Determining Diabetes: The Role of Educational Attainment and Race/Ethnicity in the Link between Health Behaviors and Diabetes

By

©2016

Kyle Alan Chapman

Submitted to the graduate degree program in Sociology and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

____

Chairperson, David Ekerdt

____

Jarron Saint Onge

____

Tracey LaPierre

____

Shirley Hill

____

Amber Watts

Date Defended: July 14th, 2016

The Dissertation Committee for Kyle Alan Chapman

certifies that this is the approved version of the following dissertation:

Determining Diabetes: The Role of Educational Attainment and Race/Ethnicity in the Link between Health Behaviors and Diabetes

Chairperson, David Ekerdt

Date approved: July 14th, 2016

Abstract

Drawing on a theoretical framework that integrates the social determinants of health perspective with health lifestyles theory (Cockerham 2005) and social psychological theories of person control (Mirowsky and Ross 2003), this dissertation examines the degree to which the relationship between health behaviors, such as physical activity and diet, and diabetes status is dependent on educational attainment and race/ethnicity. Educational attainment and race/ethnicity are powerful social factors that are associated with the prevalence of diabetes as well as the behaviors such as diet and physical activity that are known to cause many cases of diabetes. Current health policies seek to reduce or eliminate social disparities in diabetes by encouraging disadvantaged groups to increase their physical activity, eat healthier diets, and lose weight. However, some literature suggests that social factors, particularly education and race/ethnicity, may not only structure available resources and behaviors, but may influence individual's ability to benefit from healthy behaviors. Using data from National Health and Nutrition Examination Survey (NHANES), a series of multinomial logistic regression models were estimated to determine how association between health behaviors and diabetes varied by education and race/ethnicity. The difference in the probability of having diabetes for those who were active compared to inactive was higher among those with a high school or college education and lowest for those with less than high school and some college. Only for those with a college education did being active result in a lower likelihood of having prediabetes. Similarly, it was only for non-Hispanic whites that the risk of prediabetes was lower for those who were active compared to those who inactive. The findings related to diet indicate that the likelihood of having diabetes was actually higher at better scores for those with less than a college education and non-Hispanic blacks. Overall, these findings suggest that it should not be assumed that the relationship between health behaviors and diabetes status is consistent across social groups. Current efforts to foster health equity may be undermined by social stressors, as a result of social inequality, that negate the benefit of otherwise healthy behaviors.

ACKNOWLEDGEMENTS

I would like to thank David Ekerdt for his invaluable guidance throughout this process and his attentive mentorship that has helped me develop as a scholar; Jarron Saint Onge for his prominent role in training and mentoring me as a sociologist; Tracey LaPierre for her words of encourage and guidance; Shirley Hill for her thoughtful feedback and encouragement; and David Johnson and Amber Watts for their insight and service on my committee. I would also like to thank my family members Brad Chapman, Jackie Chapman, Kevin Chapman, Kolton Chapman, Floyd Chapman, Ola Chapman, and Shirley Smith for their continuous support over the years. I would like to thank my wife Grace Chapman for supporting me through everything, her unwavering confidence, and trust in me. Finally, I thank my children Kendall and Miles Chapman for bringing me more joy in life than I thought was possible.

Table of Contents

List of Tables and Figures

Chapter 1. Introduction

The purpose of this dissertation is to develop a sociological argument concerning the relationship between social factors, health behaviors, and disease outcomes. Specifically, the project focuses on the roles educational attainment and race/ethnicity play in the relationship between health behaviors and the prevalence of diabetes in the United States. Attention is drawn to the unequal distribution of diabetes particularly among adults and the differential association between health behaviors, such as physical activity and diet, and the risk of diabetes among those with varying levels of educational attainment and those of different racial/ethnic groups. This research addresses a major social problem in diabetes. In doing so, it contributes to an area of existing research concerning the social determinants of health and extends current understandings of the how social factors, health behaviors, and diabetes are related.

