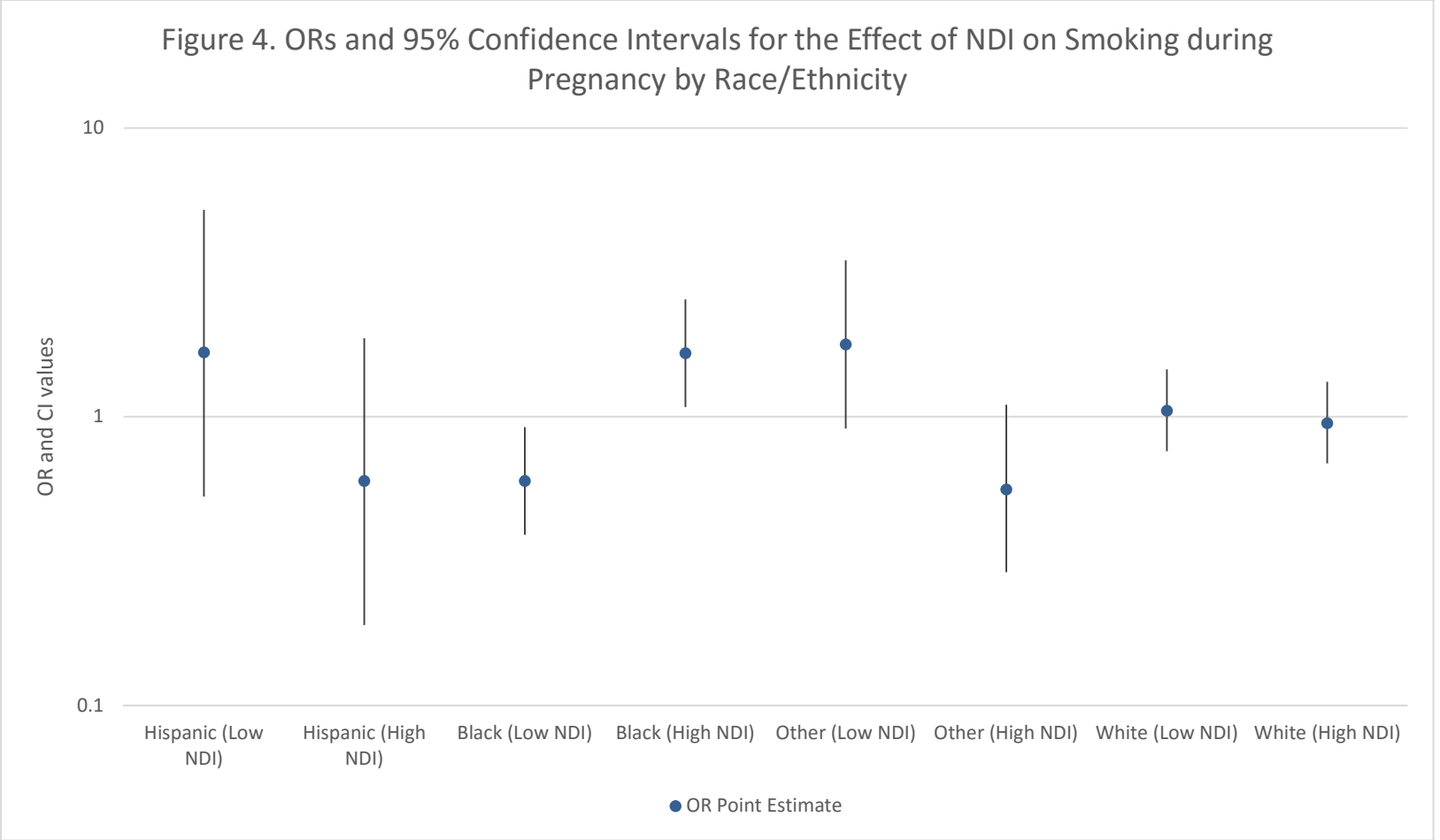
Table 3. The Association between a 1 Standard Deviation Increase in NDI and Outcomes in Crude Models

| *Outcome* | *Odds Ratio (95% CI)* |
|---|---|
| Drinking during pregnancy | 0.53 (0.37, 0.75) |
| Smoking during pregnancy | 1.26 (1.05, 1.52) |
| Drinking and smoking during pregnancy | 1.40 (0.82, 2.40) |

