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ASSOCIATION BETWEEN FOOD DESERTS AND DIABETES RELATED MORBIDITY AND MORTALITY AMONG RESIDENTS OF FULTON COUNTY, GEORGIA

BY

MADHUBANTI CHATTERJI

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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2013

ASSOCIATION BETWEEN FOOD DESERTS AND DIABETES RELATED MORBIDITY AND MORTALITY AMONG RESIDENTS OF FULTON COUNTY, GEORGIA

BY

MADHUBANTI CHATTERJI

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May 2, 2013

Abstract

BY MADHUBANTI CHATTERJI

Association between Food Deserts and Diabetes Related Morbidity and Mortality Among Residents of Fulton County, Georgia. (Under the guidance of Dr. Ike S. Okosun, PhD. Faculty Member).

Background: Diabetes is one of the leading causes of death and disability among chronic diseases in the United States. Type 2 diabetes, which accounts for 90-95% of all diabetes cases, is a preventable form of disease which can be controlled through diet and physical activity. But residents of places such as 'food deserts', with no access to fresh food, often bear the burden of chronic diseases such as diabetes. There have been very few studies which have particularly looked at the association between food environment and diabetes prevalence in such deprived areas.

Objective: The study investigated the association between living in food desert and developing diabetes or dying from the disease. It considered factors such as access to grocery stores and supermarkets, convenience stores, food joints and owning a personal vehicle that might affect diabetes related morbidity and mortality. It has also looked at factors such as income and race which might influence the association.

Methodology: The study emphasizes on the lack of access to food, in low income and deprived neighborhoods and its impact on diabetes mortality and morbidity at the micro level of census tracts in Fulton County, Georgia. Diabetes related data was obtained from OASIS and Fulton County Department of Health and Wellness for the years 1994-2010 for 204 census tracts of Fulton County. Data for food desert distribution was extracted from the 'Food desert Locator' tool of the United States Department of Agriculture (USDA). Data on food stores was obtained through ReferenceUSA. Demographic information was acquired from American Fact Finder of the US Census Bureau. SPSS version 21 was used to calculate Pearson's correlation to find the association between food environment and diabetes as well as to see whether there is an association between income and vehicle ownership with diabetes occurrence. ArcGIS 10.1 was used to represent data as maps showing the geographical distribution of various factors across the County and their association with the occurrence of diabetes.

Results: Low income African American dominated census tracts which have been designated as food deserts have a higher occurrence of morbidity and mortality from diabetes. The correlation between number of supermarkets and grocery stores, convenience stores and full service restaurants has no statistically significant relation with diabetes. Similarly, there is no statistically significant relation between car ownership and diabetes. But the relationship between income and diabetes has a statistical significance.

Conclusion: This study did not find any significant statistical association between diabetes and living in food desert. But from the GIS maps it can be observed that the number of food markets (supermarkets and grocery stores) is much less in the low income tracts than elsewhere and these are also the tracts which have higher occurrence of diabetes. Similarly, the numbers of convenience stores, which usually do not have a healthy collection of food, are more in the low income neighborhoods. The weak association between the factors studied might be because other factors such as education and access to healthcare have not been considered for this study. More research in this field is required to get a better picture of the diabetes health status in food desert areas.

Author's Statement Page

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Madhubanti Chatterji

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Signature of Author

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Lastly, I would also like to thank my family members, especially my husband and my mother-in-law for taking care of the household during my thesis submission. Without their assistance it would not have been possible to complete this study in time.

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Chapter 1-Introduction

Growing diabetes prevalence in the United States

According to the American Diabetes Association, the 2011 National Diabetes Fact sheet (Jan 26, 2011)[1] represents the total prevalence of diabetes in the United States. 25.8 million children and adults, which comprises of 8.3% of the total American population, suffered from diabetes ("Diabetes Basics; Diabetes Statistics," 2011). This includes both diagnosed and undiagnosed diabetes cases. The figure will go up drastically if we add the estimated prediabetic and new cases of diabetes to the total. The same report states that in 2007, diabetes related mortality was 231,404. Diabetes was listed as the underlying cause on 71,382 death certificates. It was also listed as a contributing factor on an additional 160,022 death certificates. Racial and ethnic differences have been observed in diabetes prevalence. The National Diabetes Fact sheet, 2011 estimates that after adjusting for population age differences, national survey data (2007–2009) showed among people aged 20 years or older, 7.1% of non-Hispanic whites, 8.4% of Asian Americans, 11.8% of Hispanics, and 12.6% of non-Hispanic blacks were diagnosed with diabetes (CDC, 2011). According to the CDC, type 1 diabetes is usually diagnosed in children and young adults but it can occur at any age. This form of diabetes accounts for 5% of diabetes cases and may be caused by genetic, environmental, or other factors. Measures for preventing this form of diabetes are still unknown and effective treatment requires the use of insulin. On the other hand, Type 2 diabetes accounts for 90%–95% of diabetes cases. This form is preventable since it is influenced by diet, physical activity and body weight. It can be controlled through healthy food choices, physical activity, and weight loss but insulin or oral medication also may be necessary. ("Successes and Opportunities for Population-Based Prevention and Control At A Glance 2011," 2011).

[1] http://www.diabetes.org/diabetes-basics/diabetes-statistics/

Reasons for increase in Type 2 Diabetes Mellitus

Type 2 diabetes is the most common form of diabetes in the United States ("Diabetes Basics Type 2," 2013). The risk of developing this type of diabetes varies by ethnicity. It is more common among African Americans, Latinos, Native Americans, Asian Americans, Native Hawaiians and other Pacific Islanders, as well as the aged population ("Diabetes Basics Type 2," 2013). Obesity and lack of physical activity are often the most important contributing factors to this type of diabetes ("Causes of Type 2 diabetes," 2012).

Recent medical findings also support the above mentioned statement that the chances of getting type 2 diabetes increase with the following health risk factors; family history of diabetes, age over 45**,** race or ethnic background, metabolic syndrome, being overweight**,** hypertension, high blood pressure, abnormal lipid levels**,** HDL cholesterol levels under 35 mg/dL (milligrams per deciliter) and/or a triglyceride level over 250 mg/dL and impaired glucose tolerance ("Type 2 Diabetes Risk Factors," 2012).

'Diabetes belt' in southern United States

Georgia has one of the highest rates of diabetes in the United States and falls in the 'diabetes belt' of the nation. The diabetes belt consists of 644 counties in 15 states in southern United States. The Centers for Disease Control and Prevention (CDC) reports that people living in this belt are more likely to have type 2 diabetes. Obesity is one of the major cause of type 2 diabetes in this belt ("Diabetes Public health Resource: CDC identifies Diabetes Belt," 2011). The diabetes belt has a higher proportion of older Americans and African Americans who are more susceptible to diabetes (Diabetes Belt, 2011).

Diabetes prevalence in Georgia and Fulton County

In 2010, the Behavioral Risk Factor Surveillance System (BRFSS) survey indicated that the prevalence of diabetes among adults in Georgia was 9.7%. This figure rose significantly from 6.8% between 2000 and

2010 ("2012 Georgia Diabetes Burden Report: An Overview," 2012). About two-thirds of the counties in Georgia are estimated to have diabetes prevalence among adults (> 20 years) greater than 11.1%. The prevalence of diabetes among Georgia adults is significantly greater in Non-Hispanic Blacks (12.8%; 236,570 adults) when compared to Non-Hispanics White (8.4%; 382,469 adults) ("2012 Georgia Diabetes Burden Report: An Overview," 2012). The report also states that households with an annual income of less than $15,000 had significantly greater diabetes prevalence than households in income groups of $25,000 or more.

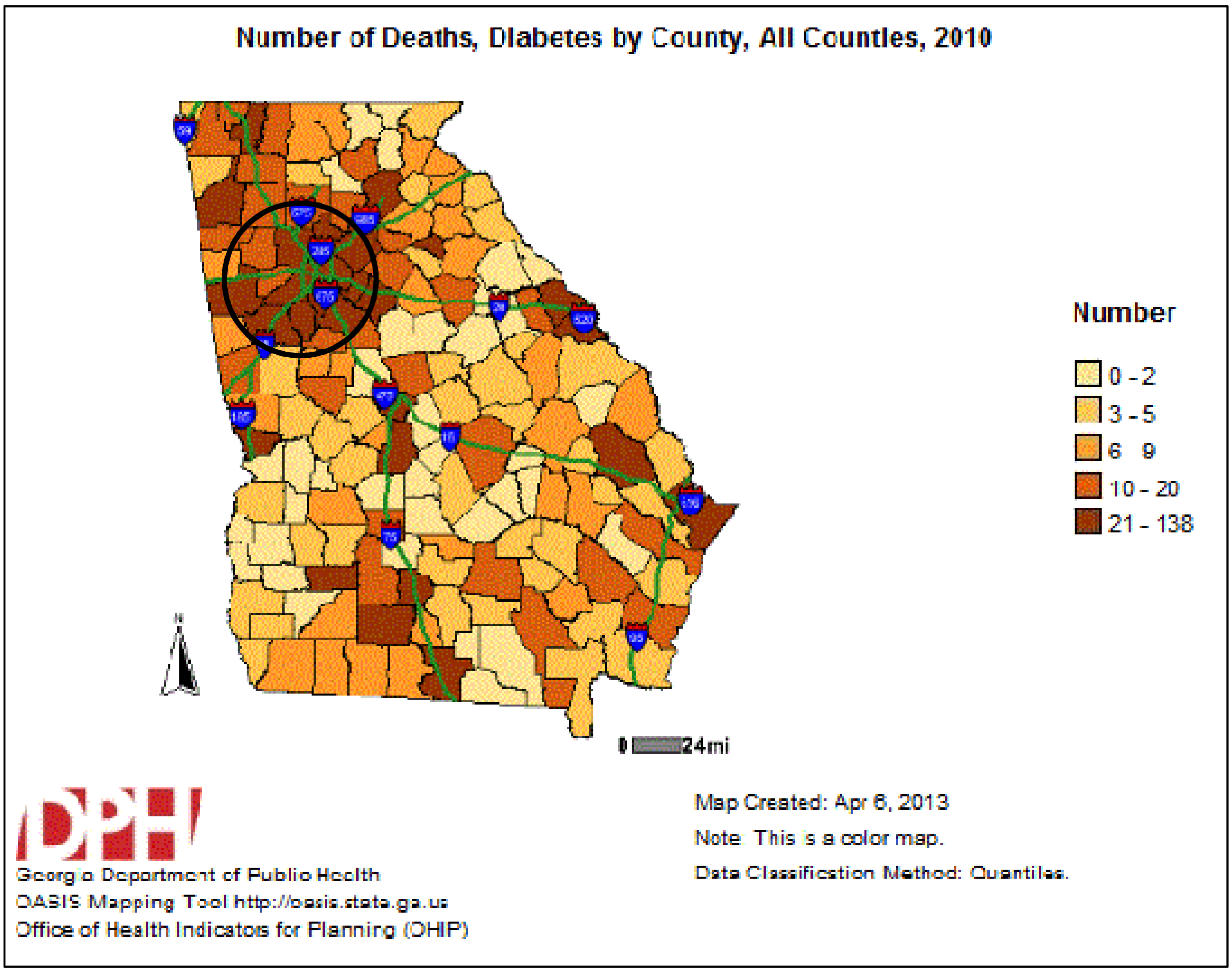

Fig 1: Diabetes Mortality County wise, Georgia 2010 (Map created using OASIS Mapping Tool)

The Georgia Diabetes Burden Report estimates that the total cost of diabetes in Georgia is approximately $5.1 billion. This includes medical costs of $3.3 billion due to diabetes and $1.8 billion in lost productivity costs due to diabetes. Among all Medicaid beneficiaries in Georgia, in 2007, $372.6 million was spent on Georgia Medicaid recipients with diabetes ("2012 Georgia Diabetes Burden Report: An Overview," 2012).

The study area, Fulton County, has a diabetes prevalence of 8.1% compared to the state average of 9.7% ("2012 Georgia Diabetes Burden Report: An Overview," 2012). This County has one of the highest diabetes related mortality in Georgia, as shown by the darkest shade in Figure 1. Fulton County is the seat of the state capital, Atlanta and is one of the five core counties of Atlanta Metropolitan area. It is also the most populous county in the state of Georgia. Diabetes is one of the most common diseases in Fulton County ("Diabetes," 2011). Diagnosed diabetes percentage in this County has increased from 7.5 % in 2004 to 8.2 % in 2009 ("Diabetes Public Health Resource > Diabetes Interactive Atlases,"). An estimated number of 36420 or 9.1% (CI: 8.9-9.2%) of all the residents of Fulton County 18 years and over have diabetes. Racial disparity in diabetes prevalence is also observed in the County with 12.2% (CI: 9.3-16.0%) of non-Hispanic Blacks having diabetes compared to 5.4% (CI: 3.9-7.5%) of all non-Hispanic Whites. 10.8% (CI: 5.5-20.1%) of all Hispanics and other non-Black non-Whites in Fulton County have diabetes. Blacks are 2.3 times more likely to have diabetes compared to Whites in Fulton County. People of color including Blacks and Hispanics are more affected by diabetes compared to their White counterparts (Mdodo, 2011). The death rate for non-Hispanic White in Fulton County in 2010 was 6.9 compared to death rate of 25.9 for non-Hispanic Blacks in the same year (OASIS, 2013).

