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Association of BMI and Census-Tract Defined Food Deserts Using Height and Weight Variables from the Georgia Birth Certificate Data for 2008-2009

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Master of Public Health

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B.S., Boston University, 2007

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An abstract of

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University

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Master of Public Health in Global Epidemiology

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Abstract

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Background: Pre-pregnancy obesity has been associated with adverse pregnancy outcomes and risks for both pregnant women and their infants. The primary aim of this analysis was to study the association of census-tract defined food deserts and pre-pregnancy BMI among women in Georgia, while the secondary aim was to study patterns of the large percentage of missing pre-pregnancy BMI data to assess the quality of the data. **Methods:** A cross-sectional secondary analysis was conducted on the Georgia residents who had a live birth from 2008-2009 using Georgia Birth Certificate data with newly documented height and weight variables compiled by the Georgia Department of Public Health**. Results:** The results of this study show a significant association of Overweight/Obese pre-pregnancy BMI and food desert exposure among Non-Hispanic White women (OR=1.26, 95% CI [1.11, 1.24]) but no significant association among Non-Hispanic Black (OR=0.97, 95% CI [0.92, 1.03]) or Hispanic women (OR=1.09, 95% CI [0.90, 1.34]). **Conclusions:** Analysis of the association for missing BMI with food desert exposure showed missing BMI is associated with food desert, and many other variables in complex ways, limiting the usefulness of birth certificate BMI data as collected in the initial two years of the 2003 revised birth certificate. With improved collection of height and weight on birth certificates moving forward, vital records could become an additional tool for surveillance of BMI in reproductive-aged women.

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Chapter I: Background

Obesity is a medical condition which has been associated with adverse effects on health and increasing health problems. Obesity rates have been increasing in the United States for the past two decades, with Georgia ranking as the 12th state with the highest obesity prevalence as of 2010. Consistent with the rising trends of obesity in adults, overweight and obesity is also increasing among the women of reproductive age. Women's BMI prior to pregnancy is a public health concern for the reason that there are significant risks for many adverse pregnancy outcomes linked to overweight and obesity in women during pregnancy, and for their infants. Many exposures have been linked to obesity, including exposure to food deserts, defined as areas with low access to healthy and affordable foods. Research studies for association of food environment and obesity are emerging, but there are still gaps of knowledge on this issue. Using the newly captured variables of height and weight on the 2003 revision of the U.S. birth certificate, this analysis studies the association of pre-pregnancy BMI and food environment among women residing in Georgia who had a live birth from 2008-2009. This study aims to assess the utility of a novel means for monitoring population-based surveillance for pre-pregnancy obesity which is not currently available.

Exposure- Food Availability

Emerging literature focused on characteristics of food environment and food deserts in neighborhoods seeks to link environment with the epidemic of obesity. A "food desert" is a term used to describe areas where residents do not have access to healthy and affordable foods, and have a higher density of fast-food restaurants[1]. Depending on the study, food availability may be measured based on supermarkets or grocery stores (both chain and non-chain), convenience stores, fast-food restaurants, and farmer's markets. Race and socioeconomic status of a neighborhood have been found to be associated with differences in food availability and access to healthy foods[2]. Evidence portraying differences among types of food availability are a concern because compared to smaller grocery stores and convenience stores, supermarkets and farmer's markets have been shown to offer healthier foods. [2] Chain supermarkets are also found to offer higher quality food products at lower prices in comparison to non-chain supermarkets and smaller grocery stores. [3]

A national study examining the availability of full-service and fast-food restaurants, which was determined by the number of restaurants that fell within the zip code, in zip codes with greater than 300 residents found that availability of fast-food and full-service restaurants was higher among low and middle income neighborhoods compared to high income neighborhoods. [2] Metropolitan and urban low income compared to high income neighborhoods have also been found to have fewer available supermarkets. Chain compared to non-chain grocery stores are less likely to be found in low income zip code areas. Zip codes with the lowest median household income were found to have 25% fewer chain supermarkets than middle-income zip code areas. The low-income neighborhoods had a greater number of convenience stores in urban areas, and more non-chain grocery stores in the total area sample including both urban and rural areas. These study findings, based on multistate samples, also suggested a significantly larger number of small grocery and convenience stores and a lower number of supermarkets available in predominantly Black compared to White neighborhoods. Fifty-two percent of chain supermarkets were available in predominantly black neighborhoods compared to predominantly white neighborhoods, and even less, at 41%, of White urban areas. [3] On average, fast-food density increases of 10% were associated with an increase of 3.7% of black residents, and a 4.8% decrease of median household income.[4] When measuring food deserts in urban areas, such as New York City and Baltimore's low-income neighborhoods, poverty and race are limiting factors. Block groups (residents within 3 blocks) consisting of a higher proportion of blacks had a significantly lower food desert index score representing more opportunities to access fast food and less opportunities to obtain healthy food, lower proportion of "most healthy" food stores, and fewer supermarkets when compared to block groups with a lower proportion of blacks or those that were predominantly white. [1] During the farmer's market season, high-income areas continue to have greater spatial access.[5] Forty-three percent of black neighborhoods compared to 4% of white neighborhoods and 46% of lower-income neighborhoods compared to 13% of high-income neighborhoods were considered to have the lowest healthy food availability, often lacking recommended foods such as whole wheat bread, skim milk, and fresh fruits and vegetables. Overall, county neighborhoods showed better healthy food availability than city neighborhoods [6]

Outcome- Obesity

Body mass index (BMI) is an indirect method used to indicate body fat in most people. BMI for both children and adults is calculated using a person's height and weight measurements, making it an inexpensive and easy method for population assessment of weight categories. BMI is an efficient method to compare an individual's weight to that of the general population. Although BMI can provide a strong correlation for body fat, it can vary by sex, race, and age. Older adults tend to have more body fat compared to younger adults, and women tend to have more body fat than men at the same BMI. For adults, BMI is interpreted using standard weight categories: <18.5 as Underweight, 18.5-24.9 as Normal, 25.0-29.9 as Overweight, and >30.0 as obese. However, for children and adolescents, BMI is interpreted by their specific age and sex. BMI is not a direct measure of body fat and therefore, can be inaccurate in determining overweight and obesity. Since BMI is calculated from weight, including both muscle and fat, some individuals may have a high BMI due to increased muscle rather than fat. An alternative method to determine overweight and obesity, and the risk of developing related diseases is to use the individual's waist circumference, which measures abdominal fat. [7]

Obesity rates have been increasing in the United States for the past 20 years. According to the Centers for Disease Control and Prevention, 33.8% of adults in the United States are considered obese. In 2010, the state obesity rates range from 21.0% to 34.0%, with Georgia's obesity rate at 29.6% ranking Georgia as the 12th state for highest obesity prevalence. [8] Consistent with the rising trends of obesity in adults, overweight and obesity is also increasing among the women of reproductive age.[9]

Women's BMI prior to pregnancy is a concern because there are significant risks for many adverse pregnancy outcomes linked to overweight, and obesity in women during pregnancy[10]. A woman who is obese is at "increased risk of cesarean delivery, increased risk of preterm delivery, increased birth weight of fetus, fetal macrosomia, pregnancy-induced hypertension, post term pregnancies, shoulder dystocia, maternal weight retention (with the lifelong consequences of obesity such as increased risks of osteoarthritis, diabetes, hypertension, urinary tract infections, obstructive sleep apnea, coronary artery disease, cerebrovascular accidents, and endometrial cancer), increased perinatal mortality, increased rates of congenital malformations…venous thromboembolic disease, and an increased rate of twinning with all its attendant fetal and maternal risks." [11] Compared to women who are normal weight, obese women are at a risk for gestational diabetes mellitus because of increased resistance to insulin. Obese women are also three times more likely to have complications due to preeclampsia compared to women who are normal weight.[10] Studies have also reported that there is a positive association with infant birth weight and pre-pregnancy BMI[9], and more importantly an increased risk of obesity for the child as an adult due to a direct association with maternal pre-pregnancy and childhood obesity[11]. Complications can lead to excess use of health care services, and medical and financial resources as a result of increased length of hospital stay both during and after the pregnancy[9]. In addition to complications with overweight and obesity, a woman with a BMI of less than 18.5, considered underweight, is also at and increased risk of complications during pregnancy including “preterm delivery, low birth weight of the neonate, small-for-gestational age, intrauterine growth restriction, and stillbirth”[11]. Studies provide evidence of the increasing public health problem of obesity among women of reproductive age and women entering pregnancy.

Pre-pregnancy obesity prevalence has risen steadily from 24.8% in 1999 to 28.5% in 2008.[12] Based on an analysis of data from the Pregnancy Risk Assessment Monitoring System (PRAMS) from 2004-2005, the state-specific pre-pregnancy obesity prevalence in women from 26 states and New York City ranged from 13.9% to 25.1%. The results of this analysis show Georgia’s pre-pregnancy BMI prevalence for the standard categories was 4.2% for underweight, 51.6% for normal, 24.6% for overweight, and 19.5% for obese. Race-specific obesity varied by location, but the overall prevalence among non-Hispanic blacks (28.9%) compared to non-Hispanic whites (17.4%) and Hispanics (17.4%) was significantly different. In Georgia, race-specific obesity was consistent with the overall trend, with Non-Hispanic blacks (26.2%) greater than Non-Hispanic whites (17.2%) and Hispanic (15.6%). Women who had their delivery paid for by Medicaid had a 50% higher obesity prevalence than women who paid through other means such as other assistance, private insurance and cash. Approximately one in five women who delivered were obese, possibly increasing to one in three women depending on the state, race, and insurance status. [13] Evidence has also suggested higher pre-pregnancy obesity among low-income women. The prevalence was examined in 1999, 2004, and 2008 among low-income women enrolled in the Women, Infants, and Children (WIC), Pregnancy Nutrition Surveillance System program, which was limited to women with a gross income below the poverty line based on the United States Poverty Income Guidelines. The study observed the pre-pregnancy obesity prevalence among the following race/ethnicities in 2008: non-Hispanic whites (28.3%), non-Hispanic blacks (33.9%), Hispanics (24.0%), Native Americans/Alaskan natives (34.5%), and Asians/Pacific Islanders (8.7%). When adjusting for maternal age and race/ethnicity, there was a 14.1% increase from 1999 to 2008 among low-income women. It was also determined that prior to pregnancy, more than 50% of women were obese or overweight.[12]