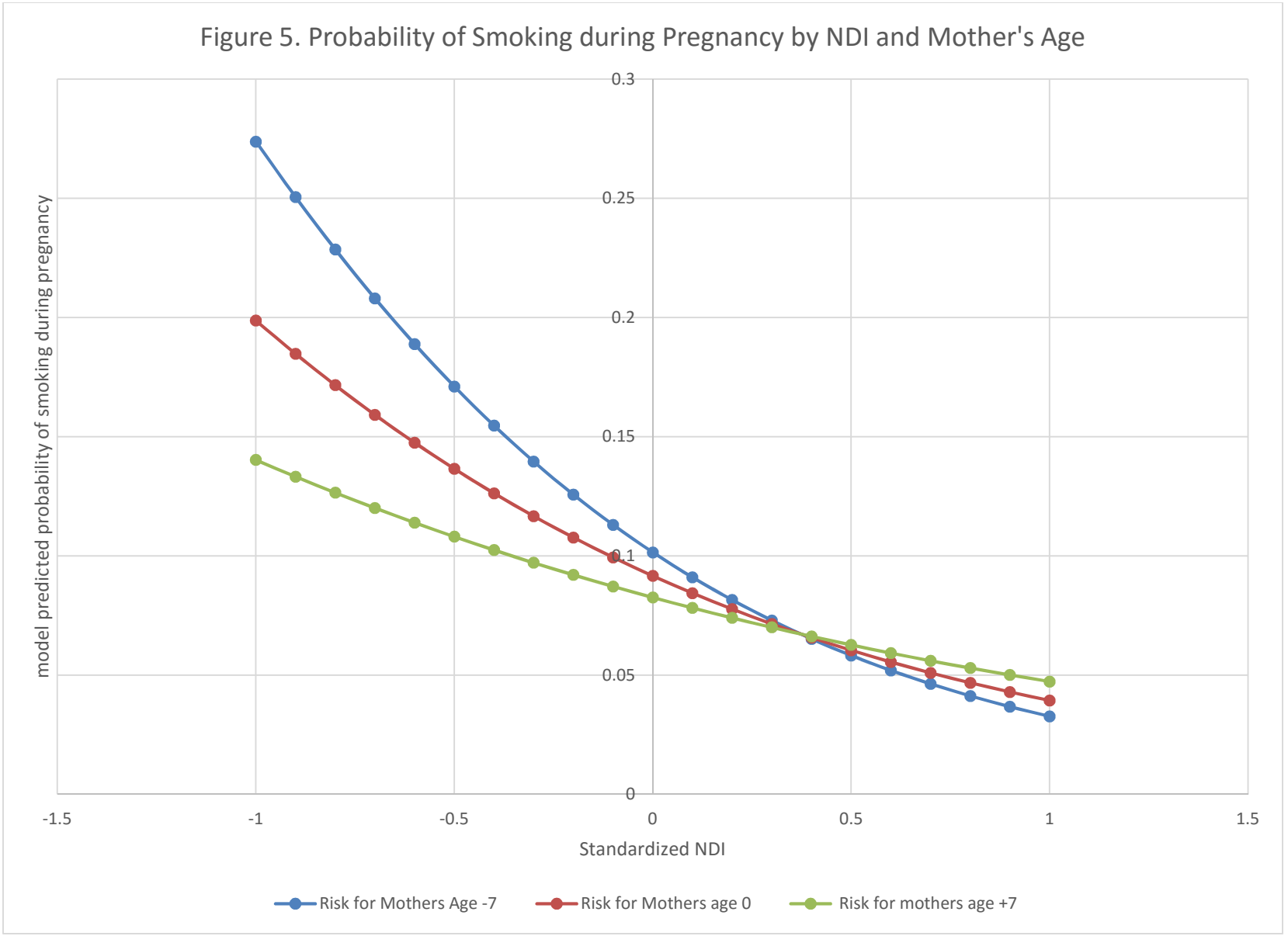
Table 4. OR Estimates for Interaction Terms

| *Outcome* | *Interaction Groups Examined* | *OR (95% CI) for 1 SD Decrease in NDI* | *OR (95% CI) for 1 SD Increase in NDI* |
|---|---|---|---|
| Drinking during pregnancy [a] | Medicaid | 1.04 (0.65, 1.64) | 0.97 (0.61, 1.53) |
| | Non-Medicaid | 1.60 (1.02, 2.51) | 0.62 (0.40, 0.98) |
| Smoking during pregnancy [b] | Non-Hispanic other race | 1.78 (0.91, 3.48) | 0.56 (0.29, 1.10) |
| | Non-Hispanic black | 0.60 (0.39, 0.92) | 1.66 (1.08, 2.55) |
| | Hispanic | 1.67 (0.53, 5.20) | 0.60 (0.19, 1.87) |
| | Non-Hispanic white | 1.05 (0.76, 1.46) | 0.95 (0.69, 1.32) |
| | 18 years old | 3.34 (0.69, 16.06) | 0.30 (0.06, 1.44) |
| | 35 years old | 1.59 (0.72, 3.49) | 0.63 (0.29, 1.38) |
| Smoking and drinking during pregnancy [c] | Overall OR | 0.74 (0.35, 1.55) | 1.36 (0.65, 2.87) |