Association between food environment and diabetes prevalence

High fat and carbohydrate diet are considered risk factors for type 2 diabetes (WebMD, 2013). Hence, food environment in which one lives determines to a large extent whether the person has a higher probability of developing diabetes in his lifetime or not (California Center for Public Health Advocacy, 2013). Most of the studies related to the built environment, food access and health outcomes thereof have focused on body mass index and obesity. There have not been a large number of studies which looked at the association between food environment and diabetes prevalence. Accessibility and availability of supermarkets, grocery stores and fast food joints influence the health status of individuals, such as diabetes and cardiovascular diseases.

Access to quality food and diabetes

A healthy diet is key to preventing and controlling type 2 diabetes. Avoiding fatty food, especially saturated fat and consuming variety of whole grains, fresh fruits and vegetables, lean meats and limited carbohydrates can reduce the prevalence of diabetes (American Diabetes Association, Fat and Diabetes, 2013). Access to quality food can play a crucial role in determining the diabetes health status of individuals. Fulton County is plagued with several food deserts where there is no access to grocery stores of supermarkets. Residents of these neighborhoods usually belong to the low income population (Food Desert Locator USDA, 2013). They often have to travel long distances to reach a grocery store which is not always possible because they might not own a car. Under such circumstances, the lack of access to healthy food puts them at higher risk for becoming overweight, obese, and experiencing health problems such as diabetes.

Purpose of study

The main purpose of the study is to highlight the importance of access to healthy food and its implications on diabetes health status. It examines whether there is a an association between lack of access to fresh food, large grocery stores or supermarkets in low income, USDA designated food deserts in Fulton County, GA and the mortality and morbidity from diabetes among the residents. The study examines whether one’s geographic location within the County influences health status measured by diabetes morbidity and mortality in each census tract. It looks at factors such as household income, transportation and race/ethnicity in food deserts in Fulton County and determines whether there is a significant difference in diabetes morbidity and mortality across the County based on the above factors. Figure 2 represents the distribution of food deserts in Fulton County. According to Census 2010, Fulton County comprises of twenty eight food deserts according to the United States Department of Agriculture (USDA).

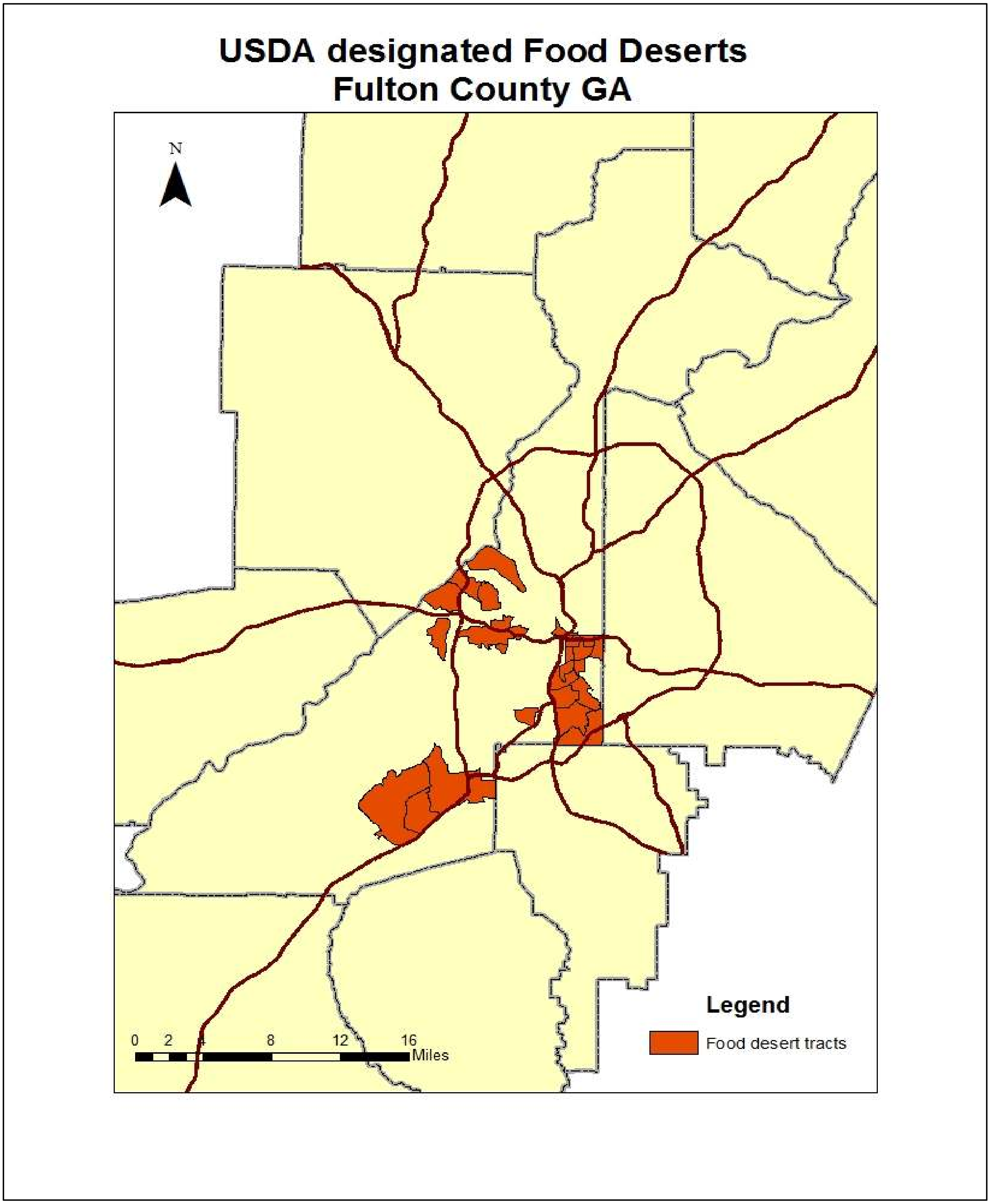

Fig 2: Food Desert Distribution in Fulton County at Census Tract Level

This research is important because little information exists that discuss the prevalence and diabetes at the state and metro area level which is associated with lack of access to healthy food. With this data and information, key stakeholders can make informed decisions concerning diabetes, its impact on their communities, and resource allocation.

Hypotheses:

Based on the study purpose and research questions mentioned in the previous paragraph, the study has the following hypotheses;

1. $\mathbf{H_0}$ = Diabetes morbidity and mortality is not associated with ones geographic location, in this case living in food deserts does not affect the diabetes morbidity and mortality of the residents.

   $\mathbf{H_1}$ = Diabetes mortality and morbidity is negatively associated with living in food deserts. People living in food deserts have a higher probability of developing diabetes than others.

2. $\mathbf{H_0}$ = Diabetes mortality and morbidity is not associated with race, income and car ownership.

   $\mathbf{H_1}$ = Income: Income has an indirect association between diabetes mortality and morbidity, higher income reduces the probability of developing diabetes and vice versa.

   Race: Blacks and Hispanics living in food deserts have a higher probability of developing diabetes.

   Car ownership: People who have their own cars have lower risk of developing diabetes than those without a car.

Chapter 2- Literature Review

Diabetes prevalence has been rising over the years with increasing number of new cases added every year. This is more noticeable in case of type 2 diabetes. Studies have projected that between 2010 and 2025, there would be an increase of 64% which means 53.1 million Americans will be suffering from this chronic disease. Diabetes related costs will also spike in this time period resulting in medical and societal costs of half trillion dollars per year. Although there is no known cure for diabetes, type 2 diabetes can be prevented with significant lifestyle changes on the part of the society as a whole (Rowley & Bezold, 2012). Major lifestyle changes which are believed to prevent diabetes prevalence are physical activity and diet. Obesity and physical inactivity are considered the key risk factors for development of type 2 diabetes. Types of diet have also been studied as risk factors for diabetes. It has been confirmed that an increased intake of sugary drinks and fast food contributes to higher risks of developing type 2 diabetes (Sekerija, Poljicanin, & Metelko, 2012).

Since diet is a risk factor for diabetes, this brings us to the fact that food environment and access to healthy food play a crucial role in determining diabetes prevalence in the population. Studies have shown behavioral changes such as improving one's diet can reduce, reverse or even prevent development of diabetes, but there might be underlying factors such as no access to healthy food options which might prevent any dietary improvement among certain groups of the society. Income, race/ethnicity, and geographic locations can determine one's access to healthy food. The literature review will look at several aspects which decide one's access to food and how it determines the risk of developing diabetes.

Food Deserts

The term "food desert" was formally introduced in 1995. It is described as areas with limited access to affordable nutritious foods, particularly in lower-income neighborhoods. Several national and regional maps have been developed that focus efforts on equity in food access. Recognition of food deserts also changes public health's approach to obesity prevention and diet related diseases such as obesity and diabetes. Studies nowadays emphasize on the role of the environment in health promotion (Karpyn, Young, & Weiss, 2012). According to the CDC, 'food deserts are areas that lack access to affordable fruits, vegetables, whole grains, lowfat milk, and other foods that make up the full range of a healthy diet'(CDC, 2012). It is difficult to estimate the number of people living in food deserts in the United States since there is no standard definition of a food desert. According to a report by the US Department of Agriculture (USDA), a small percentage of American consumers have limited ability to access affordable nutritious food because they live far from a supermarket or large grocery store and do not have easy access to transportation. The report also states the extent and characteristics of food deserts, analyzes the consequences of food deserts and policy options and lessons from various Federal programs for alleviating the effects of food deserts (Ploeg, 2009)**.** For this study purpose, food desert has been defined according to the USDA's Food Desert Locator definition which defines ,' a food desert as a *low-income census tract* where a substantial number or share of residents has *low access* to a supermarket or large grocery store'. A 'low income census tract' in this case must have a poverty rate of 20% or more or a median family income at or below 80% of the area's median family income. A 'low access community' on the other hand, should comprise of at least 500 people and/or at least 33% of the census tract's population in urban areas must reside more than one mile from a supermarket or large grocery store ("Food Desert Locator," 2012).

Food deserts can have substantial negative impacts on health. Many studies suggest that food deserts may negatively affect health outcomes, but more research is needed to determine how access to food influences the types of foods consumers purchase and eat. Researchers   believe there is a link between access to affordable nutritious foods and the intake of those foods. But studies have also shown that even when healthier food options are available in food deserts, many consumers continue to make unhealthy choices which might be because of personal preferences or socio-economic factors (CDC, 2012). It is more likely that consumers decide what to spend and where to spend on food depending on the accessibility and affordability of food retailers, travel time to shopping, availability of healthy foods, and food prices. Impoverished neighborhoods and their residents may face greater barriers in accessing healthy and affordable food retailers, which may negatively affect diet and food security ("Food Access," 2012).

Association between food environment and diet

Food environment is often considered a factor in determining one's health based on dietary choices. More studies have now established that where one lives play a crucial role in determining the person's health. It is not always personal dietary choice that influences chronic diseases such as obesity and diabetes. The environment in which one lives for the most part of his life should be conducive to making healthier dietary choices which can prevent developing diet related diseases such as obesity and diabetes.

Moore and colleagues have studied the association between neighborhood characteristics and location of food stores. They observed that the presence of strong residential segregation by income and race/ethnicity in the United States suggests that the local food environment may contribute to socioeconomic and racial/ethnic differences in health. Healthy foods including whole-grain products, low-fat dairy foods, and fresh fruits and vegetables, may be less available, and relatively more costly, in poor and minority neighborhoods than in wealthier and White neighborhoods. Supermarkets, offering nutritious foods at lower costs, have mostly moved from urban to suburban areas. There is also a lack of private or convenient transportation among the urban poor which contributes to health disparities in heart disease, obesity, and diabetes (Moore & Diez Roux, 2006).

A pilot test to measure aspects of built and food environment in urban areas was conducted known as the EURO-PREVOB Community Questionnaire, within an EU-funded project. It was based on samples from different socio-economic status in the different study areas comprising of five cities. The study concluded that environmental factors can impact dietary intake and physical activity (Pomerleau et al., 2013). One study looked at food venue choice and consumer food environment in an affluent sample at Lexington, Kentucky. The type of supermarket where individuals shop may influence intake and weight status. Those who shopped at a supermarket with healthy food reported lower odds of consuming sugar-sweetened beverages. It was observed that those who prefer to purchase fresh produce were more likely to go to farmer's markets and have higher consumption of fruits and vegetables (Gustafson, Lewis, Moore, & Jilcott, 2013). Diet related chronic diseases such as obesity and diabetes affect adults and children. Adolescents are increasingly becoming victims of obesity and associated diseases due to poor unhealthy diet. A longitudinal association in adolescents attending secondary schools in East London observed that the local food environment may influence adolescent diet. The study also observed that there were small parameter estimates of significant negative relationships between proximity to takeaways and unhealthy diet scores (Smith, Cummins, Clark, & Stansfeld, 2013). Higher consumption of unhealthy food products has been seen to be associated easy access. This effect could be reduced by use of self-regulation strategies to aid healthy eating even when the food environment might tempt to do otherwise (de Vet et al., 2013). Young children are often the most vulnerable to unhealthy food if they are exposed to an environment not favorable to healthy food. Environmental interventions such as reducing food promotion to young children, increasing the availability of smaller portions and providing alternatives to sugar-sweetened soft drinks should be considered in obesity prevention programs aimed at younger children making them less vulnerable to developing diet related diseases (Osei-Assibey et al., 2012).