Association of food availability and obesity already established

Observing factors that are associated with local food environments can help determine the important factors considered to be related to behavioral food consumption and obesity. [3] Consistent with increasing obesity rates, nationwide surveys of food consumption patterns show an increasing trend of energy intake from sources outside of the home, with a focus on fast-food restaurants. [2] The total percentage of calories consumed in the United States from fast-food consumption has increased from 3% to 12% in the past 20 years. [4] Significant associations have been reported between increased BMI and fast-food consumption, increased body weight, and probability of being overweight. This may be a result of fast-food consumption associated with higher intake of fat content, carbohydrates, sugar and carbonated soft drinks, as well as a decrease in fresh fruits and vegetables. [2] Obesity rates are positively associated with the density of both fast food restaurants and convenience stores. In metropolitan areas, one additional fast food restaurant is associated with a 2.17% increase in obesity rate and an increase of one convenience store is associated with a 0.85% increase in obesity rate, per 1000 residents. [14]

Access to healthier food sources has been demonstrated to be inversely associated with obesity. [15] The availability of supermarkets has been inversely associated obesity rates because they are more likely to stock healthy foods compared to smaller stores. [3] Density of food venues including farmers' markets, supermarkets, and grocery stores are inversely associated with obesity prevalence based on the county-level. [15] Full service restaurants are associated with lower rates of mortality, diabetes, and obesity, whereas convenience stores are associated with higher rates. [14]

Literature suggests that poor-quality retail food environments in disadvantaged areas, as well as limited economic resources contribute to an increased risk of obesity among low-income and racial minorities. The outcome of obesity is affected by not only the availability of healthy foods, but food price and distance. [16] An increase in the percentage of low-income households greater than one mile to a supermarket or grocery store has a positive association with both obesity and diabetes. [17]

While there is research studying the association of obesity and food environments, the research is at early stage with many gaps still remaining in the literature. There are several limitations that research studies share in common. Many studies have been cross-sectional which prevents indicating causality between food environments and obesity. The studies have been unable to determine whether individuals who are obese tend to reside in areas food deserts, or the unhealthy food environment is a cause of their obesity. Measurements of tools and procedures also make it less possible to compare results from research across communities or regions. Few studies have examined the relation between food environment and obesity at the individual consumer level. As a result, most studies do not examine whether individuals are more likely to shop at a food venue in a census tract or county that they reside and are more likely to shop at a type of food venue with higher density as opposed to shopping at another food venue. [18]

How this study will be useful

Although prior research has shown an association between food availability and obesity, it has not been studied specifically by Georgia census tracts. Using Georgia Birth

Certificate data from the Georgia Department of Public Health, we will be able to study the relation between neighborhood food availability and pre-pregnancy BMI for the entire population of Georgia-resident mothers in 2008-2009. Pre-pregnancy BMI will be calculated using new variables from the 2003 revision of the US birth certificate for mother's pre-pregnancy height and weight. With Georgia's increasing obesity rates, and the complications associated with pre-pregnancy BMI as well as increased childhood obesity, this research can be used determine whether there is an association among food availability and obesity in Georgia-specific census tracts. Understanding the role of food availability on obesity can offer a potential for development of interventions and policies to prevent the growing epidemic of obesity in Georgia. This study will assess the utility of a novel means for monitoring pre-pregnancy obesity which has not previously been available.

Chapter II: Manuscript

A. Title, Author, Abstract

Association of BMI and Census-Tract Defined Food Deserts Using Height and Weight Variables from the Georgia Birth Certificate Data for 2008-2009

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Background: Pre-pregnancy obesity has been associated with adverse pregnancy outcomes and risks for both pregnant women and their infants. The primary aim of this analysis was to study the association of census-tract defined food deserts and pre-pregnancy BMI among women in Georgia, while the secondary aim was to study patterns of the large percentage of missing pre-pregnancy BMI data to assess the quality of the data. **Methods:** A cross-sectional secondary analysis was conducted on the Georgia residents who had a live birth from 2008-2009 using Georgia Birth Certificate data with newly documented height and weight variables compiled by the Georgia Department of Public Health**. Results:** The results of this study show a significant association of Overweight/Obese pre-pregnancy BMI and food desert exposure among Non-Hispanic White women (OR=1.26, 95% CI [1.11, 1.24]) but no significant association among Non-Hispanic Black (OR=0.97, 95% CI [0.92, 1.03]) or Hispanic women (OR=1.09, 95% CI [0.90, 1.34]). **Conclusions:** Analysis of the association for missing BMI with food desert exposure showed missing BMI is associated with food desert, and many other variables in complex ways, limiting the usefulness of birth certificate BMI data as collected in the initial two years of the 2003 revised birth certificate. With improved collection of height and weight on birth certificates moving forward, vital records could become an additional tool for surveillance of BMI in reproductive-aged women.

B. Introduction

Women's BMI prior to pregnancy is a public health concern because of the significant risks for many adverse pregnancy outcomes linked to pre-pregnancy overweight and obesity in women and for their infants [10]. Some of the most common higher risks associated with pre-pregnancy obesity are increased risk of cesarean delivery, increased risk of preterm delivery, increased birth weight of fetus, increased perinatal mortality, diabetes, and hypertension.

Obesity in Georgia has been increasing steadily in the past two decades ranking Georgia as the 12th state with the highest prevalence of obesity. Consistent with the rising trends of obesity in adults, overweight and obesity is also increasing among the women of reproductive age. Overall pre-pregnancy obesity prevalence has risen steadily in the United states from 24.8% in 1999 to 28.5% in 2008.[12] Georgia's pre-pregnancy BMI prevalence for the standard categories was 4.2% for underweight, 51.6% for normal, 24.6% for overweight, and 19.5% for obese. Research has suggested there are significant differences for race-specific obesity rates. In Georgia, race-specific obesity for Non-Hispanic blacks (26.2%) is greater than Non-Hispanic whites (17.2%) and Hispanic (15.6%).

Many exposures have been linked to obesity, including exposure to food deserts, defined as areas with low access to healthy foods. . A "food desert" is a term used to describe areas where residents do not have access to healthy and affordable foods, and have a higher density of fast-food restaurants[1]. Emerging literature focused on characteristics of food environment and food deserts in neighborhoods seeks to link environment with the epidemic of obesity. Research studies for association for food environment and obesity are increasing, but there are still many questions that remain.

This study uses the newly documented height and weight variables from the 2008-2009 birth certificate data for women residing in Georgia who had a live birth to calculate BMI and indicate overweight/obesity according to the CDC standard weight categories: <18.5 as Underweight, 18.5-24.9 as Normal, 25.0-29.9 as Overweight, and >30.0 as obese. This analysis aims to determine the association of pre-pregnancy BMI and food environment among women residing in Georgia who had a live birth from 2008-2009 in hopes to assess the utility of a novel means for monitoring population-based surveillance for pre-pregnancy obesity which is not currently available.

C. Methods

Hypothesis

The primary aim was to study the association between census-tract defined food deserts and pre-pregnancy BMI among women in Georgia. The secondary aim was to study patterns of the missing pre-pregnancy BMI data.

Study Design/Variables

A cross-sectional secondary analysis was conducted using Georgia Birth Certificate data from 2008-2009 collected by the Georgia Department of Public Health. IRB approval was granted for the study. The original dataset consisted of birth certificate information for 287,796 Georgia-resident women who delivered a live-born infant. Variables of interest were chosen based on the factors collected from the birth certificates and previous literature on factors that may be associated with either the food desert exposure, BMI outcome, or both.

The U.S Department of Agriculture Food Desert Locator data[19] was merged with the original birth certificate dataset by census tract ID to determine which census tracts were food deserts defined by low-income and low-access. Low-income communities were defined as having either a poverty rate of greater than 20% or a median family income less than 80% of the area's median family income, and considered low-access where at least 500 people or 33% of the population live more than one mile away in urban areas and more than 10 miles in rural areas. The exposure for food desert was defined as a binary variable: yes or no as defined by the Food Desert Locator. The outcome BMI was calculated from the mother's height and weight variables using the equation BMI= (lbs*703)/(inches^2). BMI was categorized according to the CDC BMI standard adult categories: below 18.5 as Underweight, 18.5-14.9 as Normal, 25.0-29.9 as Overweight and 30.0 and above as Obese.

Females younger than 18 years old were dropped from the observations due to biological differences in comparing BMI measurements for adolescents and adults. The dataset was restricted to records for whom the geocode accuracy was determined to be at the street or census tract level as opposed to the zip code or county level. Unlikely or impossible measurements of variables were set to missing. Categories for continuous variables were determined by previous research studies or mean cut-off values. Variables initially categorized in the birth certificate data have been re-coded into categories that were logical, based on previous studied, and provided meaningful interpretation for the variables. The variables race and ethnicity for both mother and father were combined to create one variable that was categorized as Non-Hispanic White, Non-Hispanic Black, Non-Hispanic other, and Hispanic. The Non-Hispanic other category was dropped for the analysis because there was no meaningful comparison for this group compared to the others without knowing who was included in the other category.

The percentage of blacks and poverty from the U.S. Census Bureau American Community Survey from 2005-2009 were included as independent variables. These variables were dichotomized based on cutoffs at their mean values. Rural-Urban Commuting Area Codes (RUCAs)[20] were used to define the census tracts as urban or rural according to the recommended WWAMI Rural Health Research Center categorization of the RUCA codes.

Statistical Methods

All analyses were performed using SAS 9.3 at the 5% statistical significance level. Univariate analyses were performed to determine the percentage of missing data and to see whether differences were found in data completion between 2008 and 2009. The relationship between BMI and variables was tested using chi-square analysis, where a p-value of less than 0.05 was considered statistically significant.

Logistic regression was used for multivariate analysis. The overweight and obese categories were combined into a single category labeled ‘overweight/obese’ for the logistic regression models. To assess the presence of interaction, each covariate was tested for interaction with food desert, and backward elimination was used for interaction terms that had p-values greater than 0.05. If a covariate showed significant interaction, it was included in the final model and stratum-specific odds ratios were reported for the covariates. Confounding was assessed by examining changes among odds ratios and across each stratum for interaction terms compared to the gold standard models. Variables that changed models more than 10% were considered to be confounders and were controlled for in the final model.

D. Results

Approximately 4.5% of the original dataset was lost due to exclusion criteria. The final dataset consisted of 274,776 observations of mothers who had a pregnancy in 2008 or 2009 with 14 categorical covariates. The percentage of total observations for 2008 and 2009 were 50.7% and 49.3% respectively. The data for both 2008 and 2009 was grouped together for analysis after determining there were no major differences in the frequency distributions and missing values between both years.