First, I will briefly describe the contents of the dissertation. Chapter 1 is intended to provide 1) a review of applicable literature related to diabetes as a disease and a social problem, 2) a theoretical and conceptual framework for the project, and 3) a definition the project's research questions. Then, Chapter 2 describes, in detail, the data and methodological approach used to address the research questions. This chapter details the use of data from the National Health and Nutritional Examination Survey and describes the statistical approach used to generate results. In Chapter 3 the results of all analyses are presented. All results are grouped according to research questions. Following the presentation of results, Chapter 4 provides a robust discussion of the findings. In this chapter, the findings are oriented under the established theoretical framework and explanatory avenues are explored. Finally, the dissertation concludes with Chapter 5 where the strengths and weakness, the limitations and contributions, are outlined.

Section I. Diabetes: the Disease and the Social Problem

The health of a population is determined by a range of social, cultural, economic, biological, and environmental factors. Specific diseases can be more associated with specific factors than others. Some diseases can directly result from the exposure to environmental toxins and others can be largely caused by genetics. Some diseases are most closely linked to poverty and deprivation of resources and others to lifestyle and socioeconomic systems. In all cases, social and economic factors tend to either provide protection against disease or increase disease risk. This is particularly true for chronic and lifestyle-related diseases. One of the most well-known and widespread chronic diseases in the U.S. is diabetes mellitus, hereafter referred to as diabetes. Over 29 million people or just under 10 percent of the U.S. population has diabetes and the disease is unequally distributed across socioeconomic and race/ethnicity groups. In addition to the substantial prevalence of diabetes in the US, an additional 86 million people have what is referred to as prediabetes. These individuals are at a substantially increased risk for developing diabetes in the future (CDC, 2014).

Diabetes the disease

Normatively, diabetes encompasses a group of metabolic conditions characterized by high levels of blood glucose, or blood sugar, due to abnormalities in insulin secretion, insulin action, or both. Insulin is a hormone that allows the body to convert blood glucose into fat or other forms of energy for storage. Abnormalities in insulin usage can lead to chronic hyperglycemia (high blood sugar) and produce inefficient catabolic effects on carbohydrate, fat, and protein metabolism (Gabir et al., 2000). Given the varying degrees to which individuals experience abnormalities in metabolism, the experience of diabetes can vary greatly.

As a disease, diabetes mellitus comes in many forms: type 1, type 2, gestational, and other types (for more information on types of diabetes see American Diabetes Association, Classification and Diagnosis of Diabetes, 2015) . The most common form of diabetes is type 2 diabetes mellitus (T2DM) also referred to as adult onset diabetes. Roughly 95 percent of diabetes cases in the US are T2DM (CDC, 2014). T2DM occurs when an individual's body either stops producing insulin or can now longer use insulin efficiently. The latter process is referred to as insulin resistance. Over time, insulin resistance results in 1) a diminished capacity to regulate the body's blood sugar levels and 2) a need to increase the amount of insulin produced by the body. T2DM is a disease that develops overtime as the body struggles to regulate blood sugar. A precursor to T2DM is a condition called prediabetes which refers to individuals with impaired fasting glucose (IFG) or impaired glucose tolerance (IGT). IFG and IGT represent the intermediate states of abnormal glucose between normal glycemia and diabetes (Nathan et al., 2007). On average those with prediabetes are 30-40 percent more likely to develop T2DM within five years without changes to physical activity, diet, and weight (CDC, 2014).