It is still not clear what constitutes a food environment and how it influences individual dietary behavior. Researches have focused on the built environment and nutrition related outcomes. Means of travel and distance to food shopping venues differ among individuals in different food environments and individual and household level factors are associated with food shopping patterns. One study found no significant difference in shopping frequency or motivating factor behind store choice between the study groups. It also did not find any difference between the two groups for long food shopping trips. Individuals in the favorable food environment with shorter distance to travel were more likely to walk than drive. Several factors such as socioeconomic status, including car ownership, education, and income influenced distance traveled. These findings highlight the complexities involved in the study of food environments (Hirsch & Hillier, 2013). Spatial access to and frequent utilization of convenience food stores influence the amount of nutrients consumed even when food items are purchased from supermarkets or dollar stores. Households where children independently purchased food from a convenience store at least once a week had energy dense foods and beverages with increased amounts of saturated fat. Increased distance to the nearest convenience store was associated with reduced amounts of total energy, vitamin D, total sugar, added sugar, total fat, and saturated fat. Children who participated in the National School Lunch Program (NSLP) had lower levels of total energy, calcium, vitamin C, sodium, vitamin D, and saturated fat (Sharkey, Dean, Nalty, & Xu, 2013). The Philadelphia Healthy Corner Store Initiative examined whether there is an association between availability, quality, and price of key types of healthy and less-healthy foods found in corner stores in low-income urban neighborhoods and between store characteristics and store food environments. There were significantly less healthier options available in all food categories and the food items were often more expensive (Cavanaugh, Mallya, Brensinger, Tierney, & Glanz, 2013).

The knowledge of how individuals interact with their neighborhood food environment is limited. Residents of low income neighborhoods respond differently to food environments. Therefore, it is necessary to understand how residents of deprived neighborhoods interact with their food environment. This will help enhance environmental interventions to improve physical access to food (Thompson, Cummins, Brown, & Kyle, 2013). One study suggested healthier food environments might discourage fast food consumption. Respondents in areas with healthier food options had a lower likelihood of purchasing fast food while those who lived in areas with a higher unhealthy food options were more likely to purchase fast food (Thornton & Kavanagh, 2012).

Food insecurity as a risk factor for diabetes

Food insecurity is defined as limited or uncertain access to food resulting from inadequate financial resources (Seligman, Bindman, Vittinghoff, Kanaya, & Kushel, 2007). Food insecurity is often observed among food desert residents who live in the disadvantaged neighborhoods with low or no access to quality food. People living in such disadvantaged neighborhoods have worse health outcomes, often manifested by obesity and diabetes. Diabetic patients, especially the ones suffering with type 2 diabetes mellitus, can often control their diabetes by eating healthy. But lack of supermarkets makes it more difficult to maintain a nutritious and healthy diet. People suffering from type 2 diabetes in a number of Chicago neighborhoods and suburban pockets do not have access to supermarkets. The problem is more pronounced in predominantly African-American neighborhoods on the South and West sides, where access to grocery stores, farmers markets or other vendors selling fresh, high-quality, affordable food is limited or nonexistent (Garcia, 2012).

Seligman and peers evaluated whether there is an independent association between food insecurity and diabetes through a cross-sectional analysis of the nationally representative, population-based National Health and Nutrition Examination Survey (1999-2002 waves). They observed that diabetes prevalence in the food secure, mildly food insecure, and severely food insecure categories was 11.7%, 10.0%, and 16.1%. After adjusting for socio-demographic factors and physical activity level, participants with severe food insecurity were more likely to have diabetes than those without food insecurity. They concluded that food insecurity may act as a risk factor for diabetes. Adults with food insecurity consume increased amount of inexpensive food alternatives, which are often calorie dense and nutritionally poor (Seligman et al., 2007). In a study done in Perth, Australia, it was observed that low-income earners living with diabetes faced food security issues. In this qualitative study, participants reported cost barriers, as well as physical barriers relating to functional limitations and lack of transportation as factors preventing them from following a healthy and nutritious diet which will aid in self-care of diabetes (Beatriz, Sherry, & Alexandra, 2011). One particular study examined whether food insecurity is associated with poor glycemic control and whether this association is mediated by difficulty following a healthy diet, diabetes self-efficacy, or emotional distress related to diabetes. The results showed food-insecure participants were significantly more likely than food-secure participants to have poor glycemic control. Hence, this risk may be partially due to increased difficulty following a diabetes-appropriate diet and increased emotional distress regarding capacity for successful diabetes self-management (Seligman, Jacobs, Lopez, Tschann, & Fernandez, 2012). Food environments conducive to healthy eating may significantly influence weight which in turn can influence diabetes prevalence. Among youths with diabetes, the influence of built environment represented by accessibility and availability of supermarkets and fast food outlets has a significant influence on their health. In a South Carolina study, youths with diabetes participated to examine the influence of built environment on health outcomes. The results showed increased number and density of chain supermarkets around residence location were associated with lower BMI z-score and waist circumference. Similarly, lower supermarket density around residence location was associated with increased waist circumference, when compared to residence location with the highest supermarket density (Lamichhane et al., 2012). Mari Gallagher and group conducted a study in Chicago's food desert areas and the health outcomes thereof. Communities that have out-of-balance food environments have significantly higher rates of residents dying prematurely from diabetes. The more out of balance the community, more lives are lost to diabetes (Gallagher, 2006).

Racial/ethnic disparities in diabetes prevalence and reasons behind the disparity

The prevalence of diabetes has increased 47.5% from 1997 to 2008 ("Diabetes: Healthy People 2010,"). The burden of diabetes is much higher for racial/ethnic minorities than for whites. People of color have a higher prevalence of diabetes than whites, and some minorities have higher rates of diabetes-related complications and death ("Diabetes Disparities Among Racial and Ethnic Minorities Fact Sheet," 2001). The increase in diabetes prevalence is not uniformly distributed among all population groups. Disparities have been observed among racial and ethnic groups. Some minority racial and ethnic communities disproportionately suffer from diabetes compared to others. This disparity might be attributed to genetic predisposition, income, access to healthy food or healthcare, education and geographic location. Based on the Healthy People 2010 report, non-Hispanic white population had the lowest diabetes prevalence rate of 52 per 1,000 population (age adjusted) in 2008, whereas the American Indian or Alaska Native population had a rate of 109 per 1,000 population (age adjusted). The non-Hispanic black population had a rate of 127 per 1,000 population (age adjusted) which is nearly two and a half times the White population ("Diabetes: Healthy People 2010,"). Disparities in diabetes have also been studied with the help of ring maps which evaluated diabetes prevalence among adult South Carolina Medicaid recipients. County-level ring maps were used to highlight disparities in diabetes prevalence among adult African Americans and White. The maps also explored potential county-level associations between diabetes prevalence among adult African Americans and five measures of the socioeconomic and built environment— poverty, unemployment, rurality, number of fast food restaurants per capita, and number of convenience stores per capita. County-level rates for African Americans were higher than those for Whites in 45 of the state's 46 counties (Stewart et al., 2011). As discussed previously, access to healthy food determines diabetes prevalence. Studies have shown that some racial and ethnic communities have limited access to healthy food choices and are therefore, at a greater risk of suffering from diabetes. In an average African-American block in Chicago, one would have to travel one-third of a mile to reach a fast food joint whereas travel double the distance to reach some type of grocery food. Transit patterns in majority African American communities also represent low car ownership which means people rely more on close availability of food. Majority of African American communities in Chicago have greater number of years of life lost due to diseases such as diabetes (Gallagher, 2006). To examine whether there is a strong association between several variable risk factors and poor control of multiple intermediate outcomes among blacks with diabetes than among similar whites, a study found that depression and missing medication doses are more strongly associated with poor diabetes control among blacks than in whites. Blacks with diabetes have poorer control of hemoglobin A1c (HbA1c), higher systolic blood pressure (SBP), and higher low-density lipoprotein (LDL) cholesterol as well as higher rates of morbidity and microvascular complications compared to their white counterparts (Duru et al., 2009). The Agency for Healthcare Research and Quality (AHQR) issued a report on identifying underlying causes of disparities in diabetes prevalence among minorities. This broad AHRQ funded literature review of 290 articles revealed that all minorities, with the exception of the Alaska Natives, have a prevalence of type 2 diabetes that is two to six times greater than that of the white population. The study observed that African Americans are 1.4 to 2.2 times more likely to have diabetes than white persons. Similarly, Hispanic Americans have a higher prevalence of diabetes than non- Hispanic people, with the highest rates for type 2 diabetes among Puerto Ricans and Hispanic people living in the Southwest. The prevalence of diabetes among American Indians is 2.8 times the overall rate. Asian and Pacific Islander communities had higher prevalence of diabetes than that of the whites ("Diabetes Disparities Among Racial and Ethnic Minorities Fact Sheet," 2001).Other diabetes prevalence studies focusing on disparities by race and ethnicity have similarly observed that type 1 and type 2 diabetes presents a serious burden among African American youth and adolescents. In 2001, among African American youth aged 0-9 years, prevalence (per 1,000) of type 1 diabetes was 0.57 and for those aged 10-19 years, 2.04. In 50% of the youth aged 15 years and more, A1c (average blood glucose control) was greater than 9.5% with type 1 diabetes. 44.7% of African American youth with type 1 diabetes were overweight or obese. Among youths aged 10-19 years, prevalence (per 1,000) of type 2 diabetes was 1.06. Moreover, this study also observed that about 60% of African American youth with type 2 diabetes had an annual household income less than $25,000. Among those aged greater than 15 years, 27.5% had an A1c more than 9.5%, 22.5% had high blood pressure, and, across all age groups, 90% were overweight or obese (Mayer-Davis et al., 2009).

Diabetes prevalence has been attributed to two major factors – obesity and ethnic minority status. Not many studies have looked at these two factors interacting together to influence diabetes prevalence. Zhang and colleagues examined the trends in racial/ethnic disparities in the prevalence of type 2 diabetes by weight status among US adults, using nationally representative data from the National Health and Nutrition Examination Surveys. The study results showed trends in racial/ethnic disparities in prevalence of diagnosed type 2 diabetes varied by body mass index (BMI). There was increased disparity in normal weight group whereas, in the overweight group, ethnic disparities worsened. Diabetes prevalence increased 33.3% in Whites, compared to 60.0% in Blacks, and 227.3% in Mexican Americans. Minimal racial/ethnic disparities were observed in obese and severely obese groups over time. The overall racial/ethnic disparities in undiagnosed type 2 diabetes declined in all BMI groups. Hence, they concluded that racial/ethnic disparities in diabetes prevalence have become most pronounced among normal and overweight groups (Zhang, Wang, & Huang, 2009). It is often believed that culture plays a crucial role in diabetes prevalence which in turn leads to ethnic disparities in diabetes health status. Southern states of the United States which fall in the 'diabetes belt' often have diet preferences which are not conducive to a healthy lifestyle. Some researchers believe that more than any ethnic culture, socioeconomic status determines the well-being of a population when it comes to diabetes. One study examined older adults (60 years and above) belonging to different races in rural North Carolina to understand the cultural basis for variation in diabetes beliefs. The results showed substantial similarity in diabetes beliefs among African Americans, American Indians and Whites. Diabetes beliefs in this study were most similar in the symptoms and consequences domains compared to beliefs pertaining to causes and medical management. There were some beliefs which differed by ethnicity, but systematic differences by ethnicity were observed for specific educational groups (Grzywacz et al., 2012). Few studies have established a correlation between diabetes and access to fresh and fast food. There are even fewer studies that have highlighted the relationship between race and access to fast food which determines the diabetes health status of a population. In metro Atlanta, areas with high concentrations of Non-White population have the highest access to fast food. With increasing number of White population, access to fast foods decreases. As the White share of the population increases, so does access to grocery stores except in areas with the highest concentrations of Whites. Race and fresh foods access have almost no relationship at all, while race and fast food access have a strong, negative correlation (Fresh Food Versus Fast Food: A Look at Healthy Food Access in Metro Atlanta, 2011).