The mother's race and ethnicity was missing in 15.2% of the observations. Higher percentages of the father's race and ethnicity (27.7%), and education (23.6%) were missing compared to the mother's information. 78.5% of census tracts were considered urban and 21.5% were considered rural. [Table A1] 15.8% of the mothers live in food deserts.

Based on the bivariate analyses of variables by BMI, there were significant differences of overweight, obesity and missing BMI percentages between the categories with a p-value of <0.0001 for all of the covariates. Overweight/obese women tend to have Medicaid insurance. Non-Hispanic Black mothers and fathers have the highest percentages of overweight and obesity. Mothers and fathers whose highest education is a High School Diploma tend to have the highest obesity rates. Overweight/obesity increases progressively as women have more children. Women who are unmarried, have diabetes, hypertension, living in a census tract with greater than a 40% black population, or live in a census with a greater than 40% poverty have a significantly higher percentages of obesity ($p<0.0001$). Women who were smoking during pregnancy or living in rural areas have higher overweight/obesity prevalence. Higher proportions of BMI were missing in women who did not have commercial insurance; only 5.6% of women who had commercial insurance were missing BMI information, but 26.0% of women who had Medicaid Insurance had missing values. 58.1% of BMI was missing among women who were Hispanic, and 33.6% of BMI was missing among women who were Non-Hispanic Black. The highest proportion of BMI missing was among mothers (43.9%) and fathers (43.9%) with no high school diploma. Higher proportions of missing BMI were seen among women who were non-smokers (35.3%) as opposed to smokers (17.2%), and among women who were not hypertensive (30.5%) compared to women who were hypertensive (27.0%). Higher proportions of BMI were also missing among women who lived in urban areas (35.8%) than among women who lived in a rural census-tract (28.0%). [Table 1]

Census tracts that are food deserts are scattered throughout Georgia with larger areas of food deserts located in southern Georgia. When looking at the Metro-Atlanta area, there are several scattered food deserts around Atlanta, and more clustered areas around in the southern and western areas of Atlanta. [Figure 2] There is no evident spatial clustering of tract percentage of overweight and obesity. However, the southwest portion of the state has a cluster of less than 25% overweight and obesity. The census tracts around metro-Atlanta have a wide range of overweight and obesity prevalence. There are several census tracts surrounding Atlanta with greater than 67.6% of mothers overweight and obese. [Figure 3**]** These prevalence estimates may be variably unstable as a function of the number of measured births in each area.

The bivariate analysis of independent variables and food desert suggest that women who are younger, as well as women who have Medicaid insurance tend to live in food deserts. Mothers and fathers who are Non-Hispanic Black, or have less than a college education are more likely to live in a food desert. The percentages of mothers with more than one child who live in a food desert increase progressively. Women who are unmarried, live in a census tract with greater than a 40% black population, a poverty rate of greater than 20% or live in an urban census tract are more likely to live in food deserts. However, women who were smoking during pregnancy (p=0.396) or have diabetes (p= 0.956) do not have a significantly higher tendency to live in a food desert than those who do not. [Table A2]

Association of Missing BMI and Census-Tract Defined Food Deserts

As a result of missing height and weight, 34.1% of the BMI outcome was missing. Since height and weight are newly reported variables which might not be collected uniformly, it was important to understand the missing patterns of BMI prior to assessing the relationship between BMI and food desert. Census tracts with the highest percentage of missing values for BMI, greater than 48.4% were clustered in the southwest, the southeast and the northeast regions of Georgia. When focusing on the metro-Atlanta area, greater than 32.6% of BMI was missing in a majority of the census tracts. [Figure 1]

The final model results to assess the association of missing BMI with food desert and covariates are shown in Table 3 with beta coefficients on the log-odds scale and 95% confidence intervals. The full model included the independent variables, and interaction terms for each of the independent variables and food desert. Statistical interaction was tested through backward elimination for interaction terms that was considered not significant (p<0.0500). The final model included all of the independent variables as well as interaction terms for payor (p=0.0003), smoking (p=0.0037), poverty (p=0.0004), and urban areas (<0.0001) with food desert, which were significant when tested for by backward elimination [Table A4]. Based on this model, BMI is less likely to be missing if a mother is living in a food desert compared to not living in a food desert controlling for all of the independent variables (beta coefficient= -0.3884). Mothers were more likely to be missing BMI if they are between 26 and 35 years old (beta coefficient= 0.0750), and even more likely to be missing if they are between 36 and 45 years old (beta coefficient =

0.2464). BMI was more likely to be missing if the mother was Non-Hispanic Black (beta coefficient = 0.2481), and even more likely to be missing if the mother was Hispanic (beta coefficient = 0.8952). Mothers with at least a high school diploma (beta coefficient = -0.1503) or some college education (beta coefficient = -0.4211) were less likely to be missing BMI values. BMI was less likely to be missing when the father has some college or higher education (beta coefficient = -0.1218). BMI also less likely to be missing if mothers were married (beta coefficient= -0.0918), had 2 or 3 other children (beta coefficient= -0.0556 and -0.0498, respectively), or were in a census tract with less than 40% black population (beta coefficient =0.0960). [Table 3]

When taking into consideration the interaction terms, BMI missingness was less likely to be seen in mothers with commercial insurance (beta coefficient = -0.5347) or other government/champus insurance (beta coefficient = -0.1284) than Medicaid, but more likely to be missing if mothers were in the other/self-pay category (beta coefficient = 0.3885) for mothers who lived in a food desert. The effect of missing BMI was greater if mothers lived in a food desert in an urban area (beta coefficient =0.2592). BMI was less likely to be missing if a mother was in smoking and living in a food desert (beta coefficient = 0.7660). BMI was also less likely to be missing if the mother lived in a food desert with poverty greater than 20% (beta coefficient = -0.5485). [Table 3]

Association of Overweight/Obesity BMI and Census-Tract Defined Food Deserts

In the multivariate analysis, the full model for association of overweight/obesity BMI and food desert included all of the independent variables as well as the interaction terms for each of the independent variables and food desert. Statistical interaction was tested through backward elimination for interaction terms that was considered not significant ($p<0.0500$). For this model, the mother's race/ethnicity interaction term was significant (p=0.0052) and was adjusted for in the final model. There was significant interaction for father's education with food desert (p=0.0035), but was dropped from the final model because of its ineffectiveness to contribute to the interpretation of the final model results. [Table A4] Subsequently, confounding was assessed by backward elimination of the independent variables except for mother's race/ethnicity since this interaction term was in the final model. The odds ratios after dropping each of the independent variables for the association between food desert and pre-pregnancy BMI stratified by mothers race/ethnicity was within 10% of the crude odds ratio (OR= 1.26 (1.22, 1.29)). [Table A5] Therefore, none of the variables were considered confounders and were not controlled for in the final model.

Confounding was also assessed for an adjusted model without the mother's race/ethnicity interaction term to compare to the adjusted model with interaction. In the adjusted with no interaction model, father's education (OR= 1.12 (1.08, 1.17)) and the percentage of blacks in the census tract (OR= 1.10 (1.06, 1.14)) differed by greater than 10% of the crude odds ratio, and were controlled for in this reduced model.

The final model assessing the relationship between overweight/obesity BMI and food desert included the interaction term for mother's race/ethnicity and did not control for any of the independent variables after assessing confounding. Non-Hispanic White women were found to have a statistically significant relationship between overweight/obese BMI and food desert exposure. However, no significant association was found for Non- Hispanic Black women (OR= 0.970 (0.917, 1.027)) or Hispanic women (OR=1.094 (0.897, 1.335)). [Table 2]

E. Discussion

The prevalence of overweight/obesity for women 18 and older living in Georgia is 34.7% according to this birth certificate data for 2008-2009. The CDC Pregnancy Risk Assessment Monitoring System (PRAMS) reported an overweight/obesity prevalence of 37.7% for reproductive-aged women based on their sample of women who had a live birth from 2004-2006. For the PRAMS Surveillance Report, a random sample of 200 women per month were selected from Georgia's birth certificate data to collect information about pre-pregnancy, during pregnancy, and after delivery of a live-born infant through self-reported questionnaires. The response rate for the PRAMS Surveillance Report data collection was 70%. The 30% of women who were non-responsive is similar to 34.10% missing data for women in the dataset being analyzed. Given the similarities of the populations in both datasets and the percentage of missing values in each dataset, the prevalence of overweight/obesity in this dataset appeared to be comparable to population-based research studies that have attempted to study the overall overweight/obesity prevalence in reproductive-aged women in Georgia, despite the large percentage of missing BMI. [21] However demographics patterns of missing data, descriptive maps, and results of from the final model assessing missing BMI and food desert suggest the missing data for BMI may be non-random, and therefore not representative of the total prevalence in Georgia. The descriptive demographic patterns for missing BMI provide information about individual correlates of the missing data. Based on descriptive analysis, differences in BMI proportions for several independent variable categories were determined. As expected, the proportion of missing BMI is higher among women who did not have commercial insurance, women who had more than three other children, and women who were unmarried. Women who were Non-Hispanic Black and Hispanic or who were less educated had a higher proportion of missing BMI. A possible explanation for the higher proportions may be that women of these demographics choose not to self-report information on the birth certificate. The higher proportions of missing BMI in non-smokers and women who were not hypertensive were unexpected. Both variables are indicators for higher risk of adverse outcomes. This may be a result of underreporting by medical professionals due to the knowledge that these women may be at lower risk for adverse pregnancy outcome. Reporting the height and weight variables for these women may not be as beneficial as opposed to BMI of women who have higher health risks. There may be less self-reporting for women who are not smokers or not hypertensive because they feel they're healthier and do not consider it helpful to report their information that is not required.

The descriptive maps and final model for the association of food desert and missing BMI provide information on area-based correlates for missing BMI. The clusters in the southwest, southeast, northeast, and Metro-Atlanta area as opposed to random scattered areas around Georgia suggest that BMI is not randomly missing throughout Georgia. A comparison of the maps suggests that some of the clusters of missing BMI overlap with areas that are food deserts and have range of overweight/obesity prevalence. The census tract areas missing high percentages of BMI in the southwest region and specifically south of Atlanta were also food desert areas. This southwest area and an area north of Atlanta, which is also an area with one of the highest percentage of missing BMI, have the lowest overweight and obesity prevalence in Georgia. In addition to interpretation of the maps, the final model analyzing the association of missing BMI and food desert indicates complex patterns for missing BMI with several interaction terms with food desert remaining significant in the final model. Contrary to what was expected, BMI was less likely to be missing for a mother living in a food desert when controlling for all other factors in the model. In addition, results for BMI were less likely to be missing for mothers who were smoking during their pregnancy and living in a food desert.