With the exception of type 1 which often occurs earlier in life and is characterized as a form of diabetes where the pancreas does not produce insulin, many cases of diabetes can be treated with a regimen of diet and exercise or prescription medication that either reduces insulin resistance or enables the pancreas to produce enough insulin to regulate blood sugar. In the event the body cannot produce insulin or even with medication the production is too low, individuals may become insulin-dependent and require the use of synthetic insulin. Controlling blood sugar (glycemic control) is important for many reason. Mainly, stabilizing blood sugar levels over time reduces the risk of diabetes-related complications and is the major indicator that diabetes is being prevented or well-managed (Hoerger, Segel, Gregg, & Saaddine, 2008). Chronic hyperglycemia can cause serious complications including tissue damage resulting in diabetic neuropathy and retinopathy (nerve damage), infection of the skin, kidney disease, and ketoacidosis or high levels of ketones which can be poisonous and result in coma or death (Campos, 2012).

Those with diabetes are also much more likely to develop other chronic conditions. Comorbidities associated with T2DM include: metabolic syndrome, cardiovascular disease, kidney disease, depression, dementia, and sleep disorders among others. When taken together, these conditions advance risks of morbidity, mortality, disability, and diminished quality of life (Edson, Sierra-Johnson, & Curtis, 2009). Additionally, combining overweight and obesity with T2DM significantly compounds the risk of all-cause mortality (Batty, Kivimaki, Smith, Marmot, & Shipley, 2007), and overall the risk of death among people with diabetes is about twice that of people of similar age without diabetes (CDC, 2011b).

Diabetes: the social problem

The last 50 years signify a dramatic increase in the prevalence of diabetes, primarily T2DM. In the late 1950s, fewer than 2 million cases of diabetes existed in the U.S. In 2012, an estimated 21 million people had been diagnosed with diabetes and additional 8 million people were estimated to have undiagnosed diabetes (CDC, 2014). Since 1990, the prevalence of diagnosed diabetes in the U.S. has risen sharply among all age groups, both men and women, and all racial/ethnic groups for which data is available (CDC, 2011a). According to the US Behavioral Risk Factor Surveillance System, in 1995 the age adjusted prevalence was ≥6 percent in only three states, District of Columbia, and Puerto Rico, but by 2010 it was ≥6 percent in every state, DC, and Puerto Rico (CDC, 2011a). Overall prevalence in the U.S.

increased during that time by 82.2 percent (CDC, 2011a). If current trends continue, 1 in 3 U.S. adults could have diabetes by 2050 (Boyle, Thompson, Gregg, Barker, & Williamson, 2010).

Recently, conflicting evidence concerning trends in the prevalence of diabetes have been widely covered in medical journals and the mainstream media. In 2014, Geiss and colleagues reported a plateauing of prevalence between years 2008 and 2012. However, Menke and colleagues (2015), which included several of the same authors as the Geiss paper, found diabetes prevalence in 2012 had risen significantly over the last ten year period and most drastically among racial/ethnic minorities. Similarly, the increase in the prevalence of T2DM in recent years has been significantly higher among those with less than a high school degree compared to those with greater educational attainment (Beckles & Chou, 2013). In addition, incidence of diabetes which refers to new cases of diabetes, is expected to rise sharply over the next 40 years due to an aging population who is more likely to develop type 2 diabetes, increases in minority populations who are at high risk for type 2 diabetes, and people living longer with diabetes (Boyle et al., 2010).

Generally, the prevalence of diabetes is markedly higher among some racial minorities and those of lower socioeconomic status (SES) (Batty et al., 2007; Marmot & Brunner, 2005). In 2012, 13.2 percent of non-Hispanic blacks and 12.8 percent of Hispanic adults had diabetes compared to just 7.6 percent of their non-Hispanic white counterparts (CDC, 2014). Similarly, the prevalence of diabetes among those with less than high school education was more than twice that of those with a four- year college degree in 2012 (Beckles & Chou, 2013).