Income disparity and diabetes prevalence

A growing body of literature indicates the importance of income as a key socioeconomic status marker accounting for the increased prevalence of type 2 diabetes. Income disparities have been cited as one of the major factors in differential health outcomes. The impact of low income on mortality is likely transmitted through several potential mediating pathways that influence an individual’s health. Studies have emphasized on several factors such as food and access to services, and psychosocial conditions such as depression, insecurity and stress. Most of the key risk factors of mortality are more common among individuals with low income. These could be unhealthy behaviors, such as consumption of a low-quality diet, physical inactivity, tobacco use, and heavy alcohol use; lack of health insurance which determines access to medical care in the United States, and worse health status, including disability and poor perceived health. Jarvandi and colleagues observed in their study that compared to the high-income group, people with low-income were on average 3.4 years younger, less likely to be non-Hispanic White, college graduates, physically active, consume alcohol moderately, were more likely to smoke, be obese, have cardiovascular disease and diabetes morbidity, and disabilities (Jarvandi, Yan, & Schootman, 2012). Although diabetes is increasing dramatically and several factors have been associated with the rampant rise in incidence of diabetes in the United States, the effect of income on diabetes incidence is less well understood. Low income population is generally at higher risk of developing diabetes due to several inherent factors. In a study conducted in Ontario, Canada, the researchers observed that increasing income quintile was associated with a significantly decreased diabetes incidence. This population-based study found that diabetes risk is significantly higher in lower compared to higher income groups, and that this income gap was widest in younger persons and females (Lysy et al., 2013). In another Canadian study similar observations were made. In 2005 an estimated 1.3 million Canadians (4.9%) reported having diabetes. It was observed that the prevalence of type 2 diabetes in the lowest income group is 4.14 times higher than in the highest income group. Prevalence of diabetes decreased steadily as income rose. The likelihood of diabetes was significantly higher for low-income groups even after adjusting for socio-demographic status, housing, BMI and physical activity. The researchers observed that there is a graded association between income and diabetes with odds ratios almost double for men and almost triple for women in the lowest income compared to those in highest income (Dinca-Panaitescu et al., 2011). Researchers, who aimed at establishing a relationship between socioeconomic status and type 2 diabetes as risk factor for chronic diabetes complications, observed that the prevalence of known type 2 diabetes was higher in patients of lower socio-economic status, especially among women. In type 2 diabetes patients, obesity, sedentary lifestyle, and abnormal levels of low-density lipoprotein (LDL) cholesterol and HbA1c were more prevalent among those from lower socio-economic status. Macroangiopathy was inversely associated with socio-economic status after adjustment for clinical and demographic variables. The poor visited primary care services more frequently than those of higher status**.** This study showed an association between deprivation and type 2 diabetes prevalence, cardiovascular risk factors and chronic diabetic complications in type 2 diabetes patients. Although the low SES population used health services more frequently, they showed worse glycaemic control and more chronic complications (Larranaga et al., 2005). Diabetes prevalence is more strongly associated with poverty income ratio (PIR) than with education or occupational status. The associations are largely independent of other risk factors, especially among African American women (Robbins, Vaccarino, Zhang, & Kasl, 2001). Diabetes may be up to two times more prevalent in low income populations compared to wealthy populations. In patients with diabetes, low income is associated with an increased rate of hospitalization for acute diabetes related complications. Even within a universal health care system, the least affluent patients are more likely to be hospitalized than the wealthiest patients (Rabi et al., 2006). Prevalence of diabetes among Georgia adults by annual household income (2008-2010) showed a decrease with higher income. Prevalence increased with lower household incomes. With a diabetes prevalence of 17.5% (95,345 adults), households with an income of less than $15,000 had a significantly greater diabetes prevalence than households in income groups of $25,000 or more. As compared to the diabetes prevalence in households with incomes of $75,000 or more (5.4%; 119,007 adults), the diabetes prevalence was 3.4 times higher in households with incomes of less than $15,000 ("2012 Georgia Diabetes Burden Report: An Overview," 2012).

Future research areas

As mentioned earlier, diabetes prevalence has steadily increased in the United States and is becoming one of the nation’s most challenging public health threats. Both the prevalence and incidence of diabetes have increased rapidly since the mid-1990s, with minority racial/ethnic groups and socioeconomically disadvantaged groups experiencing the maximum increases and most substantial effects from the disease (Beckles, Zhu, & Moonesinghe, 2011). Although there is evidence in literature about factors affecting diabetes, more emphasis has been placed on diabetes related comorbidities and mortality. There is little research on what could be potential ways to prevent diabetes prevalence and incidence, especially among low income and ethnic minority population who have limited access to healthy lifestyle, supporting a diabetes risk free life. Lifestyle change including diet modifications, physical activity, and reduced stress have been cited as most effective ways of reducing the risk of diabetes, especially type 2 diabetes. Since diabetes is a chronic condition with no known cure but highly preventable, researchers are trying to look at ways which can reduce the prevalence of this disease. But this is most challenging for people who do not have the abilities to lead a risk free life given their geographic location, economic status and racial and ethnic background. Some initiatives have been undertaken in recent times to reduce the incidence of this chronic disease among the disadvantaged groups.

With the nation facing a grave challenge of controlling the epidemic related to obesity and diabetes, it is necessary for the healthcare system and communities to apply primary prevention strategies at the population level while simultaneously tackling the pervasive geographic and socioeconomic disparities in diabetes prevalence care, and complications that remain. Such an initiative has been undertaken by the Centers for Disease Control and Prevention (CDC) and the National Institute of Diabetes and Digestive and Kidney Diseases - Natural Experiments in Translation for Diabetes, or NEXT-D. The mission of NEXT-D is to examine the effectiveness of population-level health policies on diabetes prevention, control, and inequalities through rigorous health policy research. A collaborative approach has been chosen to facilitate multisite studies and the use of common measurements and indicators. This collaboration aims at enhancing the design, analysis, and dissemination of translational research. The ultimate goal of the collaboration is to provide stakeholders with better understanding of best practices that can be implemented by employers, health plans, health systems, communities, legislatures, or governments to prevent and control diabetes (Gregg et al., 2013). One of the most effective interventions to reduce diabetes related disparities would be to improve the food environment in deprived neighborhoods. Studies have come up with results which suggest that accurate measures of food environments can lead to informed policy making, particularly in relation to the zoning of food outlets and food labeling or nutrition information requirements. Additionally, descriptive information relating to the nature of food environments can also assist in identifying intervention points to improve communities' access to and the availability of healthy foods (Kelly, Flood, & Yeatman, 2011). Diabetes prevalence can be reduced by medications but it has been observed that lifestyle changes can have a more profound impact. In one study, the results show that lifestyle intervention reduced the number of new cases of diabetes by 58% whereas metformin reduced it by 31%. The lifestyle intervention was significantly more effective than metformin (Knowler et al., 2002). Although lifestyle intervention is effective in reducing and postponing diabetes prevalence, such interventions have not been implemented as conventional treatment alternatives for high risk individuals. Intensive lifestyle intervention can induce several beneficial changes in diet, physical activity, blood glucose, and lipid concentrations and a highly significant reduction in diabetes incidence (Lindstrom et al., 2013). Weight loss is considered to be a leading factor in reducing diabetes prevalence. Weight gain is also associated with living in deprived neighborhoods where there is lack of access to healthy food options; hence, residents in such areas are more susceptible to weight related chronic diseases such as diabetes. Most of the principles of lifestyle change to reduce weight and diabetes incidence can be generalizable to any high-risk population. Diabetes prevention trials can be transformed into community settings through the available resources, differences between healthcare delivery organizations and cultural variations between settings. The interventions should be designed in such as manner that they meet the requirements of the target group (Johnson et al., 2013). The risk of developing type 2 diabetes mellitus is high among African Americans, Hispanic or Latino Americans, American Indians and some Asian Americans and Native Hawaiians or other Pacific Islanders. The prevalence of diagnosed diabetes is twice as high in non-Hispanic black and Mexican-American persons as in non-Hispanic white persons. Factors such as reductions in physical activity, dietary changes, and increased frequency of testing, might increase prevalence of diabetes (USPSTF, 2008).

Chapter 3 – Methods and Procedures

Data Collection: The study emphasizes on the lack of access to food, especially healthy fresh food in low income and deprived neighborhoods and its impact on diabetes mortality and morbidity at the level of census tracts in Fulton County, Georgia. This also requires studying the racial-ethnic mix of population and vehicle ownership to have a comprehensive understanding of the association between living in a food desert and the probability of developing diabetes. The data used in this study are all secondary data and were obtained from various sources.

***Diabetes data*:** Diabetes related data was provided by Fulton County's Epidemiology department. This data was obtained from the Georgia Department of Public Health's data warehouse known as Online Analytical Statistical Information System (OASIS). OASIS is a group of interactive tools used to access the Georgia Department of Public Health's standardized health data repository. These are designed, built and maintained by the Office of Health Indicators for Planning (OHIP). The Mapping Tool is developed and maintained by the University of Georgia's Carl Vinson Institute of Government, ITOS Division. The standardized health data repository used by OASIS currently has information on vital statistics such as births, deaths, fetal deaths, induced terminations, pregnancies, hospital discharge, emergency room visit, arboviral surveillance, Youth Risk Behavior Survey (YRBS), Behavioral Risk Factor Surveillance Survey (BRFSS), sexually transmitted diseases, motor vehicle crash, and population data. Indicators in each tool are selectable by a variety of population, disease, and survey characteristics. Available data can be extracted by age groups, race, ethnicity, sex (person), census tract, county commission district, county, health district, legislative district, perinatal region, state (place), and year (time). All datasets pertain to place of residence, not occurrence (OASIS, 2013).

Diabetes morbidity in Fulton County at census tract level is represented by the hospital discharge from diabetes mellitus data starting from 1999 to 2010. There were no data available before that. The deduplicated hospital discharge data according to OASIS is ‘the number of persons discharged live from non-Federal acute-care inpatient facilities (hospitals) for illness. Persons are counted only once if readmitted for the same chronic condition during a calendar year. Causes are based on the principal diagnosis, except in cases where an External (E-code) cause supersedes the principal diagnosis. Deduplicated discharges also exclude people discharged dead, healthy newborn infants, and healthy mothers giving birth to newborn infants. Since the number and rate are derived only from hospitalizations, they do not include all existing cases (prevalence) or new cases (incidence) among residents of Georgia’ (OASIS, 2012). Similarly, mortality data represents the number of deaths from diabetes mellitus in Fulton County from 1994 to 2010 with the exception of 2009. Data were not available for the indicated population in 2009. Both morbidity and mortality data represent total numbers for all age groups and race/ethnicity. Due to unavailability of data in certain years, for analysis purpose, an average value was derived for each census tract by summing values for diabetes morbidity and mortality for each year. This aggregate was divided by the number of years data was available for each census tract. The value was then used to study the correlation with other variables census tract level using SPSS.

Food desert data: Data associated with food desert distribution in Fulton County, Georgia was extracted from the ‘Food desert Locator’ tool of the United States Department of Agriculture (USDA). Population data are from the 2010 Census and data on income and vehicle availability are from the 2006-10 American Community Survey. Store information was derived from the 2010 STARS directory of stores authorized to accept Supplemental Nutrition Assistance Program (SNAP) benefits and the 2010 Trade Dimensions TDLinx directory of stores (Documentation, Food Desert Locator, USDA, 2013). The Dataset version 1.2 has been used and population statistics are only provided for census tracts that meet the definition of a food desert. According to the Economic Research Service of USDA, a food desert has been defined as ‘a low-income census tract’ where a substantial number or share of residents has low access to a supermarket or large grocery store. To qualify as low-income, census tracts must meet the Treasury Department's New Markets Tax Credit (NMTC) program eligibility criteria. Furthermore, to qualify as a food desert tract, at least 33 percent of the tract's population or a minimum of 500 people in the tract must have low access to a supermarket or large grocery store. A low-income census tract is defined as one where the poverty rate is at least 20 percent or more of the federal level if they are not located within a metropolitan area, the median family income for the tract does not exceed 80 percent of statewide median family income. If the tracts are located within a metropolitan area, the median family income for the tract does not exceed 80% of the greater of statewide median family income or the metropolitan area median family income (Documentation, Food Desert Locator, USDA, 2013). Similarly, low access to a healthy food retail outlet is defined as living more than 1 mile from a supermarket or large grocery store in urban areas and as more than 10 miles from a supermarket or large grocery store in rural areas. The criteria applied by the definition also includes the fact that if the aggregate number of people in a census tract with low access is at least 500 or the percentage of people in the census tract with low access is at least 33 percent then the census tract is considered a food desert (Documentation, Food Desert Locator, USDA, 2013). Information on population and income used by the food desert locator is based on the 2000 Census of Population and Housing. Supermarket and large grocery store location information was obtained from a directory of supermarkets and large grocery stores developed from a list of stores authorized to receive Supplemental Nutrition Assistance Program (SNAP) benefits, augmented by data from Trade Dimensions TDLinx (a Nielsen company), a proprietary source of individual supermarket store listings, for the year 2006 (Documentation, Food Desert Locator, USDA, 2013). According to Census 2010, there are twenty eight food desert census tracts in the study area identified by the USDA.