The results of BMI missing patterns may suggest there are differences in hospital practices for collecting and reporting birth certificate data. The clusters of missing BMI and the unexpected associations of missing BMI may be due to hospitals not reporting the height and weight variables. Therefore, the likelihood of a woman's BMI to be missing might be related to the hospital where the woman seeks care and the practices of that hospital. Medical professionals may also be more likely to record the data on a birth certificate for women who are more at risk for adverse pregnancy outcomes than for women who are not, which may also be an explanation for the results showing BMI was less likely to be found in women who did not live in food deserts. Overall, these patterns of missing BMI indicate that the areas of missing BMI may not be similar to each other and therefore, overweight and obesity prevalence as well as the independent variables we are looking may not be generalizable for these areas.

Finally, after studying the quality of data, the association of overweight/obese BMI and food desert was analyzed. The crude model with just exposure of food desert and outcome of BMI resulted in strongest association. However, the significant results for models adjusted for confounders or interaction terms showed weaker associations. The model with no interaction terms also confounded for father's education and for the percentage of blacks in census tracts. However, when stratified on mother's race for the final model, these variables were no longer considered confounders suggesting both father's education and the percentage of blacks in the census tracts are indicators of mother's race. As expected, the final model showed there was a significant association of higher overweight/obesity for Non-Hispanic White women who lived in food deserts. However, there were no significant associations found between overweight/obese and food desert among Non-Hispanic Black and Hispanic women. The associations for Non-Hispanic Black and Hispanic women may have been insignificant because of a possibility of a combination of variables affecting BMI such as race, education, and payor along with food desert. However, food desert may be independently associated with BMI for Non-Hispanic White women, so that that outcome of obesity is only determined by whether the woman lives in a food desert. Additionally, the insignificant associations may result from disproportionately represented women who were Non-Hispanic Black or Hispanic based on the missing model because women who were either Non-Hispanic black or Hispanic were more likely to be missing.

These findings suggest that there is an association between food desert and pre-pregnancy BMI but also identify important data quality issues. With improved collection of height and weight on birth certificates moving forward, vital records could become an additional tool for surveillance of BMI in reproductive-aged women.

Strengths and Weaknesses

This dataset provides a potential population-based surveillance tool for BMI associated with food deserts in reproductive-aged women residing in Georgia. There were a low percentage of observations dropped based on the exclusion criteria, which provided a large sample size for the dataset. The findings on patterns of missing data, as well as the association between BMI and food deserts in Georgia, can help provide a background for the data quality and insight on relationship between food environment and BMI for future studies.

While this study may have provided critical information about the data quality and implications for future studies, this study is not without limitations. A large percentage of missing data for the BMI outcome and for some of the independent variables due to missing data on the birth certificates. This analysis also excluded females younger than 18 years old, who may have shown different demographic patterns associated with food deserts or BMI. In addition to exclusion of women by age, women who were considered “Non-Hispanic, Other” were excluded from the analysis. The women in this category could not be defined as a specific race/ethnicity and was not a category that would provide a meaningful comparison and interpretation for results. However, the women in this category may have had different demographics and missing BMI pattern, which was not accounted for in the final models. There also may be measurement error since analysis of missing BMI suggested non-random missing patterns and potential underrepresentation of certain populations.

Public data sources, such as the Food Desert Locator, are generally less accurate and are more likely to have measurement error compared to on-site assessment. The data used to define a food desert based on the Food Desert Locator may not be identical to other studies in terms of distance and inclusion criteria for food deserts. Additionally, the RUCA codes and other independent variables may have been categorized differently which might prevent this study from being comparable to other research studies. Women may have been less likely to self-report undesired information on the birth certificates, which may have resulted in reporting biases. Similar to limitations of previous research studying the association of BMI and food environments, this study cannot assess directionality or causality. The results may show an association, but it cannot be determine whether food desert exposure causes pre-pregnancy overweight and obesity in women, or whether overweight and obese women are more likely to reside in food deserts due to factors such as low poverty, race, and education.

Table 1: Bivariate Analyses of Variables by BMI for GA Residents Giving Birth to a Live Infant in 2008-2009

N= 274776			**BMI Categories**				
Variable	**Total** N	**Under** %	**Normal** %	**Over** %	**Obese** %	**Missing** %	**P-value**
Food Desert							
Yes	43297	2.38	24.54	16.83	19.38	36.87	<0.0001
No	231479	2.63	29.35	17.13	17.31	33.58	
MATCH							
Street level	192894	2.52	27.63	16.86	17.88	35.11	<0.0001
Block level	58075	2.62	31.05	17.55	16.45	32.33	
Census tract level	4117	3.06	30.87	17.29	18.78	30.00	
Missing	19690	3.03	30.31	17.85	18.51	30.30	
Mother's Age							
1 (18-25)	114424	3.34	28.38	16.67	17.28	34.33	<0.0001
2 (26-35)	131621	2.15	28.81	17.34	17.93	33.76	
3 (36-45)	28468	1.57	28.45	17.52	17.72	34.74	
4 (46-55)	263	2.28	29.28	14.83	16.35	37.26	
Payor							
Medicaid	103707	3.29	28.44	19.03	23.24	26.00	<0.0001
Commercial	78615	0.77	11.20	5.79	5.29	5.57	
Gov't/Champus	11573	2.61	31.12	18.27	15.25	32.75	
Other/Self-pay	24993	2.08	24.01	16.08	13.66	44.18	
Missing	55888	1.37	15.59	9.21	8.31	65.51	
Mother's Race							
Non-Hispanic White	114665	3.28	35.74	17.75	16.87	26.35	<0.0001
Non-Hispanic Black	83533	1.95	22.22	18.29	23.94	33.61	
Non-Hispanic Other	19692	3.81	34.77	15.79	11.49	34.15	
Hispanic	15225	1.35	18.26	12.37	9.95	58.08	
Missing	41661	1.83	22.58	15.14	12.81	47.64	
Father's Race							
Non-Hispanic White	97073	3.18	36.88	17.54	15.67	26.73	<0.0001
Non-Hispanic Black	58448	1.85	21.91	18.68	24.47	33.09	

Non-Hispanic Other	28371	3.44	30.09	15.63	13.83	36.89	
Hispanic	14703	1.53	21.46	14.54	12.16	50.31	
Missing	76181	2.28	23.95	16.30	17.36	40.11	
Mother's Education							
No HS Diploma	52145	2.68	21.96	15.44	16.04	43.89	<0.0001
HS Diploma/Grade	80523	2.77	25.73	17.11	20.18	34.21	
College and above	126510	2.52	33.64	18.15	17.30	28.39	
Missing	15598	1.89	24.70	13.75	12.50	47.17	
Father's Education							
No HS Diploma	39883	2.18	20.91	15.91	17.09	43.91	<0.0001
HS Diploma/Grade	72385	2.70	25.86	17.76	21.01	32.66	
College and above	97547	2.68	36.32	17.79	14.71	28.50	
Missing	64961	2.57	24.76	15.97	18.60	38.10	
Birth Event Order							
1	106834	3.09	31.26	16.08	15.14	34.43	<0.0001
2	83446	2.55	29.72	17.70	18.16	31.86	
3	46525	2.11	25.79	17.80	19.42	34.87	
4+	33053	1.76	21.12	17.97	21.55	37.60	
Missing	4918	2.38	28.20	15.51	19.78	34.12	
Marital Status							
Unmarried	118716	2.74	24.77	16.62	19.02	36.85	<0.0001
Married	155637	2.46	31.54	17.45	16.57	31.97	
Missing	423	4.49	18.44	11.35	18.20	47.52	
Smoking							
No	256678	2.39	28.19	16.86	17.28	35.29	<0.0001
Yes	17819	5.45	34.28	20.32	22.79	17.15	
Missing	279	4.66	36.20	15.41	17.56	26.16	
Diabetes							
No	244432	2.72	30.37	18.02	18.45	30.44	<0.0001
Yes	1834	0.76	12.65	16.30	39.80	30.48	
Missing	28510	1.53	14.39	9.09	9.23	65.76	
Hypertension							
No	242857	2.74	30.49	18.04	18.25	30.49	<0.0001

Yes	3409	0.67	12.44	15.72	44.21	26.96	
Missing	25810	1.53	14.39	9.09	9.23	65.76	
% Black							
< 40%	216369	2.68	29.96	17.03	16.61	33.73	<0.0001
≥ 40%	58047	2.26	23.54	17.28	21.44	35.48	
% Poverty							
< 20 %	213168	2.65	29.78	17.04	16.82	33.72	<0.0001
≥ 20%	61608	2.36	24.50	17.24	20.46	35.44	
Urban/Rural							
Rural	59128	2.87	28.01	18.50	22.63	27.99	<0.0001
Urban	215648	2.51	28.76	16.69	16.26	35.78	
Total	274776	2.59	28.60	17.08	17.63	34.10	

Figure 1: BMI Missing by Census Tract for GA Residents Giving Birth to a Live Infant in 2008-2009