Broadly, evidence persists that behaviors mediate the relationship between SES and diabetes. For instance, those with higher levels of education engage in behaviors that help protect themselves from developing diabetes (i.e. education influences physical activity and diet and those factors influence the development of diabetes) (Robbins, Vaccarino, Zhang, & Kasl, 2005). However, education has also shown to have an effect on the development of diabetes independently of behavioral characteristics (Sacerdote et al., 2012). Similarly, the disparities related to race/ethnicity have been attributed to the disproportionate number of minorities who are overweight or obese and engage in too little physical activity or poor diets (Cossrow & Falkner, 2004). However other causal pathways between race, education, and diabetes have been documented and include: economic and occupational opportunities, access to health services and health related information, available healthy foods, and environments conducive to physical activity (Agardh, Allebeck, Hallqvist, Moradi, & Sidorchuk, 2011; Brown et al., 2004; Brown, Miller, & Miller, 2003; Lutfey & Freese, 2005).

Risk factors and prevention

The sharp rise in prevalence of diabetes over the last 50 years has occurred in tandem with the obesity epidemic, shifting sources of dietary intake, and consistently low levels of physical activity among the U.S. population. Because of this co-occurrence particular attention has been devoted to identifying the risk factors associated with diabetes, particularly type 2. Generally, the risk factors for T2DM are divided into two categories: 1) non-modifiable risk factors such as genetic predispositions, family history, and age, and 2) modifiable risk factors such as overweight and obesity, physical inactivity, poor diet, and stress (Gillett, Royle, Snaith, & al., 2012). There are well-defined biological and behavioral risk factors for T2DM, most of which are thought to increase insulin resistance such as age, physical inactivity, overweight, and obesity, specifically the accumulation of visceral fat and excessive abdominal fat. T2DM is certainly influenced by biological mechanisms (i.e., family history, hormonal function, aging), but the development of T2DM is also heavily dependent on health behaviors and statuses, particularly diet, activity, and weight (American Diabetes Association, 2010).

Today, public health interventions have been rather successful in preventing and managing diabetes by addressing modifiable risk factors. In fact T2DM is largely believed to be preventable through dietary restriction, regular physical activity, and weight management. The Diabetes Prevention Program (2002) found that quality diet, regular physical activity, and weight reduction can prevent the development of diabetes for nearly 60% of those at risk for diabetes (prediabetes). Other studies have found similar results (The Diabetes Prevention Program Research Group, 2002; Tuomilehto et al., 2001; Turner, Cull, Frighi, & Holman, 1999); however, the degree to which healthy diet and physical activity are associated with the prevalence of diabetes at the population level has received less attention.

Results from studies like the Diabetes Prevention Program suggest that healthy diet and physical activity are equally effective regardless of social characteristics such as race, income, and education. However, the capacity to make behavioral changes is underestimated and difficult to implement within a population. These interventions struggle to confront the social inequalities that create an environment where implementing behavioral changes permanently are dependent on forces outside the control of the individual.

In particular, these studies are unable to address the role of stress in daily life. Stress management has shown to be an effective tool for the management of diabetes and other illnesses (Surwit et al., 2002). However, the focus of stress management training focuses heavily on mindfulness, breathing, and techniques to reduce the level of stress experienced in particular situations or to reduce anxiety-induced stress. These techniques do not necessarily address the prevention of social stressors such as discrimination and feelings of helplessness that have shown to cause abnormalities in metabolic function (Björntorp, 1997; Pascoe & Richman, 2009).

Because T2DM is so closely related to lifestyle, efforts to understand the disease as an individual and population-level issue have for over 50 years been dominated by a behavioral perspective on the disease. Efforts to decrease the prevalence of diabetes have been minimal; however, techniques to prevent diabetes, through behavior modification, have been quite successful. Although behavioral components have received the bulk of attention, it is also widely understood that the social environments in which people live have significant influence over individuals' behaviors. The behaviors people engage in are often dependent on the physical and social environments.