Food store data: Information and data on food stores distribution in Fulton County, Georgia was obtained through ReferenceUSA which is a leading provider in business and consumer research and is a research and reference tool licensed to libraries, educational institutions and government agencies (ReferenceUSA, 2013). This full service platform was accessed through the Georgia State University library. Data were extracted through a customized search from the U.S. Business database using business type and geographic information. The business types were selected on the basis of the 6-digit Standard Industry Classification (SIC) code in Fulton County, Georgia. The search terms included supermarkets, convenience stores, grocery stores and full service fast food restaurants. The search returned 403 supermarkets and grocery stores (excluding convenience stores), 726 full service fast food restaurants, and 421 convenience stores. ReferenceUSA does not have a specific definition for supermarkets but the primary NAICS description of the dataset combines supermarkets with other grocery stores with the exception of convenience stores. In general supermarkets are often the primary source of food for the general population especially the low income population. Lack of supermarkets in food desert neighborhoods is therefore critical for the purpose of this study. Similarly, convenience stores include food marts located in gas stations and service centers apart from the usual convenience stores which are small corner stores or shops mostly located in poor neighborhoods with some daily provisions of grocery, tobacco products, toiletries and soft drinks. The full service fast food restaurants include all restaurants which have sit down as well as take out or drive through provisions. These restaurants mostly serve cheap and affordable fast food and include chains such as McDonalds, Burger King, Arby's, Zaxby's and the like.

Demographic data: Demographic data pertaining to this study has been extracted from the Atlanta Regional Commission's (ARC) GIS dataset. The data is based on Census 2010 and has information on racial distribution of population at the census tract level. ARC is currently processing the data released by the U.S. Census Bureau for 2010 population, race and housing unit totals for the state of Georgia on March 17, 2011. This information is used for creating interactive mapping tools for counties and cities within the 20-county Atlanta region (Atlanta Regional Commission, 2013). The ARC publishes the Atlanta

Region Information System (ARIS) GIS data in Zip file format which can be downloaded for research purpose. The population data was available in excel format as well. Once downloaded, the data was cleaned to extract information pertaining to census tracts in Fulton County, Georgia (Atlanta Regional Commission, 2013).

Car ownership: Data on vehicle ownership was obtained from the American Fact Finder of the United States Census Bureau. The data comprises of number of workers 16 years and older who do not have a personal vehicle from the information provided in the means of transportation to work by vehicles dataset. The population includes all workers 16 years and above in households in Fulton County census tracts. The data is based on information collected by the American Community Survey's 2007-2011 5-year estimates. The original data was modified in the data view option by including information on number of workers who did not own a car to represent the distribution of population without cars in each census tract (U.S. Census Bureau, 2007-2011 American Community Survey). The downloaded data explains the procedure of data collection and sampling as follows, 'Data are based on a sample and are subject to sampling variability. The degree of uncertainty for an estimate arising from sampling variability is represented through the use of a margin of error. The value shown here is the 90 percent margin of error. The margin of error can be interpreted roughly as providing a 90 percent probability that the interval defined by the estimate minus the margin of error and the estimate plus the margin of error (the lower and upper confidence bounds) contains the true value. In addition to sampling variability, the ACS estimates are subject to nonsampling error (for a discussion of nonsampling variability, see Accuracy of the Data). The effect of nonsampling error is not represented in these tables'. The estimates and characteristics reflect boundaries of urban areas as defined in Census 2000 data. The boundaries have not been updated since Census 2000. Therefore, data for urban and rural areas from the American Community Survey do not necessarily reflect the results of ongoing urbanization.

Methodology and Procedure for map creation:

Maps for this study purpose were created using ArcGIS Desktop version 10.1. The base map showing Fulton County boundaries and census tract divisions within the County was downloaded from the GIS data and maps section of the Atlanta Regional Commission. This shapefile also included Census information pertaining to demography, race and ethnicity. Data from other sources such as ReferenceUSA and American FactFinder were downloaded from their respective websites in excel spreadsheet formats and added to the existing shapefile's attribute table using the join and relate tool. Charts and gradient colors were then used to represent the variation of distribution of different features across the County. The map layout was then exported as JPEG image for representation purpose. Geographical Information System (GIS) was used to represent the association between variables and diabetes.

The maps for diabetes morbidity and mortality were created using the mapping tool in OASIS. At the census tract level, all data were standardized to the year 2000 Census Geographies. The data class break labels in the legend indicate the relative difference between data classes within a selected area. This feature means that the levels in each County have been calculated for that specific area, so they might represent different highs and lows. The actual number ranges are suppressed to assure confidentiality (OASIS Mapping tool, 2013).

For data analysis purpose, statistical programs available in SPSS version 21 for Windows were used. Pearson's Product Moment coefficient was calculated to determine the association between diabetes and food environment, car ownership and income.

Chapter 4 – Results and Data Analysis

Results

Pearson's correlation coefficient was calculated to determine association between diabetes mortality and diabetes morbidity with factors such as food environment comprising of variables like number of supermarkets, fast food restaurants and convenience stores and personal vehicle ownership. The statistical value measures the linear relationship between two variables which ranges in value from +1 to -1, indicating a perfect positive and negative linear relationship respectively between two variables. The results were further tested with data analysis through GIS maps (Figures 7- 11) representing the relationship between diabetes and associated factors.

When represented through GIS maps using ArcGIS 10.1, it is observed that the distribution of food stores across Fulton County varies by census tracts. Diabetes mortality and morbidity actross the tracts correspond to the food availability. The disparity is most noticeable in the food desert census tracts of Fulton County.

Figure 2 represents the distribution of the twenty eight food desert census tracts of the County as identified by USDA. These tracts are exclusively distributed in the central and southern portion of the County, which comprises of low income communities with higher proportion of African American population. The GIS maps (Figures 8, 9 and 10) show the distribution of food stores – supermarkets and grocery stores, convenience stores and full service fast food restaurants across the County. The maps (Figure 11) also represent the areas whose residents do not own a personal vehicle for commuting purposes and hence, do not have easy access to food stores unlike other residents in the County. GIS maps have also been created to represent the racial and ethnic distribution of population in Fulton

County so as to determine the races and ethnic populations who bear the burden of diabetes mortality and morbisity.

Diabetes morbidity (number of deduplicated discharges) and mortality (number of deaths) have been denoted in Figures 3 and 4 respectively. The darker shades represent higher concentration of reported cases of diabetes morbidity and deaths. The circled areas correspond to the food deserts identified in Figure 2.

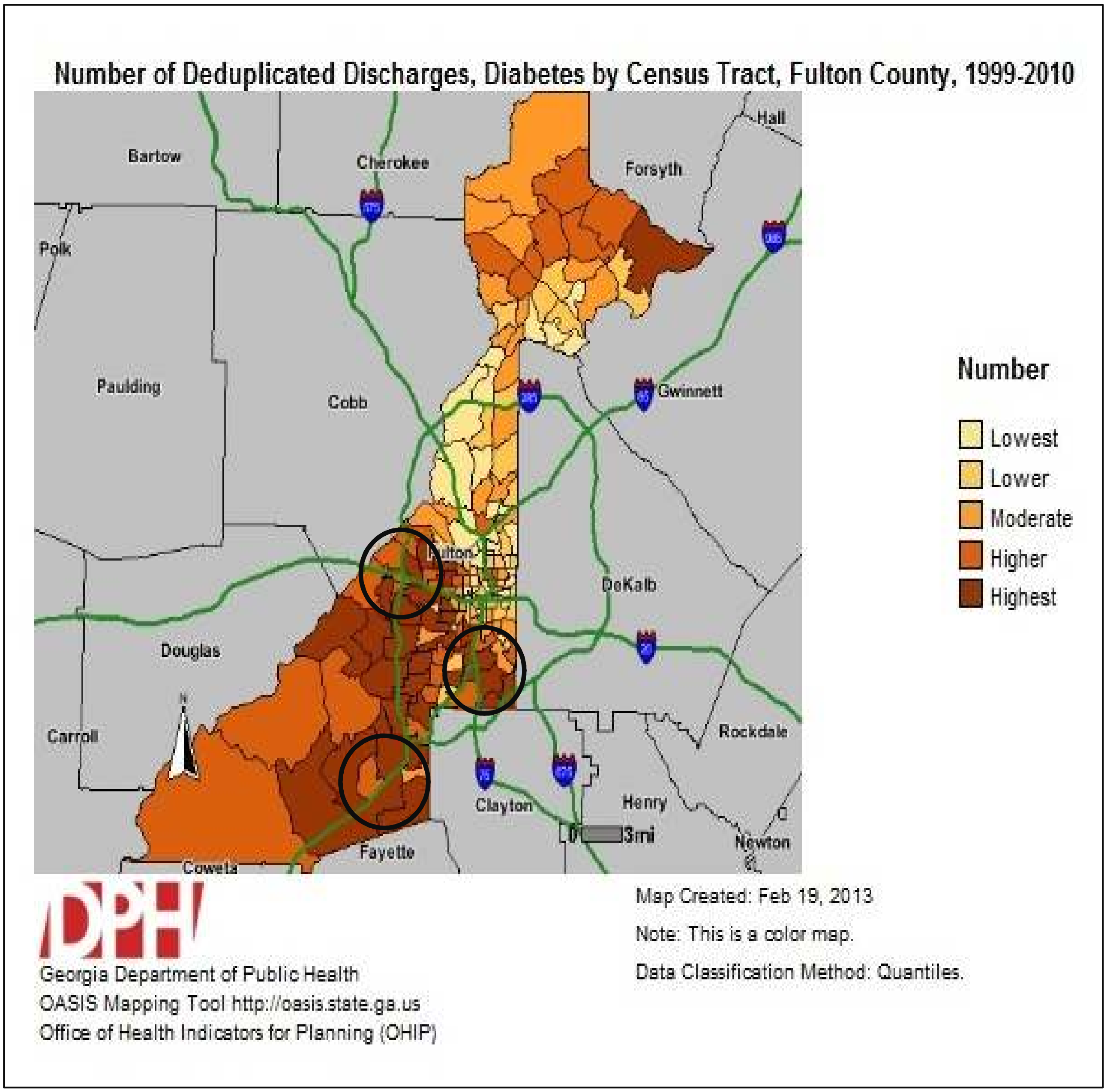

Fig 3: Diabetes morbidity represented by deduplicated hospital discharges in Fulton County by Census tracts 1999-2010

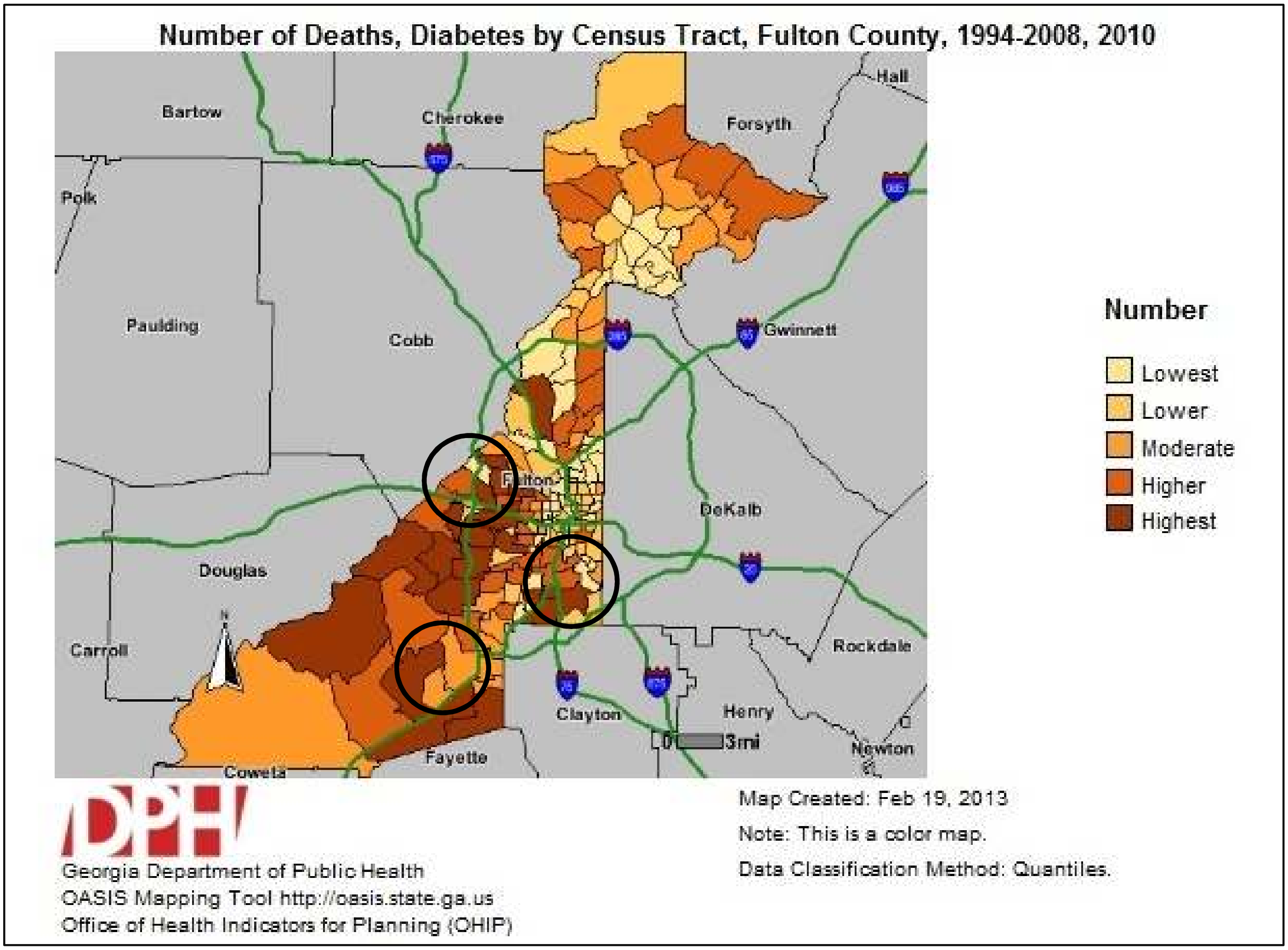

Fig 4: Diabetes mortality represented by number of deaths in Fulton County by Census tracts 1994-2008, 2010

The racial distribution of population in Fulton County shows a predominance of non-Hispanic Whites (47.5%) and non-Hispanic Black (44.5%) population (Census, 2011[2]). The census tracts which have been designated as food deserts also have the highest concentration of non-Hispanic Black population compared to the rest of the County. According to the Census 2010 data, 79.49 % of the total population in the food desert census tracts is non-Hispanic Black. These are also the tracts where diabetes

[2] http://quickfacts.census.gov/qfd/states/13/13121.html

mortality and morbidity are highest. Figures 5 and 6 represent the diabetes mortality and morbidity occurrences among non-Hispanic Black population in Fulton County.