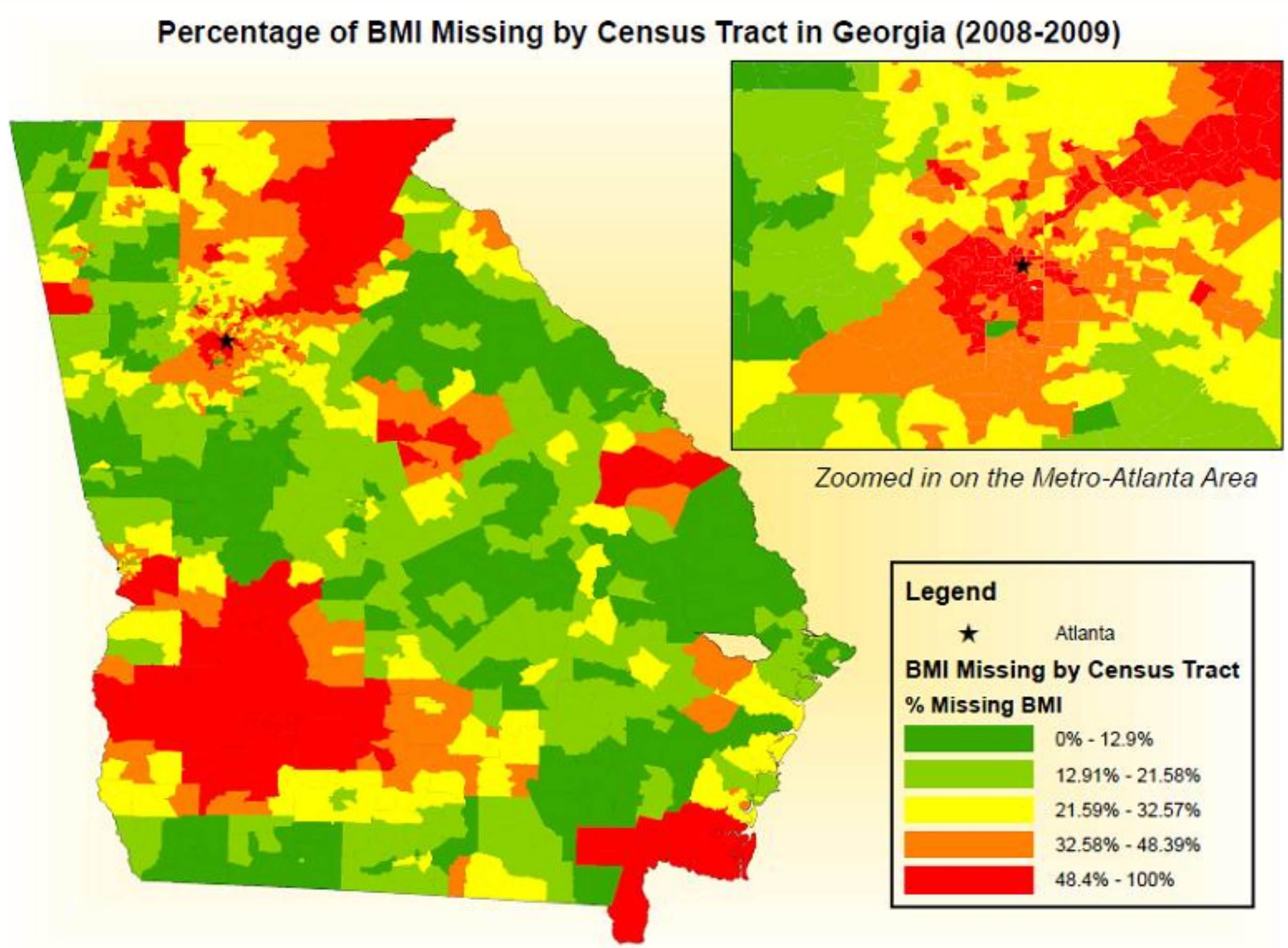

Figure 2: Food Desert by Census Tract in Georgia (2008-2009)

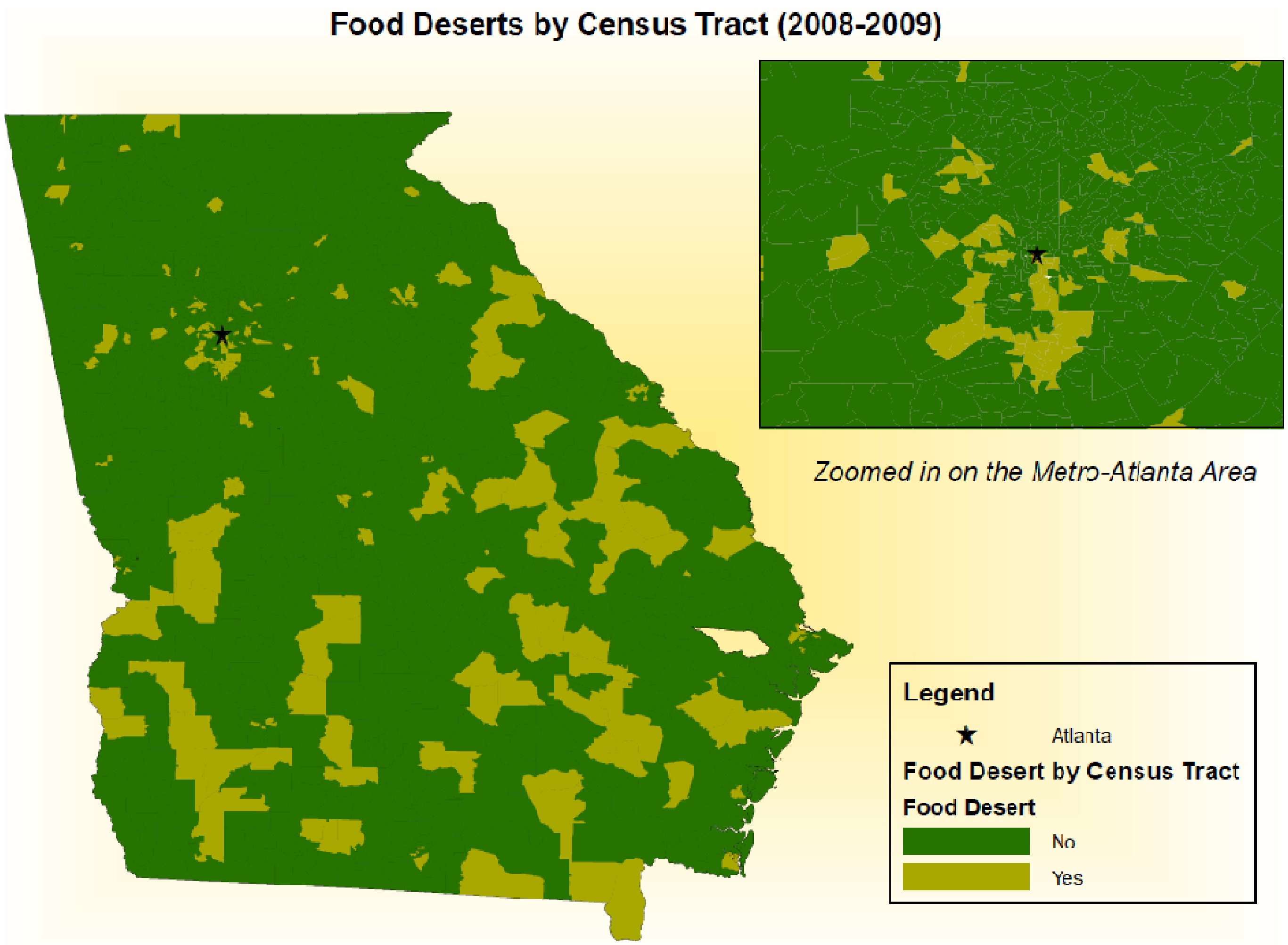

Figure 3: Obesity Prevalence by Census Tract for GA Residents Giving Birth to a Live Infant in 2008-2009

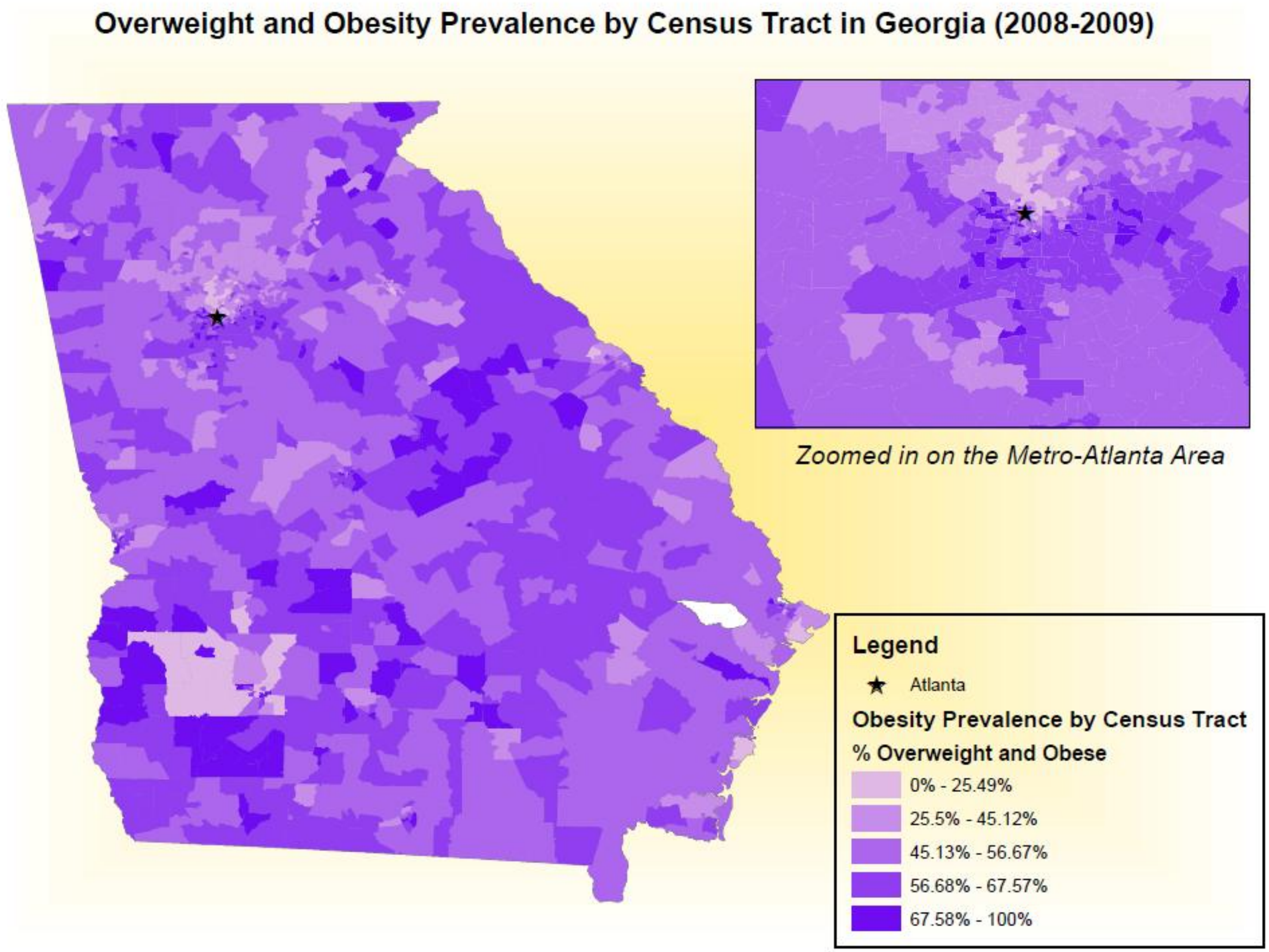

Table 2: Model Results for Association of Food Desert and Overweight/Obese BMI for GA Residents Giving Birth to a Live Infant in 2008-2009