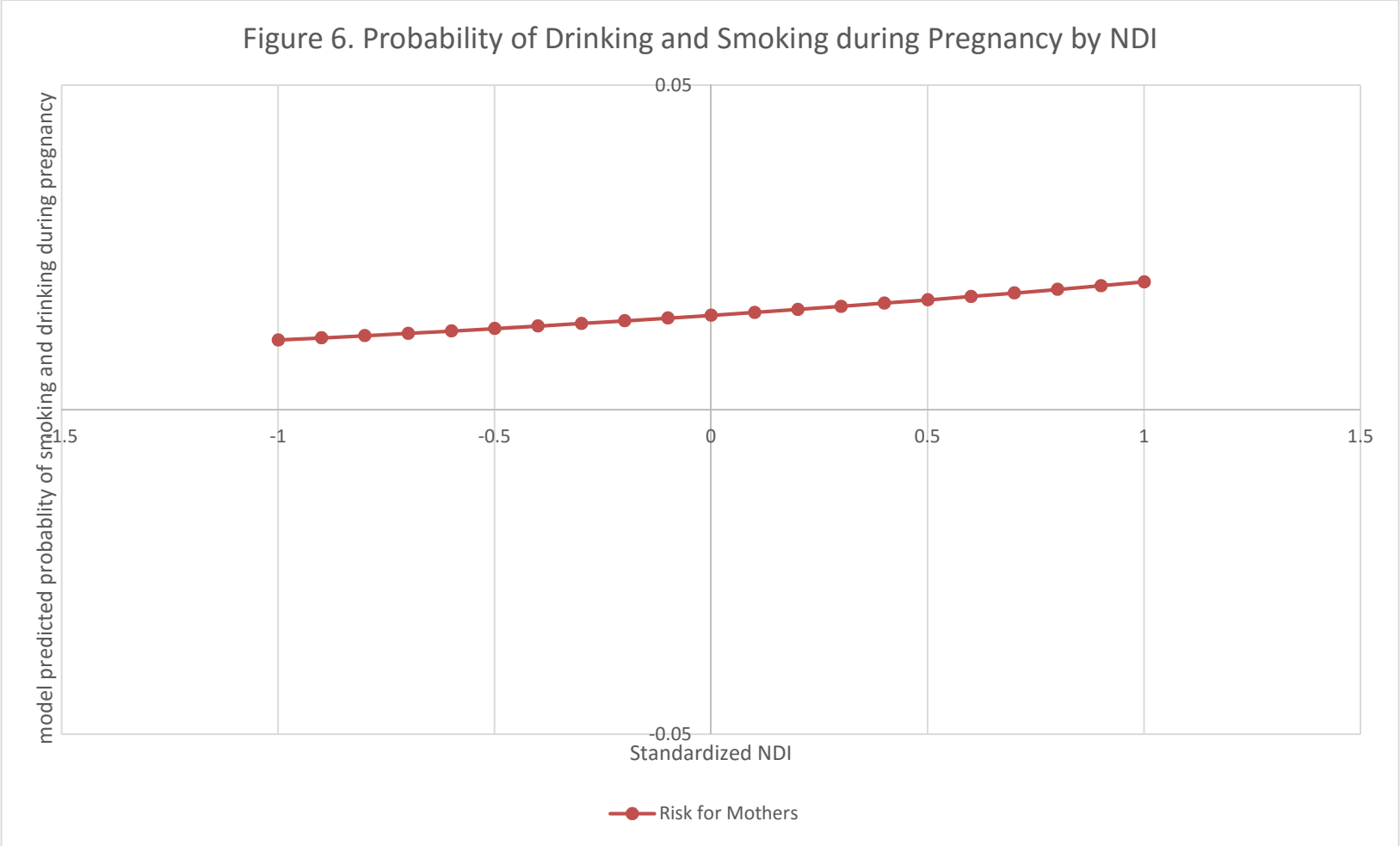
[a] Adjusted for Age, Payment, and NDI*Payment
[b] Adjusted for Age, Payment, Race, Education, NDI*Age, and NDI*Payment
[c] Adjusted for Age, Race, Payment, NDI*Age, and NDI*Payment




High NDI = 1 standard deviation increase in NDI
Low NDI = 1 standard deviation decrease in NDI
Model was adjusted for Age, Payment, Race, and Education




Model adjusted for Age, Payment, Race, and Education




Model adjusted for Age, Race, and Payment