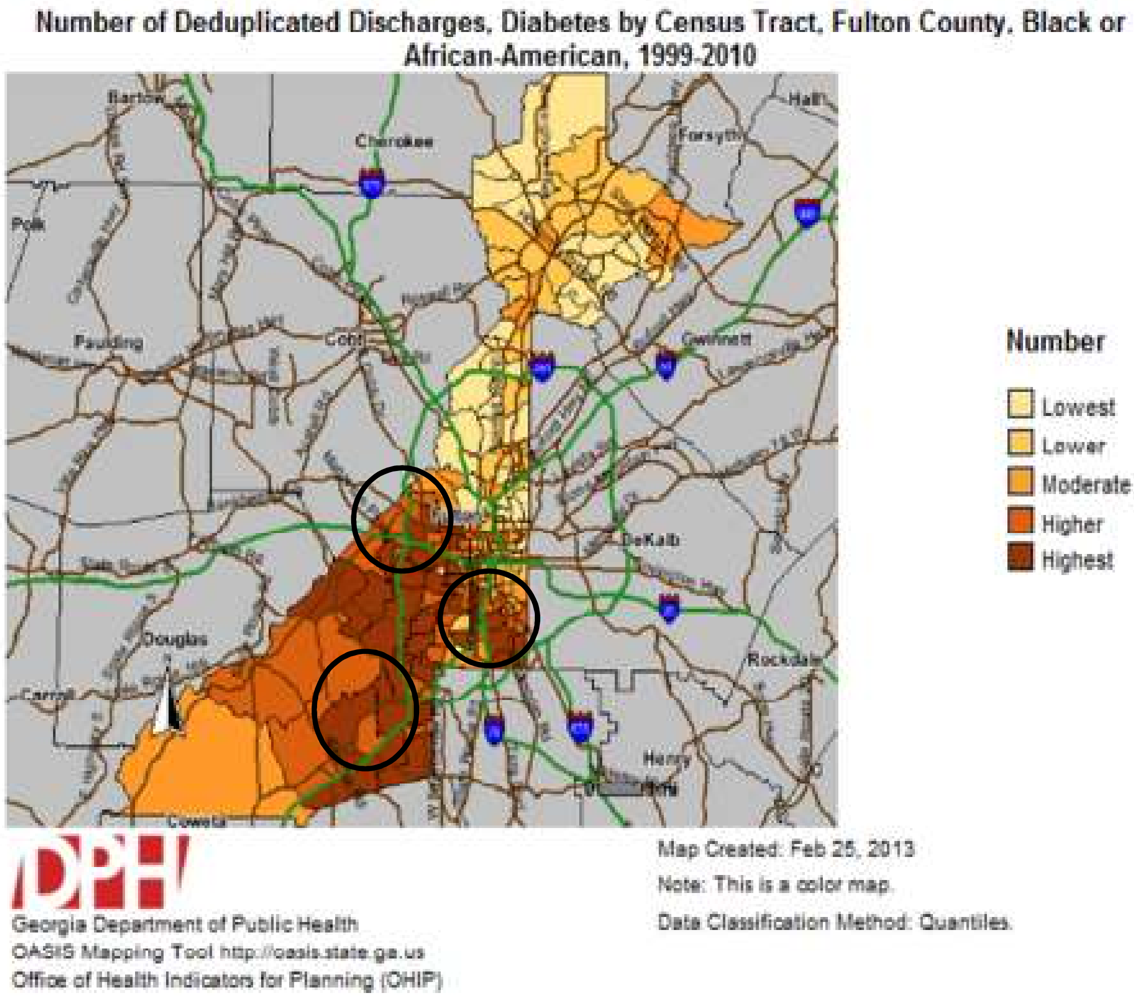

Fig 5: Diabetes Morbidity among African-Americans in Fulton County Census tracts (1994-2008, 2010)

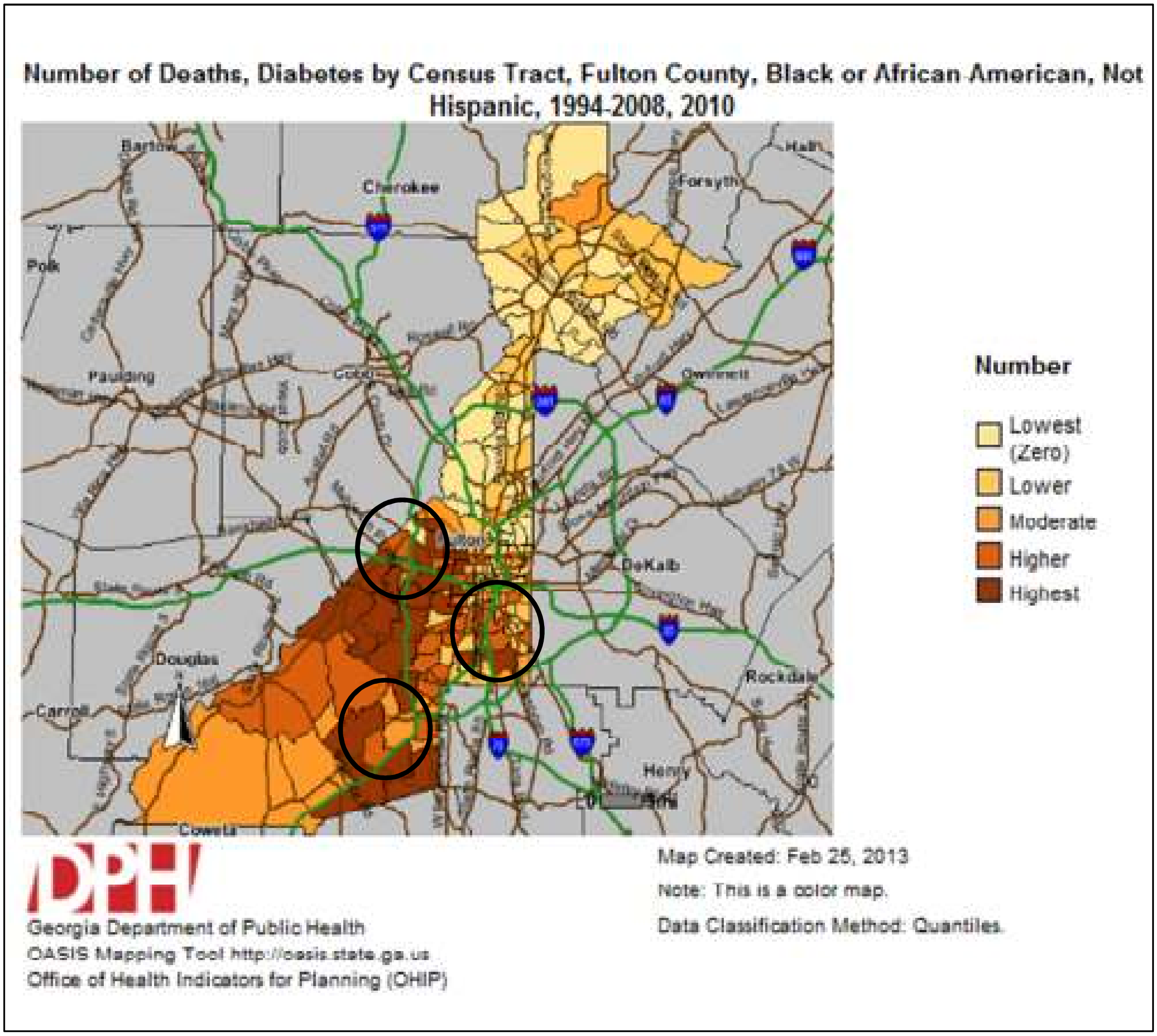

Fig 6: Diabetes mortality among African Americans in Fulton County, GA

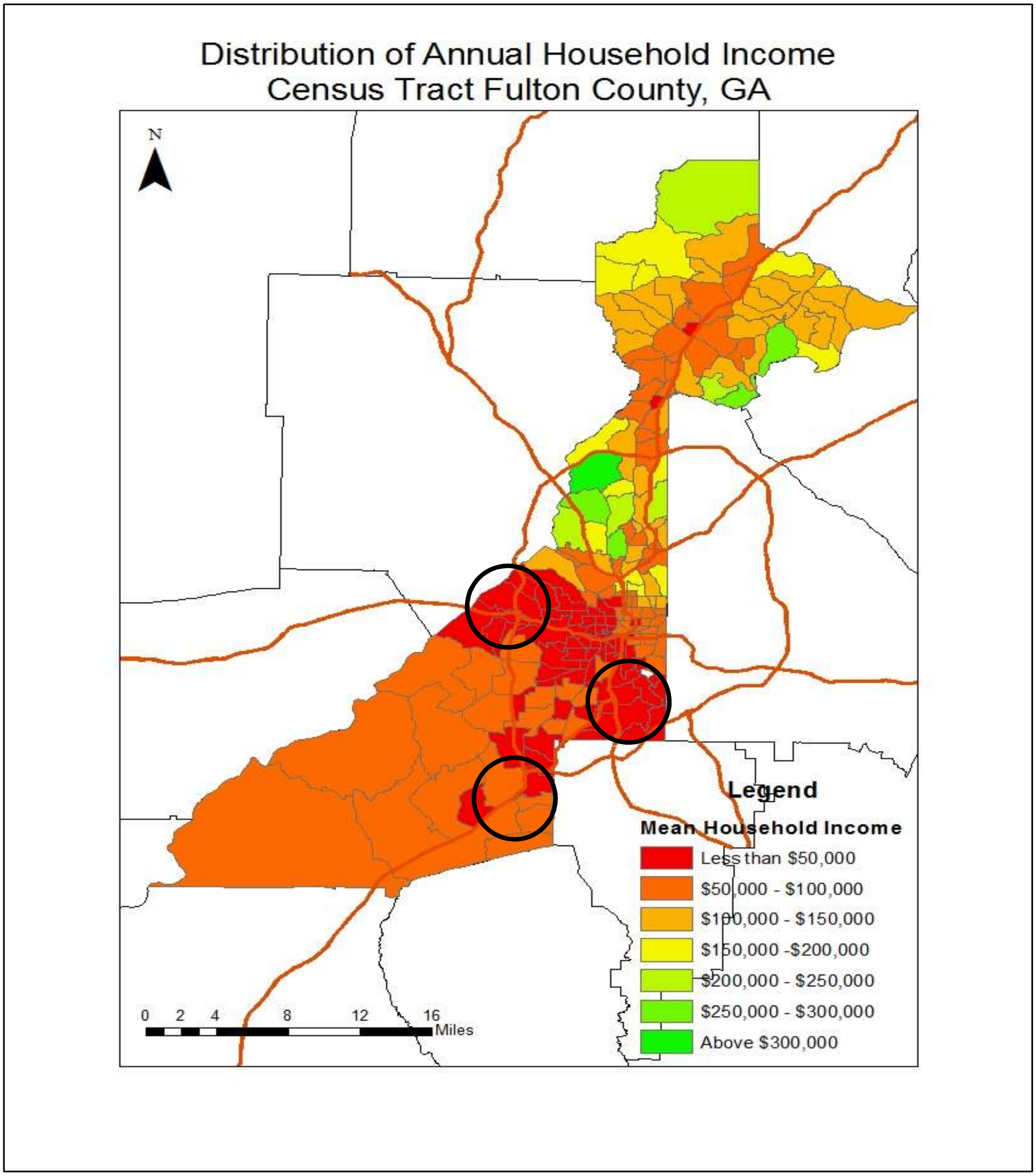

Fig 7: Mean Household Income Distribution in Fulton County, GA

Figure 7 represents the mean annual household income of population by Census Tracts in Fulton County. The data is available from the American Community Survey 5-Year estimates (2007-2011). Although the American Community Survey (ACS) produces population, demographic and housing unit estimates, it is the Census Bureau's Population Estimates Program that produces and disseminates the official estimates of the population for the nation, states, counties, cities and towns and estimates of housing units for states and counties. The map shows how the low income population is concentrated mostly in and around central Fulton County which also houses the food desert neighborhoods. These areas are marked by the red color. The more affluent neighborhoods, represented by the shades of yellow and green are mostly located in the northern part of the County which also has better diabetes health status and access to food.