	Crude		Adjusted- no interaction		Adjusted with interaction[1]					
					Non-Hispanic White		Non-Hispanic Black		Hispanic	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Food Desert	1.26	(1.22, 1.29)	1.10	(1.06, 1.14)	1.18	(1.11, 1.24)	0.97	(0.92, 1.03)	1.09	(0.90, 1.34)
Father's Education										
HS Diploma/Grade vs No HS Diploma			0.94	(0.90, 0.98)						
College and above vs No HS Diploma			0.59	(0.56, 0.61)						
% Black										
<40% vs ≥ 40%			1.37	(1.32, 1.42)						

[1] Interaction term for Mother's Race/Ethnicity and Food Desert p-value=0.005

Table 3: Beta-Coefficients and 95% CI for Association of Food Desert and Missing BMI for GA Residents Giving Birth to a Live Infant in 2008-2009

Parameter	Beta-Coefficient	95% CI
Intercept	-1.2425	(-1.3069, -1.1780)
Food Desert	-0.3884	(-0.4997, -0.2770)
Age (18-25)- Referent		
Age (26-35)	0.0750	(0.0376, 0.1124)
Age (36-45)	0.2464	(0.1898, 0.3029)
Age (46-55)	0.1691	(-0.4485, 0.7867)
Payor- Medicaid- Referent		
Payor- Commercial	0.0146	(-0.0293, 0.0584)
Payor- Gov't/Champus	0.1590	(0.0832, 0.2349)
Payor- Other/Self-pay	0.5799	(0.5187, 0.6411)
Race/Eth- Non-Hispanic White –Referent		
Race/Eth- Non-Hispanic Black	0.2481	(0.1728, 0.3235)
Race/Eth- Hispanic	0.8952	(0.8178, 0.9726)
Father’s Race/Eth- Non-Hispanic White –Referent		
Father's Race/Eth- Non-Hispanic Black	-0.0127	(-0.0880, 0.0626)
Father's Race/Eth- Hispanic	-0.0038	(-0.0774, 0.0698)
<HS Diploma- Referent		
HS Diploma/Grade	-0.1503	(-0.2016, -0.0990)
College and above	-0.4211	(-0.4776, -0.3646)
Father’s Educ- <HS Diploma- Referent		
Father's Education- HS Diploma/Grade	-0.0377	(-0.0866, 0.0112)
Father's Education- College and above	-0.1218	(-0.1175, -0.0661)
Birth Event Order- 1- Referent		
Birth Event Order- 2	-0.0556	(-0.0911, -0.0201)
Birth Event Order- 3	-0.0498	(-0.0938, -0.0058)
Birth Event Order- 4+	-0.0189	(-0.0721, 0.0343)
Married	-0.0918	(-0.1308, -0.0527)
Smoking During Pregnancy	-0.6356	(-0.7100, -0.5612)
Diabetes	-0.1031	(-0.2757, 0.0695)
Hypertension	-0.0967	(-0.2148, 0.0213)
% Black - ≥ 40%	0.0960	(0.0506, 0.1414)
Poverty- ≥ 20%	0.0012	(-0.0469, 0.0492)
Urban	0.0571	(0.0184, 0.0958)
Food desert*Commercial	-0.1609	(-0.2617, 0.2740)
Food desert*Gov't/Champus	0.1010	(-0.0719, 0.2740)
Food desert*Other/Self-Pay	0.1470	(-0.0034, 0.2973)
Food desert*Smoking Status	0.2580	(0.0836, 0.4325)
Food desert*Poverty	-0.1613	(-0.2504, -0.0722)
Food desert*Urban	0.5905	(0.4807, 0.7003)

<u>Chapter III</u>: Future Studies

Pre-pregnancy obesity has been associated with adverse outcomes for both the pregnant women and the infant. Emerging literature has also shown associations of obesity with food environments. This analysis provides an approach to studying the relation between pre-pregnancy BMI and exposure to food deserts using newly documented height and weight variables to determine overweight/obesity prevalence among women residing in Georgia who had a live birth from 2008-2009. However, since these are newly documented variables, there appears to be a high percentage of women missing BMI, and therefore the data quality needs to be assessed to determine whether the association can be considered accurate and useful.

The study shows that there is an association of food desert and pre-pregnancy overweight/obese BMI for Non-Hispanic White women. However, improvements can be made to the quality and the completion rates of the information collected on the Georgia birth certificate data to reduce the large percentage of missing BMI and help to understand the complex patterns of missing data.

Future studies can include researching the hospital practices and locations for the populations to provide information on the complex patterns found for missing BMI. Determining the differences of demographics in women choosing certain hospitals, hospitals treating women with certain demographics due to location, or hospital staff reporting information on birth certificate data can provide a more clear understanding of whether the data can be representative of women in Georgia.

It may also be beneficial to explore specific food desert county areas to see differences among food access and BMI. Food desert in this dataset is binary, but each food desert may have dissimilar types of unhealthy food such as fast food restaurants, convenience stores, or smaller supermarkets. An analysis of food types in food deserts and BMI can determine whether there are stronger associations of overweight/obesity with certain types of unhealthy food providers.

This dataset contains all standard categories of BMI including underweight, normal, overweight, and obese. However, this study only looks at the association for women who are overweight/obese. Research shows women who are underweight are also at risk for adverse outcomes for both the mother and infant. Therefore, the association for pre-pregnancy underweight BMI and food desert exposure may be important to research.

Lastly, a cross-sectional secondary analysis can only determine an association between food desert and BMI, but does not indicate causality. A longitudinal study design can help understand long term exposure and causality. By tracking demographics of neighborhoods and identifying the establishment of food venues, researchers mat be able to determine a temporal causal relationship.

As the collection of birth certificate data becomes more complete, particularly with newly documented height and weight, the study can provide a novel method for population-based surveillance for pre-pregnancy BMI in Georgia with less biases and more robust data. Accurate data for pre-pregnancy BMI can help identify high risk areas or populations which can be useful in designing interventions related to increasing access to healthy foods and reducing overweight/obesity in the most at risk populations.

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Appendices

Table A1. Frequency Distributions of All Variables

N= 274776	**2008 (50.70%)**	**2009 (49.30%)**	
Variable	n (%)	n (%)	Total
MATCH			
Street level	95523 (34.76)	97371 (35.15)	192894 (70.20)
Block level	29427 (10.71)	28648 (10.43)	58075 (21.14)
Census tract level	1914 (0.70)	2203 (0.70)	4117 (1.50)
Missing	12444 (4.53)	7246 (2.64)	19690 (7.17)
Mother's Age			
1 (18-25)	58373 (21.24)	56051 (20.40)	114424 (41.64)
2 (26-35)	66453 (24.18)	65168 (23.72)	131621 (47.90)
3 (36-45)	14368 (5.23)	14100 (5.13)	28468 (10.36)
4 (46-55)	114 (0.04)	149 (0.05)	263 (0.10)
Payor			
Medicaid	50461 (18.36)	53246 (19.38)	103707 (37.74)
Commercial	37063 (13.68)	41012 (14.93)	78615 (28.61)
Gov't/Champus	5046 (1.84)	6527 (2.38)	11573 (4.21)
Other/Self-pay	11831 (4.31)	13162 (4.79)	24993 (9.10)
Missing	34367 (12.51)	21521 (7.83)	55888 (20.34)
Height (Inches)			
Missing	46543 (16.94)	34925 (12.71)	81468 (29.65)
Weight (lbs)			
Missing	42948 (15.63)	30376 (11.05)	73324 (26.69)
BMI			
normal	38045 (13.85)	40528 (14.75)	78573 (28.60)
overweight	22321 (8.12)	24613 (8.96)	46934 (17.08)
obese	22491 (8.19)	25962 (9.45)	48453 (17.63)
underweight	3575 (1.30)	3535 (1.29)	7110 (2.59)
Missing	52876 (19.24)	40830 (14.86)	93706 (34.10)
Mother's Race/Eth			
Non-Hispanic White	57226 (20.83)	57439 (20.90)	114665 (41.73)
Non-Hispanic Black	42260 (15.38)	41273 (15.02)	83533 (30.40)

Non-Hispanic Other	11202 (4.08)	8490 (3.09)	19692 (7.17)
Hispanic	8005 (2.91)	7220 (2.63)	15225 (5.54)
Missing	20615 (7.50)	21046 (7.66)	41661 (15.16)
Father's Race/Eth			
Non-Hispanic White	48240 (17.56)	48833 (17.77)	97073 (35.33)
Non-Hispanic Black	29389 (10.70)	29059 (10.58)	58448 (21.27)
Non-Hispanic Other	21115 (7.68)	7256 (2.64)	28371 (10.33)
Hispanic	7689 (2.80)	7014 (2.55)	14703 (5.35)
Missing	32875 (11.96)	43306 (15.76)	76181 (27.72)
Mother's Education			
No HS Diploma	26354 (9.59)	25791 (9.39)	52145 (18.98)
HS Diploma/Grade	41626 (15.15)	38897 (14.16)	80523 (29.30)
College and above	64263 (23.39)	62247 (22.65)	126510 (46.04)
Missing	7065 (2.57)	8533 (3.11)	15598 (5.68)
Father's Education			
No HS Diploma	20339 (7.40)	19544 (7.11)	39883 (14.51)
HS Diploma/Grade	37123 (13.51)	35262 (12.83)	72385 (26.34)
College and above	49786 (18.12)	47761 (17.38)	97547 (35.50)
Missing	32060 (11.67)	32901 (11.97)	64961 (23.64)
Father's Age			
Missing	21401 (7.79)	19096 (6.95)	40497 (14.74)
Birth Event Order			
1	54317 (19.77)	52517 (19.11)	106834 (38.88)
2	42361 (15.42)	41085 (14.95)	83446 (30.37)
3	23633 (8.60)	22892 (8.33)	46525 (16.93)
4+	16523 (6.01)	16530 (6.02)	33053 (12.03)
Missing	2474 (0.90)	2444 (0.89)	4918 (1.79)
Marital Status			
Unmarried (0)	60125 (21.88)	58591 (21.32)	118716 (43.20)
Married (1)	78971 (28.74)	76666 (27.90)	155637 (56.64)
Missing	212 (0.08)	211 (0.08)	423 (0.16)
Smoking			
No	130141 (47.36)	126537 (46.05)	256678 (93.41)
Yes	8888 (3.23)	8931 (3.25)	17819 (6.48)
Missing	279 (0.10)	0	279 (0.10)