T2DM is essentially the physical manifestation of social and economic systems that make healthy choices more difficult than unhealthy choices. Food quality has declined over the past 50 years, working conditions and leisurely pursuit are more sedentary, and activity from transportation is low (e.g. less walking or biking and more driving). This is all the result of the complex cultural and economic systems that largely influences the behaviors of the population. People live and work in environments where they are forced to counterbalance the inactivity of work and leisure with planned and properly executed exercise. They are required to access a range of nutritional information and have a fairly sophisticated understanding of the relationship between physiology and diet. Their social and physical environments are engineered in ways that reduce walkability or require transportation to obtain healthy foods. T2DM is largely the result of particular behaviors that over time result in negative metabolic conditions. However, the behaviors associated with the disease are heavily influenced by social and economic forces operating outside individuals. Behaviors such as physical activity and diet are highly structured by family, race, class, gender, and occupation.

Furthermore, recent research has suggested that the pressures and exposures related to social factors can have differential effects on the utility of such behaviors to foster health. Liu and colleagues (2015) found genetic vulnerability to T2DM and the probability of developing diabetes was moderated by educational attainment. Educational attainment was not only related to behaviors that decrease the likelihood of developing diabetes, but was negatively associated with the activation of genes associated with T2DM. In addition, recent research has found that even after controlling for health behaviors, perceived discrimination results in increased levels of stress hormones (Adam et al., 2015). Chronic activation of the specific neuro-metabolic systems related to stress can alter glucose metabolism, promote insulin resistance and influence multiple appetite-related hormones (Adam & Epel, 2007). Björntorp (1997) argues that perceived stress and the resulting feelings of helplessness and defeatism activate the hypolthalamo-pituritary-adrenal (HPA) axis that causes endocrine abnormalities of elevated cortisol and low secretion of gender-specific steroid and growth hormone that can increase blood glucose and insulin resistance. In other words, the social environment exposes some groups to more stressful situations than others. Even when behaviors such as physical activity and diet or health statuses such as overweight or obesity are the same, other factors like stress that result that economic disadvantage, discrimination, and a reduced capacity to overcome social barriers may influence the effectiveness of those behaviors in promoting metabolic health.

Diabetes: bridging the disease and the social problem

Because diabetes is a major social problem that disproportionately affects particular segments of the population and because the focus of prevention and management assumes a consistent behavioral-disease relationship, this project seeks to examine whether the link between behavior and disease is indeed consistent between different social groups. This project focuses on the population-level rather than the clinical level to determine if trends related to behaviors and diabetes are observed generally among the U.S. adult population as opposed to among a specific group observed in a more controlled setting. Additionally, the focus on social factors as variables with the potential to change the strength or direction of a relationship between health behaviors and diabetes requires a broader sociological framework. Further understanding the role of social factors in the population health is important for the direction of health policy and population health management. In the next section, I bring together a range of theories from medical sociology, public health, and social psychology that provide the necessary conceptual components to understand how social factors and health behaviors interact to influence health. In doing so, I am able to build upon existing work related to the social determinants of health by extending the traditional "downward" model. In this traditional model, social factors are assumed to influence the likelihood of engaging in specific behaviors that determine health. The perspective that I put forth questions whether the relationship between behaviors and health is consistent among all individuals or varies for individuals of different social statuses.

Section II. Social Determinants of Health: Integrating and Extending Theory

Addressing the issues related to the diabetes-behavior-social factor connection can be difficult because the focus of medical and social science research has, to varying degrees, determined the direction of the physiological, psychological, and social dimensions that contribute to the prevalence of diabetes. In most health-related fields, the health determinants model is widely recognized as an inclusive and robust conceptual model of how health of populations is determined. As shown in Figure 1, health is determined at varying levels of individual and social life. Individual health is thought to be determined by individual lifestyle factors that are determined by social and community networks, living conditions, and general