Lack of supermarkets and grocery stores in food deserts is one of the main reasons behind people living in such areas depending on less healthy fast food which in turn often leads to chronic diseases such as diabetes. Food desert census tracts have very few supermarkets or grocery stores with access to fresh fruits and vegetables. The tracts which have been designated as food deserts by USDA in Fulton County, GA have very few such stores as depicted by the lightest shade in Figure 8.

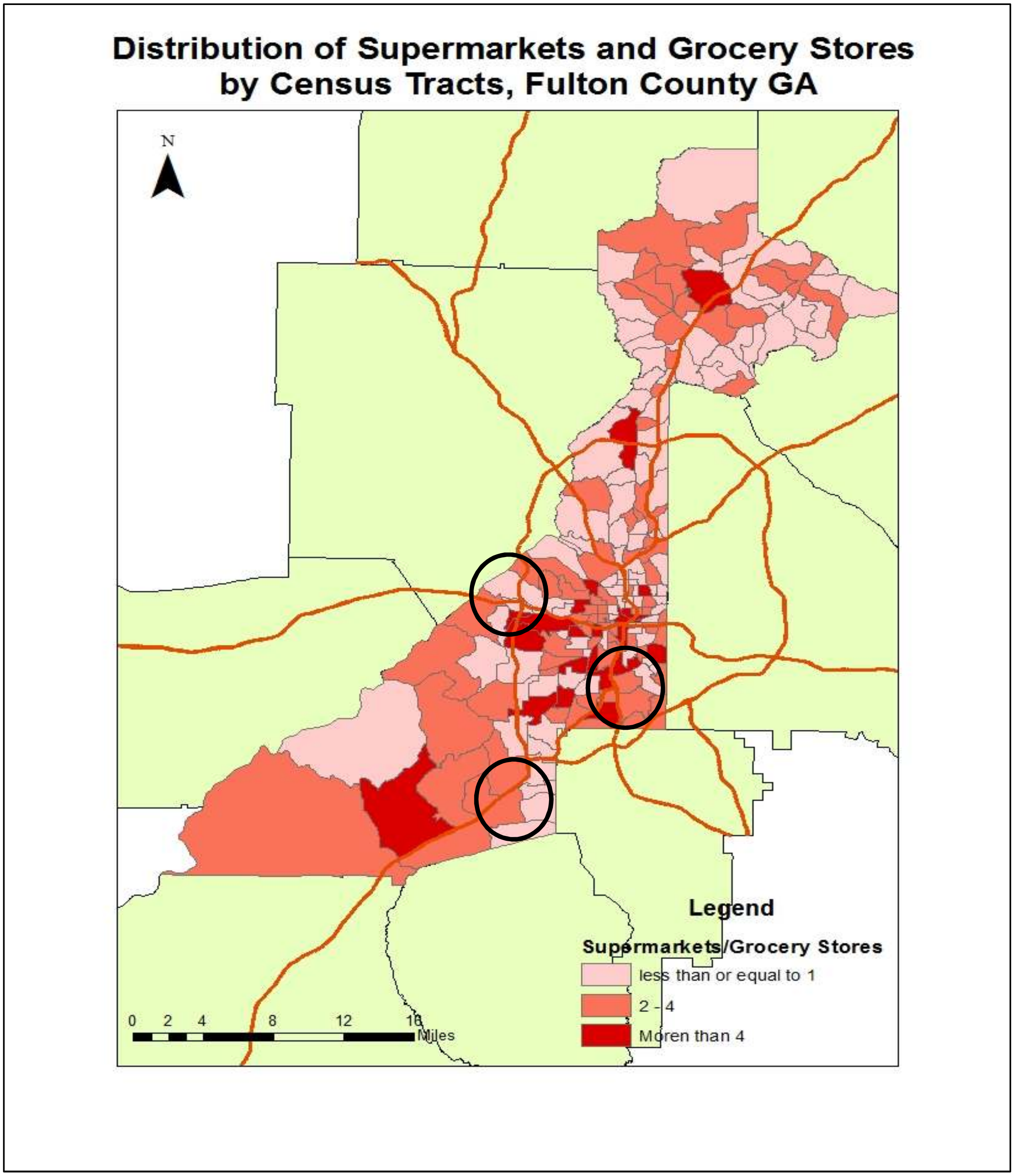

Fig 8: Distribution of supermarkets and grocery stores in Fulton County, GA

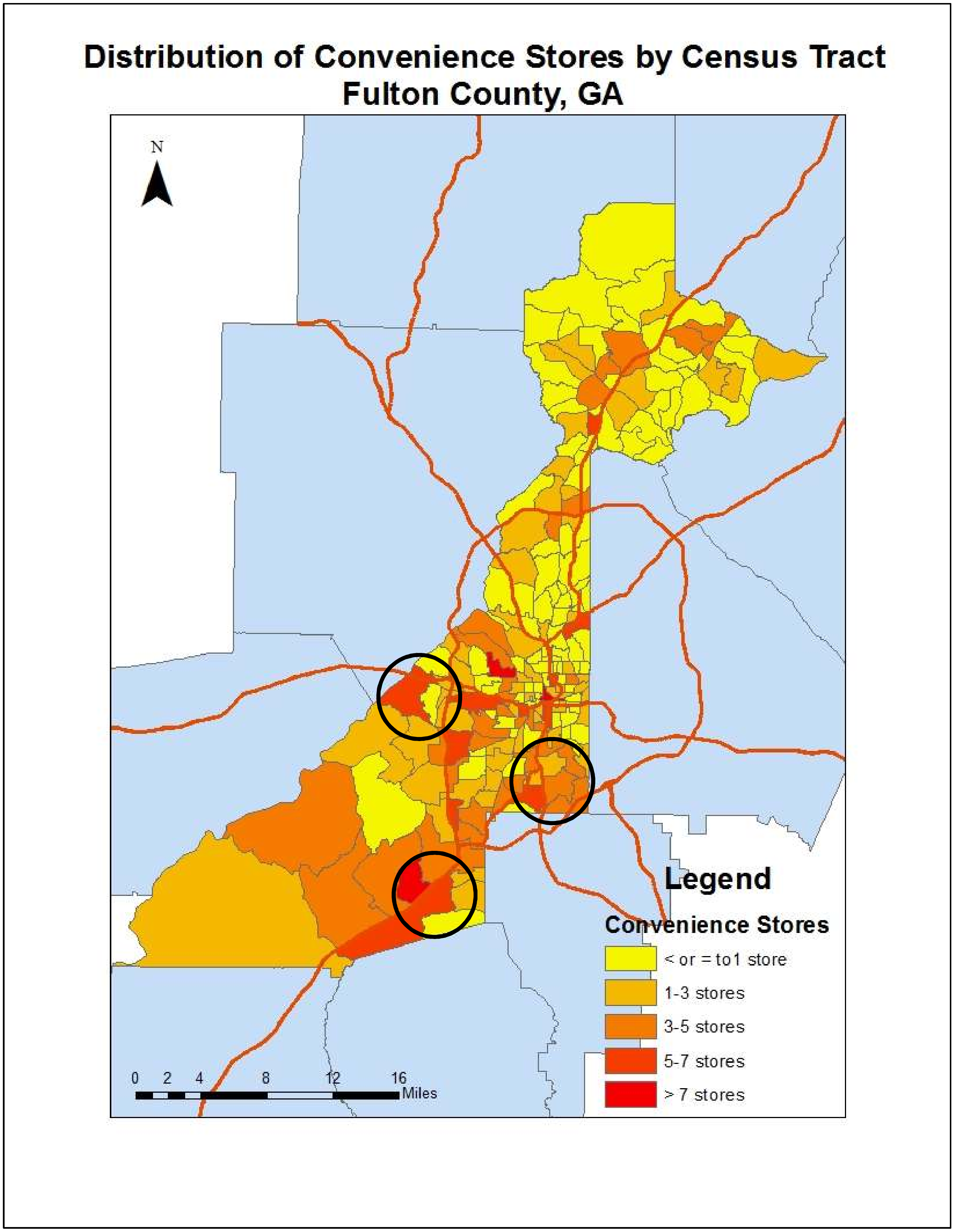

Fig 9: Distribution of convenience stores in Fulton County, GA

Figure 9 represents the distribution of convenience stores in Fulton County census tracts. The convenience stores are more pronounced in census tracts which are in and around the designated food deserts of Fulton County. It can be observed from the GIS map in Figure 9 that the neighborhoods in the north of Fulton County have the lowest concentration of convenience stores which are usually the only sources of food for the low income neighborhoods as in food desert locations. The higher concentration of convenience stores corresponds with the census tracts which have highest number of morbidity and mortality from diabetes in Fulton County.

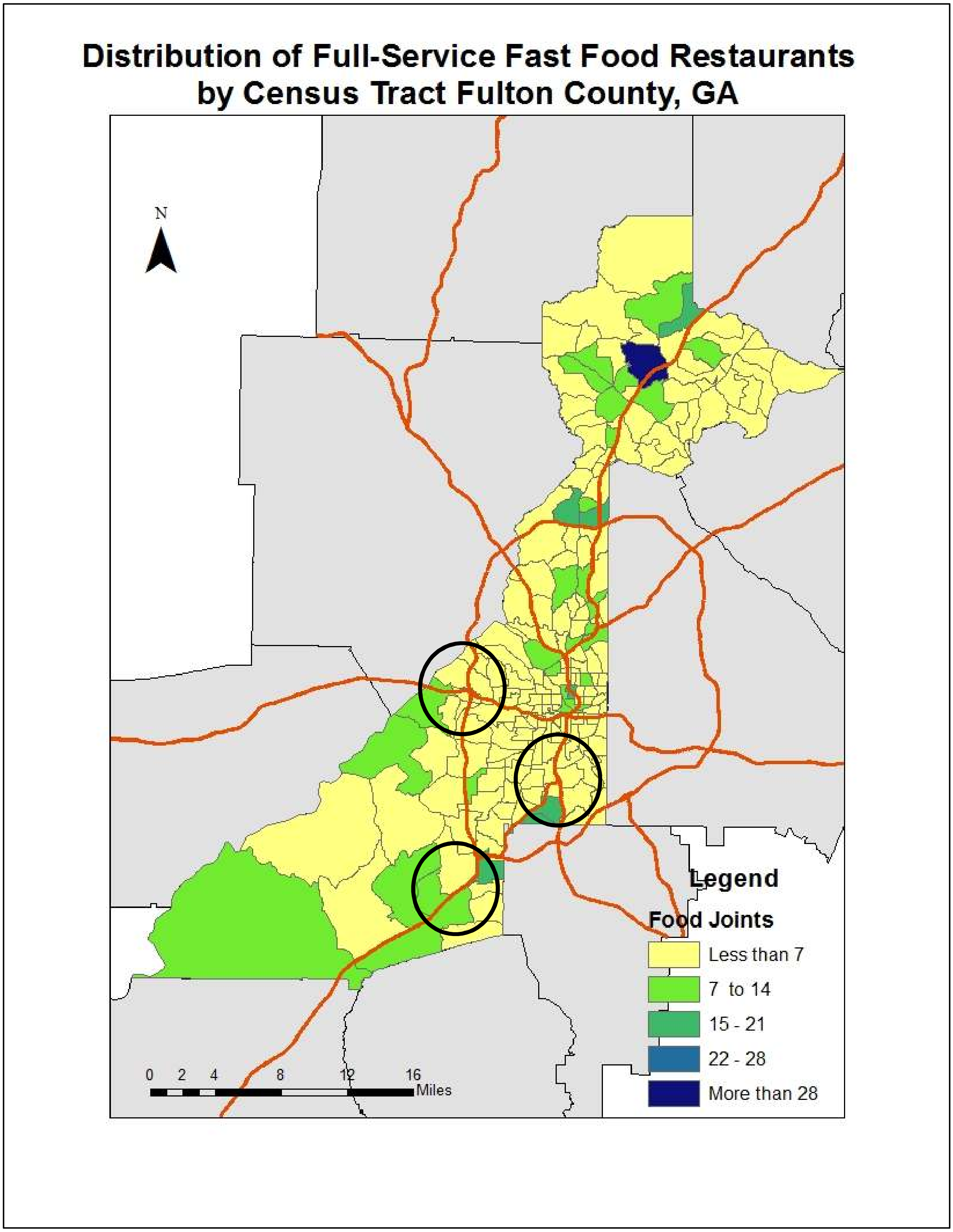

Fig 10: Distribution of Full Service Fast Food Restaurants in Fulton County, GA

Figure 10 shows the distribution of full service fast food restaurants in different census tracts of Fulton County. It can be observed that the tracts with dark green shade representing higher number of full service restaurants are mostly located in the northern parts of the County. The tracts which have highest number of diabetes related morbidity and deaths, located in the central and southern parts of the County have very few full service restaurants. These also include the census tracts which have been designated as food deserts.