Diabetes			
No	120731 (43.94)	123701 (45.02)	244432 (88.96)
Yes	998 (0.36)	836 (0.30)	1834 (0.67)
Missing	17579 (6.40)	10931 (3.98)	28510 (10.38)
Hypertension			
No	119941 (43.65)	122916 (44.73)	242857 (88.38)
Yes	1788 (0.65)	1621 (0.59)	3409 (1.24)
Missing	17579 (6.40)	10931 (3.98)	28510 (10.38)
Urban/Rural			
Rural	30108 (10.96)	29020 (10.56)	59128 (21.52)
Urban	109200 (39.74)	106448 (38.74)	215648 (78.48)

Table A2. Bivariate Analyses of Independent Variables by Food Desert for GA Residents Giving Birth to a Live Infant in 2008-2009

N= 274776		**Food Desert**		
Variable	**Total N**	**Yes %**	**No %**	**P-value**
MATCH				
Street level	192894	16.80	83.20	<0.0001
Block level	58075	11.17	88.83	
Census tract level	4117	14.06	85.94	
Total	255086	15.47	84.53	
Mother's Age				
1 (18-25)	114424	19.17	80.83	<0.0001
2 (26-35)	131621	13.76	86.24	
3 (36-45)	28468	11.37	88.63	
4 (46-55)	263	5.70	94.30	
Total	274776	15.76	84.24	
Payor				
Medicaid	103707	20.37	79.63	<0.0001
Commercial	78615	9.20	90.80	
Gov't/Champus	11573	16.34	83.66	
Other/Self-pay	24993	19.51	80.49	
Total	218888	16.05	83.95	
Body Mass Index				
underweight	7110	14.49	85.51	<0.0001
normal	78573	13.52	86.48	
overweight	46934	15.52	84.48	
obese	48453	17.32	82.68	
Total	181070	15.09	84.91	
Mother's Race/Eth				
Non-Hispanic White	114665	8.75	91.25	<0.0001
Non-Hispanic Black	83533	25.27	74.73	
Non-Hispanic Other	19692	12.89	87.11	
Hispanic	15225	15.40	84.60	
Missing	233115	15.45	84.55	
Father's Race/Eth				
Non-Hispanic White	97073	8.17	91.83	<0.0001

Non-Hispanic Black	58448	23.51	76.49	
Non-Hispanic Other	28371	16.02	83.98	
Hispanic	14703	13.29	86.71	
Total	198595	14.19	85.81	
Mother's Education				
No HS Diploma	52145	21.81	78.19	<0.0001
HS Diploma/Grade	80523	18.36	81.64	
College and above	126510	11.84	88.16	
Total	259178	15.87	84.13	
Father's Education				
No HS Diploma	39883	20.15	79.85	<0.0001
HS Diploma/Grade	72385	16.62	83.38	
College and above	97547	10.13	89.87	
Total	209815	14.27	85.73	
Birth Event Order				
1	106834	14.95	85.05	<0.0001
2	83446	14.90	85.10	
3	46525	16.31	83.69	
4+	33053	19.95	80.05	
Total	269858	15.78	84.22	
Marital Status				
Unmarried	118716	21.80	78.20	<0.0001
Married	155637	11.15	88.85	
Total	274353	15.76	84.24	
Smoking				
No	256678	15.75	84.25	0.3960
Yes	17819	15.99	84.01	
Total	274497	15.76	84.24	
Diabetes				
No	244432	15.21	84.79	0.9555
Yes	1834	15.16	84.84	
Total	246266	15.20	84.80	
Hypertension				
No	242857	15.18	84.82	0.0036
Yes	3409	16.98	83.02	
Total	246266	15.20	84.80	

% Black				
< 40%	216369	11.46	88.54	<0.0001
≥ 40%	58407	31.66	68.34	
Total	274776	15.76	84.24	
% Poverty				
< 20%	213168	10.90	89.10	<0.0001
≥ 20%	61608	32.57	15.12	
Total	274776	15.76	84.24	
Urban/Rural				
Rural	59128	12.06	87.94	<0.0001
Urban	215648	16.77	83.23	

Figure A1: Obesity Prevalence by Census Tract in Georgia

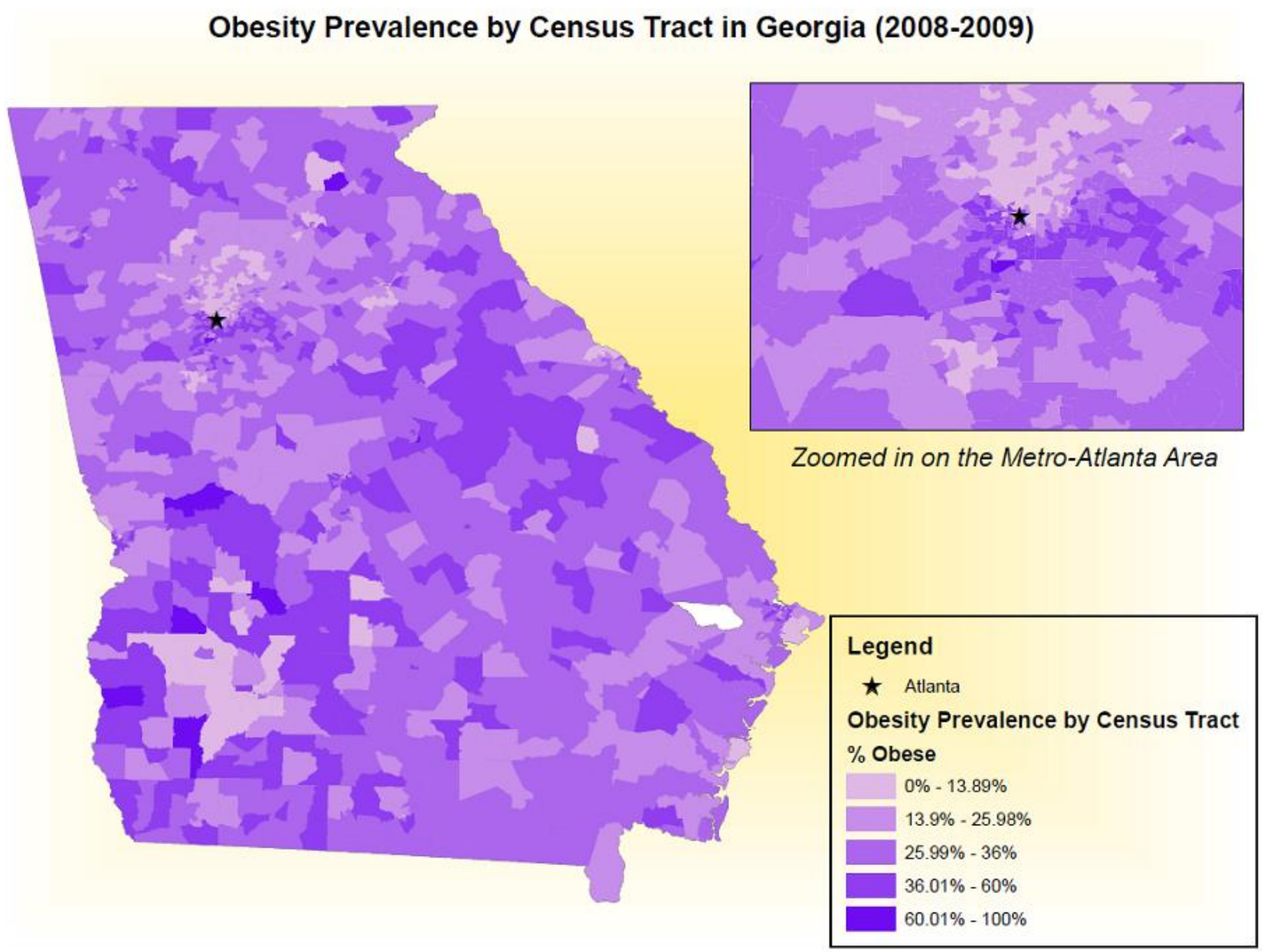

Table A2. Odds of Living in a Food Desert for Overweight/Obese Women Compared to Women With Normal BMI for GA Residents Giving Birth to a Live Infant in 2008-2009 (N=274776)

Variable	OR	95% CI	P-value
MATCH			
Street level	1.243	(1.205, 1.283)	<0.0001
Block level	1.380	(1.292, 1.473)	<0.0001
Census tract level	1.086	(0.855, 1.379)	0.4980
Total			
Mother's Age			
1 (18-25)	1.120	(1.079, 1.163)	<0.0001
2 (26-35)	1.416	(1.359, 1.475)	<0.0001
3 (36-45)	1.461	(1.325, 1.612)	<0.0001
4 (46-55)	2.960	(0.579, 15.135)	0.1924
Payor			
Medicaid	1.084	(1.045, 1.125)	<0.0001
Commercial	1.355	(1.281, 1.432)	<0.0001
Gov't/Champus	1.168	(1.032, 1.321)	0.0136
Other/Self-pay	1.153	(1.054, 1.261)	0.0019
Mother's Race			
Non-Hispanic White	1.167	(1.113, 1.225)	<0.0001
Non-Hispanic Black	0.992	(0.951, 1.034)	0.6965
Non-Hispanic Other	1.268	(1.140, 1.410)	<0.0001
Hispanic	1.165	(1.009, 1.345)	0.0369
Father's Race			
Non-Hispanic White	1.140	(1.080, 1.202)	<0.0001
Non-Hispanic Black	0.997	(0.047, 1.049)	0.9001
Non-Hispanic Other	1.275	(1.172, 1.387)	<0.0001
Hispanic	1.075	(0.923, 1.252)	0.3543
Mother's Education			
No HS Diploma	1.005	(0.948, 1.065)	0.8740
HS Diploma/Grade	1.158	(1.105, 1.213)	<0.0001
College and above	1.346	(1.291, 1.404)	<0.0001

Father's Education			
No HS Diploma	0.986	(0.921, 1.057)	0.6977
HS Diploma/Grade	1.152	(1.095, 1.2120	<0.0001
College and above	1.284	(1.220, 1.350)	<0.0001
Birth Event Order			
1	1.214	(1.162, 1.267)	<0.0001
2	1.226	(1.167, 1.287)	<0.0001
3	1.301	(1.218, 1.389)	<0.0001
4+	1.227	(1.138, 1.323)	<0.0001
Marital Status			
Unmarried	1.110	(1.070, 1.152)	<0.0001
Married	1.229	(1.248, 1.352)	<0.0001
Smoking			
No	1.271	(1.236, 1.306)	<0.0001
Yes	1.119	(1.019, 1.228)	0.0189
Diabetes			
No	1.261	(1.227, 1.297)	<0.0001
Yes	1.317	(0.863, 2.012)	0.2021
Hypertension			
No	1.260	(1.225, 1.295)	<0.0001
Yes	1.417	(1.039, 1.932)	0.0277
% Black			
< 40%	1.232	(1.191, 1.275)	<0.0001
≥ 40%	1.014	(0.969, 1.062)	0.5484
% Poverty			
< 20%	1.268	(1.224, 1.314)	<0.0001
≥ 20%	1.019	(0.976, 1.065)	0.3906
Urban/Rural			
Rural	1.061	(1.000, 1.125)	0.0500
Urban	1.330	(1.291, 1.370)	<0.0001