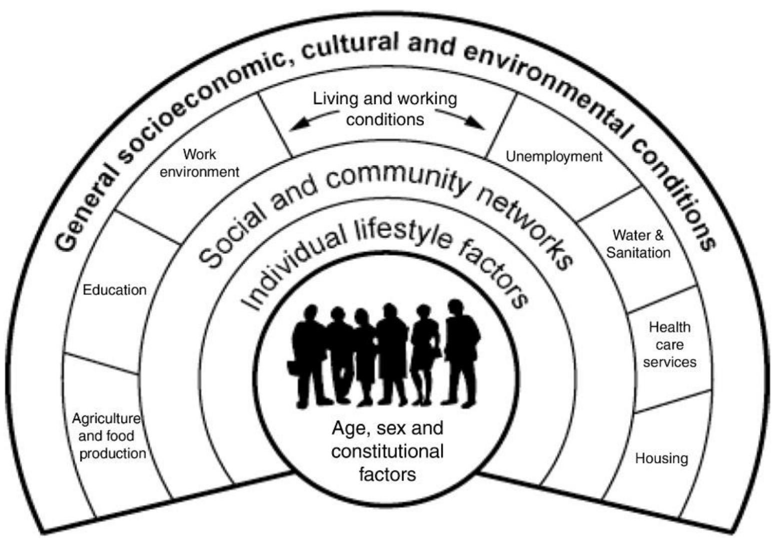


Figure 1. The main determinants of health.
Source: Dahlgren and Whitehead (1991)

socio-economic conditions. This model of health has shaped policy and research for decades and contributed to a new understanding of how individuals and society influence health. However, because the model of health has been successful in addressing concerns of public health, policies and research related to health have largely taken for granted that although people do not have the same access to resources and healthy living conditions, our behaviors tend to have the same result. For instance, although growing up in a family of smokers increases the likelihood that an individual will begin smoking, it is assumed that the risk of resulting health problems applies equally to everyone. This model assumes that social conditions influence lifestyle factors such as smoking or physical activity and it is the behaviors that cause ill-health. By and large there is a wealth of research to support this claim. However, there is also a body of literature, essentially scattered throughout a variety of research areas that suggest our behaviors might not always be uniformly associated with health outcomes. There is evidence that smoking, physical activity, diet, and obesity do not accompany the same risk of ill-health for members of different social groups (Krueger & Chang, 2008; Krueger, Saint Onge, & Chang, 2011; Lantz et al., 1998; Liu et al., 2015). Therefore, conceptualizing the relationship between social factors, behaviors, and diabetes under the determinants of health model may not fully capture the role that social factors play in shaping population health. Specifically, greater attention needs to be drawn to the relationship between behaviors and health outcomes.

The ways in which our current health policies are designed do not necessarily account for the potential variation in the relationship between behavior and health. For example, current recommendations for diet and physical activity are designed to increase overall health and eliminate health disparities. By modifying the behavior of everyone, our population can become a healthier and more equal society. This perspective assumes that engaging in healthy behaviors has the same healthy benefit to all individuals of society. If this is true, then achieving health equity would indeed be possible through current health policies. If this is not true, current health policies may either only raise overall health while maintaining current disparities or actually create larger health disparities due to the disproportionate benefit of some groups over others.

Therefore, it is necessary integrate a broader conceptualization of the determinants of health model in order to more fully understand the relationship between social contexts, health behaviors, and diabetes.

Health and lifestyle

Generally, T2DM is considered an issue of lifestyle. Lifestyle is seen as both the cause and cure for the disease. As a concept, lifestyle has been adopted by varying disciplines and largely refers to the individual behavioral patterns that affect disease status (Frohlich, Corin, & Potvin, 2001). Lifestyle, as it has been adopted by researchers in public health and social epidemiology, reflects an agency-oriented approach to the study of health (Cockerham, 2005). This approach results in the characterization of health behaviors and lifestyle as matters of individual choice and targets the individual as the point of intervention to optimize health behaviors through education (Cockerham, 2005). Research in this area focuses primarily on individual mechanisms responsible for making positive health decisions. These methods have proved extremely effective for individuals undergoing targeted interventions.