The study intended to look at whether owning a personal vehicle had a direct correlation with diabetes morbidity and mortality. Several studies have confirmed the association of socioeconomic status with diabetes. But there have not been a lot of studies which looked particularly at vehicle ownership and its relation to diabetes. If people live in neighborhoods which do not have food stores with healthy food options, they can still access food stores in nearby places if they own a personal vehicle. But in most cases, people living in low income neighborhoods such as food deserts, often do not own vehicles. As depicted in Figure 11, there is more number of people without cars living in neighborhoods which are located in the central part of the County and which also include the food deserts. These are also those neighborhoods who have higher diabetes related morbidity and mortality as well.

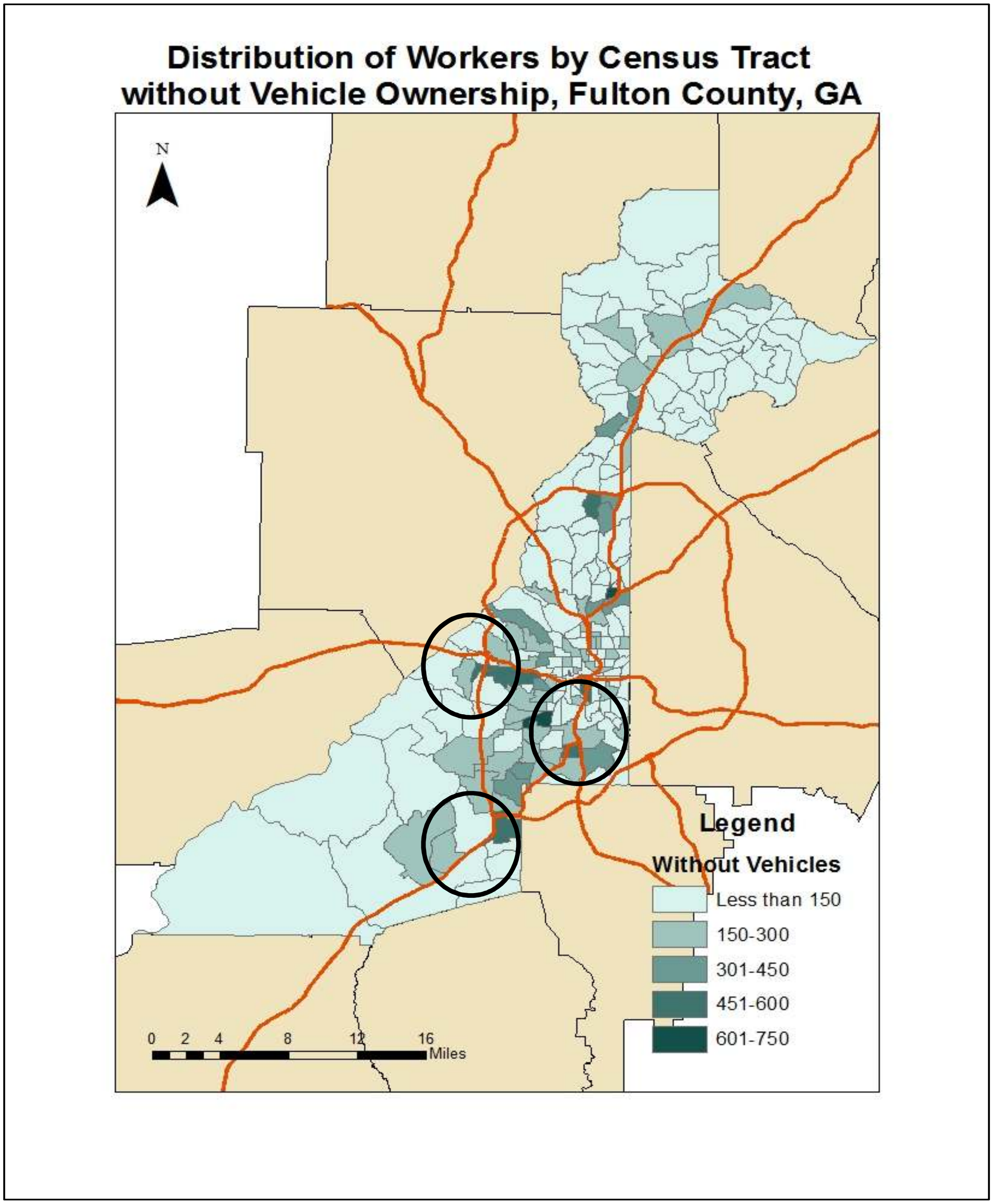

Fig **11: Distribution of Workers without Vehicles in Fulton County, GA**

Data Analyses

A Pearson's product-moment correlation was run to determine the relationship between diabetes morbidity, mortality and food environment, income and vehicle ownership. The results are shown in Table 1. The number of census tracts (cases) considered for calculating the correlation is 167. The relationship with diabetes mortality, morbidity and food environment and vehicle ownership is statistically non-significant. But there is a negative correlation between mean annual household income and diabetes morbidity, which was statistically significant (r = -0.201, n = 167, p < .0005).

		Pearson's Correlation (ρ)		**Significance level (two-tailed)**		**Number of census tracts in Fulton County (N)**
		Morbidity	**Mortality**	**Morbidity**	**Mortality**	
Food Environment	Supermarkets and Grocery stores	0.062	0.046	0.429	0.552	167
	Convenience stores	0.150	0.003	0.053	0.970	
	Full service fast food joints	- 0.036	0.016	0.645	0.842	
Vehicle Ownership	Workers without personal vehicles	0.070	-0.060	0.369	0.439	167
Income	Mean Household Income	-0.201**	-0.036	0.009	0.646	167

** Correlation is significant at the 0.01 level (2-tailed).

Table 1: Pearson's Correlation coefficient representing association between diabetes morbidity and mortality with availability of food stores and vehicle ownership in Fulton County census tracts

The table (Table 1) represents the correlations between diabetes morbidity and mortality with variables such as food environment represented by supermarkets and grocery stores, convenience stores and full service restaurants as well as vehicle ownership and income. The correlation between diabetes morbidity and mortality and presence of supermarkets and grocery stores indicates with more number of supermarkets and grocery stores in a census tract, the chances of diabetes related illness or death increases among the residents of that census tract. This correlation is in contrary to previous research which states that with more number of supermarkets and grocery stores, the access to fresh and quality food increases which in turn reduces the risk of developing diet related illness such as diabetes. There could be other factors affecting this correlation which need to be studied. This correlation is not statistically significant. Similarly, there is also a weak positive correlation between location of convenience stores and diabetes morbidity and mortality in the census tracts. The correlation is also not statistically significant. There is a weak negative correlation between diabetes morbidity and presence of full service fast food joints in the census tracts of Fulton County. The correlation is statistically not significant. Hence, according to this relationship, more number of restaurants in a census tract indicates less chances of developing diabetes. The correlation with diabetes mortality indicates a positive relation between mortality and presence of restaurants in a census tract. Therefore, chances of dying from diabetes increases with increasing number of restaurants in the County.

Higher body mass index (BMI) is often considered to put a person at higher risk of developing type 2 diabetes. One’s food environment is often the most important contributing factor to higher BMI and hence diabetes. People who live in food deserts without fresh food supply might still have access to quality food if they own a personal vehicle which makes commuting to grocery stores elsewhere easier. In our study area, there is a weak positive correlation between diabetes morbidity and not owning a personal vehicle. The relation is not statistically significant. A negative correlation between diabetes related morbidity and mortality and income shows that low income population are more vulnerable to diabetes related health concerns compared to their more affluent peers.

Chapter 5 – Discussions and Conclusions

This descriptive study was initiated to determine whether there is a correlation between food environment and diabetes mortality and morbidity, especially among low income people who live in areas which are designated as food deserts in Fulton County, Georgia. The study intended to highlight the importance of access to healthy food and its implications on diabetes health status.

Study Limitations

This study had some limitations which could have potentially affected the statistical results in the data analysis. The data available for diabetes mortality and morbidity from OASIS has some data gaps and missing data due to which the results might have some irregularities. Another major limitation in the dataset is that the diabetes data is from the year 1994 to 2010. During this period, the total number of census tracts has changed. The number of census tracts at present is 204 (Census 2010) but previously it was 167. The data for diabetes is based on 167 census tracts, and the rest of the dataset has values for the new increased number of tracts as per 2010 Census. Hence, some census tracts have been split into more than one tract and therefore, there is some inconsistency while comparing the two datasets. Another limitation of the study is that the diabetes data available for this study is the total number of diabetes related cases in the County. This does not differentiate between type 1 and type 2 diabetes. Type 2 diabetes mellitus is responsible for nearly 95% of diabetes cases in the United States (WebMD, 2013). Among the causes of this type of diabetes, overweight, obesity and lack of physical activity are the most common causes (Diabetes Health Center, 2013). Food environment has a profound impact on one's diet and can affect the health status of people without access to quality food in the form of type 2 diabetes. But this study has not been able to show the relationship of food environment with type 2 diabetes alone. Other limitations of the study include not considering built environment and demographic changes in the time period which could have influenced the diabetes health status of the

County. The food stores were classified using ReferenceUSA's customized search terms. The terms used for classifying different food stores were restricted to supermarkets and grocery stores, convenience stores and fast food joints. Hence, the tracts could have other food stores such as farmers market or personal kitchen gardens as source of fresh food. Food store classification errors could have modified the results of the study.

Discussion

The first research question looked at whether there is an association between diabetes mortality and morbidity and living in food deserts. GIS analysis of the data using ArcGIS 10.1 suggests that food desert census tracts have a higher occurrence of diabetes related morbidity and mortality compared to other census tracts in the County. It was hypothesized that there is a negative relationship between living in food deserts and developing diabetes or dying from the disease. This hypothesis stands true. Studies have reported how lack of access to quality food can lead to diet related chronic diseases such as obesity and type 2 diabetes mellitus. But contrary to previous studies, this study area shows a positive correlation between presence of a supermarket and grocery store and diabetes. The areas which have more supermarkets and grocery stores have higher occurrences of diabetes.

The positive correlation between convenience stores in census tracts and number of diabetes related illness and deaths, supports previous research. While this research question was partially answered by the findings, some new questions were generated. Some census tracts that were designated as food deserts have less deaths and hospitalizations from diabetes while other tracts that are not food deserts fare poorer in their diabetes health status. Hence, there are other factors associated with diabetes health status which need to be studied. None of the variables except for income had a strong correlation or was statistically significant, which was expected since there are number of factors which can influence the disease status but were not included in this particular study. The likelihood of the relationship between food environment and diabetes, or car ownership and diabetes might be merely due to chance than caused by the variables studied. The GIS analysis in this study to some extent supports evidence found in the literature review that shows diet related diseases such as obesity and diabetes are more pronounced in food deserts. Although the correlation is weak it still corresponds with previous studies. USDA's Economic Research Service (ERS) Reported in 2009 that 23.5 million Americans, including 6.5 million children, live in low-income areas more than one mile from a supermarket (Healthy Food Access. Know Your Farmer, Know Your Food Compass). Low income communities with more African Americans suffer from lack of access to grocery stores and supermarkets with fresh food and vegetables (Williams, 2010). They have depended on convenience stores and fast food joints which provide cheap and easy alternative to healthy food. As a result, African Americans are more prone to develop diet related diseases such as diabetes. This study partially supports evidence from previous research that there are few healthy food stores in most of the low income neighborhoods of color. Predominance of convenience stores is observed in the food desert census tracts of Fulton County although the study could not come up with a statistically significant correlation between diabetes mortality, morbidity and presence of convenience stores. Convenience stores do not provide for healthy fruits and vegetables. Many common convenience store choices like hot dogs, candy bars and soft drinks are rich in calories but low in healthy nutrients (Healthy Food at Convenience Stores, 2013).

Apart from food environment and income, lack of personal vehicles has been an important factor associated with diabetes prevalence. Few studies have looked at this aspect of diabetes prevalence. This study shows a positive association with lack of personal vehicle and diabetes related illness in the census tracts. One reason could be since these areas do not have sufficient number of food stores, lack of personal vehicle restrict the residents from travelling greater distances in search of fresh quality food. This could be another reason why they rely more on fast food and convenience store food which is readily available in the low income tracts, triggering occurrence of diabetes among the residents.

Studies have shown that eating out and particularly fast food consumption has contributed to weight gain and related diseases. Greater access to fast food outlets and other restaurants can contribute to higher levels of obesity, especially in individuals who rely largely on the local environment for their food purchases. Car ownership might moderate this association (Inagami S, Cohen D.A., Brown A.F., Asch S.M., 2009).

Conclusions

This study is among the first to consider association of diabetes and access to food in Fulton County, Georgia. Most of the studies to date have looked at similar associations with obesity. Recommendations have also been made to reduce prevalence of obesity by enhancing access to fresh healthy food in low income neighborhoods through policy changes or by encouraging farmers market so that the residents have easy access to fresh food. But similar recommendations are not in place to alleviate diabetes prevalence. Fulton County ranks high in diabetes related mortality (OASIS). Studies like this one will provide information to County health officials to address diabetes health status by improving access to quality food in low income neighborhoods with higher prevalence of the disease. The study not only demonstrates the geographic distribution of the disease, but also provides a comprehensive picture of the association with factors that can potentially influence this prevalence such as race and income along with supermarket and grocery store distribution and car ownership. The study can serve as a base for future interventions into diabetes related policy changes at micro levels such as census tracts in Fulton County, Georgia.

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