Table A3. Odds of Living in a Food Desert for Women With Missing BMI Compared to Women With Reported BMI for GA Residents Giving Birth to a Live Infant in 2008-2009 (N=274776)

Variable	OR	95 % CI	P-Value
MATCH			
Street level	1.192	(1.163, 1.221)	<0.0001
Block level	1.048	(0.992, 1.107)	0.0929
Census tract level	2.143	(1.791, 2.564)	<0.0001
Total			
Mother's Age			
1 (18-25)	1.096	(1.063, 1.130)	<0.0001
2 (26-35)	1.203	(1.165, 1.243)	<0.0001
3 (36-45)	1.271	(1.179, 1.370)	<0.0001
4 (46-55)	1.510	(0.530, 4.300)	0.4406
Payor			
Medicaid	1.156	(1.118, 1.196)	<0.0001
Commercial	1.085	(1.022, 1.152)	0.0078
Gov't/Champus	0.993	(0.894, 1.104)	0.9030
Other/Self-pay	1.274	(1.197, 1.357)	<0.0001
Mother's Race			
Non-Hispanic White	0.803	(0.765, 0.843)	<0.0001
Non-Hispanic Black	1.179	(1.141, 1.218)	<0.0001
Non-Hispanic Other	1.001	(0.917, 1.093)	0.9865
Hispanic	1.121	(1.025, 1.226)	0.0128
Father's Race			
Non-Hispanic White	0.773	(0.732, 0.816)	<0.0001
Non-Hispanic Black	1.160	(1.115, 1.208)	<0.0001
Non-Hispanic Other	1.154	(1.081, 1.231)	<0.0001
Hispanic	1.578	(1.433, 1.739)	<0.0001
Mother's Education			
No HS Diploma	1.049	(1.006, 1,094)	0.0255
HS Diploma/Grade	1.078	(1.038, 1.119)	<0.0001
College and above	1.079	(1.040, 1.120)	<0.0001
Father's Education			
No HS Diploma	1.070	(1.019, 1.124)	0.0071

HS Diploma/Grade	1.069	(1.026, 1.115)	0.0015
College and above	1.070	(1.022, 1.120)	0.0035
Birth Event Order			
1	1.107	(1.069, 1.146)	<0.0001
2	1.187	(1.141, 1.236)	<0.0001
3	1.153	(1.096, 1.214)	<0.0001
4+	1.132	(1.071, 1.197)	<0.0001
Marital Status			
Unmarried	1.127	(1.096, 1.160)	<0.0001
Married	1.086	(1.050, 1.123)	<0.0001
Smoking			
No	1.149	(1.124, 1.174)	<0.0001
Yes	1.363	(1.234, 1.506)	<0.0001
Diabetes			
No	1.068	(1.043, 1.094)	<0.0001
Yes	0.947	(0.716, 1.252)	0.7011
Hypertension			
No	1.065	(1.040, 1.091)	<0.0001
Yes	1.251	(1.029, 1.521)	0.0245
% Black			
< 40%	1.170	(1.139, 1.203)	<0.0001
≥ 40%	1.090	(1.051, 1.130)	<0.0001
% Poverty			
< 20%	1.166	(1.134, 1.200)	<0.0001
≥ 20%	1.100	(1.062, 1.139)	<0.0001
Urban/Rural			
Rural	0.684	(0.644, 0.725)	<0.0001
Urban	1.234	(1.205, 1.263)	<0.0001

Table A4: Assessing Interaction For Both Final Models

	Overweight/Obese vs. Normal BMI		Not missing vs. Missing BMI	
Interaction term	**P-value**	**Keep**	**P-value**	**Keep**
Mother's Age	0.6553	No	0.2024	No
Payor	0.6875	No	**0.0003**	**Yes**
Mother's Race/Eth	**0.0052**	**Yes**	0.5034	No
Father's Race	0.1008	No	<0.0001	No
Mother's Education	0.0799	No	0.9559	No
Father's Education	**0.0035**	**No**	0.2525	No
Birth Event Order	0.1058	No	0.2687	No
Marital Status	0.1969	No	0.3698	No
Smoking	0.5584	No	**0.0037**	**Yes**
Diabetes	0.4504	No	0.2101	No
Hypertension	0.5822	No	0.068	No
% Black	0.1128	No	0.8411	No
% Poverty	0.6894	No	**0.0004**	**Yes**
Urban/Rural	0.509	No	**<0.0001**	**Yes**

A5: Confounding Assessment of Model for Association of Overweight/Obese BMI and Food Desert Adjusted with Interaction

			Food Desert Yes vs. No White mothers		Food Desert Yes vs. No Black mothers		Food Desert Yes vs. No Hispanic mothers		Confounder (>10% of GS)
Model	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	
Food Desert	1.258	(1.224, 1.292)	-	-	-	-	-	-	-
Gold Standard (GS)			1.083	(1.021, 1.149)	0.951	(0.895, 1.009)	1.038	(0.845, 1.275)	-
GS- Age			1.075	(1.014, 1.140)	0.944	(0.889, 1.002)	1.037	(0.844, 1.272)	No
GS- Age- Payor			1.077	(1.015, 1.142)	0.945	(0.890, 1.004)	1.039	(0.846, 1.275)	No
GS- Age-Payor- Father's Race/Eth			1.084	(1.023, 1.150)	0.947	(0.892, 1.006)	1.056	(0.860, 1.295)	No
GS- Age-Payor- Father's Race/Eth-Education			1.084	(1.022, 1.149)	0.948	(0.893, 1.007)	1.049	(0.855, 1.287)	No
GS- Age- Payor- Father's Race/Eth- Education- Father's Educ			1.111	(1.049, 1.178)	0.971	(0.915, 1.030)	1.096	(0.894, 1.343)	No
GS- Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order			1.101	(1.039, 1.167)	0.979	(0.923, 1.039)	1.090	(0.890, 1.335)	No

GS- Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order- Marital Status	1.100	(1.038, 1.166)	0.973	(0.917, 1.032)	1.082	(0.883, 1.325)	No
GS- Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order- Marital Status- Smoking	1.104	(1.042, 1.170)	0.974	(0.918, 1.034)	1.081	(0.882, 1.324)	No
GS-Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order- Marital Status- Smoking- Diabetes	1.105	(1.043, 1.171)	0.974	(0.918, 1.033)	1.078	(0.880, 1.320)	No
GS- Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension	1.105	(1.044, 1.170)	0.970	(0.916, 1.028)	1.092	(0.895, 1.333)	No
GS- Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension- % Black	1.109	(1.048, 1.175)	0.973	(0.919, 1.031)	1.095	(0.897, 1.337)	No

GS- Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension- % Black- Poverty	1.130	(1.068, 1.195)	0.993	(0.938, 1.052)	1.123	(0.920, 1.370)	No
GS- Age-Payor- Father's Race/Eth- Education- Father's Educ- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension- % Black- Poverty- Urban	1.176	(1.112, 1.244)	0.970	(0.917, 1.027)	1.094	(0.897, 1.335)	No

A6: Confounding Assessment of Model for Association of Overweight/Obese BMI and Food Desert Adjusted Without Interaction

	OR	95% CI	
Food Desert	1.258	(1.224, 1.292)	-
Gold Standard (GS)	1.017	(0.975, 1.061)	-
GS- Age	1.01	(0.968, 1.053)	No
GS- Age- Payor	1.012	(0.970, 1.055)	No
GS- Age-Payor- Race/Eth	1.015	(0.973, 1.058)	No
GS- Age- Payor- Race/Eth- Father's Race/Eth	1.092	(1.048, 1.137)	No
GS- Age- Payor-Race/Eth- Father's Race/Eth- Education	1.092	(1.048, 1.137)	No
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- **Father's Educ**	1.121	(1.076, 1.168)	Yes
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order	1.095	(1.01, 1.141)	No
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order- Marital Status	1.096	(1.052, 1.141)	No
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order- Marital Status- Smoking	1.096	(1.052, 1.142)	No
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order- Marital Status- Smoking- Diabetes	1.096	(1.052, 1.142)	No
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension	1.097	(1.054, 1.142)	No

GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension- **% Black**	1.135	(1.091, 1.181)	Yes
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension- Poverty	1.100	(1.058, 1.145)	No
GS- Age- Payor- Race/Eth- Father's Race/Eth- Education- Birth Event Order- Marital Status- Smoking- Diabetes- Hypertension- Poverty- Urban	1.099	(1.057, 1.144)	No

EMORY UNIVERSITY

Institutional Review Board

TO: **Amee Khamar**
Principal Investigator
Public Health

DATE: **December 28, 2011**

RE: **Expedited Approval**
IRB00055064
Association of Women's Pre-conceptional BMI, and Neighborhood and Food Availability

Thank you for submitting a new application for this protocol. This research is eligible for expedited review under 45 CFR.46.110 because it poses minimal risk and fits the regulatory category F(5) as set forth in the Federal Register. The Emory IRB reviewed it by expedited process on 12/28/2011 and granted approval effective from 12/28/2011 through 12/27/2012. Thereafter, continuation of human subjects research activities requires the submission of a renewal application, which must be reviewed and approved by the IRB prior to the expiration date noted above.

Complete waivers of HIPAA authorization and of informed consent are granted for this study

Any reportable events (e.g., unanticipated problems involving risk to subjects or others, noncompliance, breaches of confidentiality, HIPAA violations, protocol deviations) must be reported to the IRB according to our Policies & Procedures at www.irb.emory.edu, immediately, promptly, or periodically. Be sure to check the reporting guidance and contact us if you have questions. Terms and conditions of sponsors, if any, also apply to reporting.

Before implementing any change to this protocol (including but not limited to sample size, informed consent, study design, you must submit an amendment request and secure IRB approval.

In future correspondence about this matter, please refer to the IRB file ID, name of the Principal Investigator, and study title. Thank you

Rebecca Rousselle, CIP
Assistant Director
This letter has been digitally signed

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