The Diabetes Prevention Program is perhaps the best example of the power of individual health behaviors to prevent and even reverse diabetes. The risk of developing T2DM among those with prediabetes was reduced by 60 percent when accompanied by education and consultations with a life coach to aid individuals in making dietary changes, engaging in physical activity, and weight reduction (The Diabetes Prevention Program Research Group, 2002). However, the type of targeted change that occurs within the intervention settings is not analogous to the experience of a population. The context of the intervention provides individuals with resources that are not available outside a specific program. Programs such as the Diabetes Prevention Program are intended help people prevent or manage diabetes not to assess whether already being physically active or being overweight is associated with the same risk for diabetes across social classes or race/ethnicity groups. The agency-oriented approach is prone to making assumptions about health behaviors based on the individual process of decision-making while underestimating the structural entities or processes whose construction allows individuals to make those decisions (Cockerham, 2005). Furthermore, evidence exists that the connections between health behaviors and health outcomes are, in some cases, dependent on social factors. Those of lower SES have higher rates of mortality related to smoking than those of high SES (Lantz et al., 1998). African-American women of high SES have more low birth weight children than their white counterparts, even with recommended neonatal care (Collins Jr, David, Handler, Wall, & Andes, 2004). Genetic vulnerability to T2DM has shown to be moderated by educational attainment (Liu et al., 2015).

The agency-oriented concept of lifestyle differs significantly from the concept of *lebensführung* that originated in the works of Max Weber ([1992] 1978). As Weber describes in *Economy and Society*, status is often found in the "style or conduct of life" or *lebensführungart* and the way people act reflects the position of one's prescribed status. Weber observed that lifestyles were primarily reflective of what people consumed as opposed to what people produced. The variation between status groups was not necessarily dependent on the means of production but in their relationship to the means of consumption (Sacerdote et al., 2012). Weber viewed social action, not as individuals' making decisions, but as regularities and uniformities of numerous actors that are repeated over time (Cockerham, 2005). Lifestyle, in the Weberian context, does not reflect an individual's health decisions but illustrates how social institutions and widespread belief systems shape the thoughts and behaviors of individuals. Practices related to physical activity, work, food, and recreation are culturally embedded our groups and dependent on social and economic systems.

Weber's perspective on lifestyle helps us understand how life chances, status differences, health outcomes, and lifestyle choices become evident in ways that represent each other. Weber claimed that the structural-level of lifestyle should be the object of sociological analysis (Katz, 2013). To examine the processes that play out among individuals, the social processes that influence and interact with the choices of individuals require acknowledgment. For instance, a person's may decide to stop eating fast food for health reasons, but the choice itself is influenced by the distribution of available foods, the concentration of fast food restaurants in a region, the social stigma associated with eating fast food, policies and discourses about the health risks associated with unhealthy eating and the rising healthcare costs associated with fast food consumption. Furthermore, if one's social position exposes them to discrimination, poverty, unemployment, and other social stressors the impact of consuming unhealthy foods may be even greater than those with a more favorable position. Several studies have found social and psychological stressors to have ill-effects on physiology, specifically endocrine function and metabolism (Björntorp, 1997; Lovallo, 2015).

Research on experienced and perceived stress and its relationship to social hierarchy is well documented. The work of Robert Sapolsky (1982, 2005; Sapolsky, Krey, & McEwen, 1986) laid the groundwork for studying the relationship between social hierarchy, stress, and health outcomes. Over the years, Sapolsky has studied social hierarchy among baboons. He has repeatedly reported an inverse relationship between rank in the social hierarchy overall levels of cortisol (stress hormone), glucose metabolism, prevalence of hypertension and high cholesterol, and ability to utilize stress hormones beneficially. More recent research on human populations indicates that stress, unhealthy behaviors, and low SES independently increase the risk of mortality and, when combined, these factors result in markedly greater disadvantage (Krueger & Chang, 2008). This type of research highlights the importance of understanding the differential distribution and related outcomes of unhealthy behaviors among those of varying social statuses.

The disconnect between agency-oriented and structural perspectives reflects the long standing debate within sociology surrounding structure and agency (Cockerham, 2005). Lifestyle, framed as the accumulation of individual decisions, neglects or underestimates how individual behaviors and subsequent health outcomes are embedded in social processes. In health lifestyles theory, Cockerham (2005; Cockerham, Rütten, & Abel, 1997) uses Bourdieu’s (1984) notion of the habitus to describe the way that individuals internalize aspects of their structural surroundings. People develop tendencies related to decision-making that reflect their status groups, thus making individual behavior socially determined. While this perspective keenly addresses the social components of health behaviors and orients the idea of lifestyle under a more inclusive and structurally-oriented approach, integrating additional ideas concerning the psychosocial dynamics of social position and behavior may provide a more robust understanding of why the behaviors of some individuals are more related to health outcomes than others.

Opportunity and the likelihood of making various decisions related to health are subject to external pressures given that individuals reside within specific social contexts. Furthermore, the capacity for individuals to act within their social contexts varies not only by their access to resources in the forms of economic, cultural, and social resources, but by the psychosocial dimensions that accompany social position. The work of John Mirowsky and Catherine Ross highlight the dynamic relationship between human agency and social structures. Mirowsky and Ross (Mirowsky & Ross, 1986, 2003a, 2003b, 2015; Ross & Mirowsky, 1989) focus on the ability for individual to be "effective" in their daily lives. They use a wide variety of data to show that individuals with high levels of education tend to have a greater sense of personal control in their lives. For example, their theory of education as learned effectiveness purposes that education enables people to coalesce health-producing behaviors into a coherent lifestyle, and that a sense of control over outcomes in one's own life encourages a healthy lifestyle and conveys much of education's effect. Essentially, personal control is an individual's perceived power over social structures and a lack of such power can result in feelings of helplessness. Feelings of helplessness are associated with increased levels of perceived stress and diminished capacity to seek out environments and behaviors that support health (Maier & Seligman, 1976; Mirowsky & Ross, 2003a; Seeman & Seeman, 1983). Furthermore, perceived stress and feelings of helplessness have shown to activate neuro-endocrine systems that result in physiological abnormalities that are associated with increased risk for diabetes (Björntorp, 1997).

From a personal control perspective, individuals who feel as if they can control the outcome of their lives are more capable of making healthy decisions, but they are also able to arrange their lives in a way that deflects or reduces exposure to unhealthy activities and environments. Work in this area dating to the 1980's indicates that a sense of control over one's life can be generally associated with reduced exposure to stress by making individuals more capable of assessing situations and making decisions from which they benefit (Folkman, 1984). Those in more favorable social positions are not only more likely to feel as if they can control the outcome of their own health, but able to manipulate their situations in a way that makes the healthy choice, the easier choice. Along with the procedural advantages associated with social position, those with greater education or those who are less likely to experience issues such as racial discrimination or unemployment may encounter situations that require they utilize their sense of control less frequently. Those in such positions are more likely to be exposed to social structures that confer health and possess a greater capacity to overcome structural obstacles that buffer the negative effects of social structures. Engaging in behaviors that are associated with reduced risk for diabetes such as physical activity and a healthy diet may be beneficial for all individuals. However, those in particular social positions may be uniquely positioned and skilled to capitalize on such behaviors while minimizing the exposure to factors that negative confer health such as stress resulting from discrimination, financial instability, and other factors that produce feelings of helplessness and a reduce sense of control.

Integrating theories related to social position and behaviors (health lifestyles theory) and effective human agency (learned effectiveness) provides a more nuanced conceptual framework related the role that social factors play in the relationship between behavior and health. Applying this framework to the topic of interest can assist in formulating specific research questions related to social factors, health behaviors, and diabetes. In the next section, two general research questions will be proposed. These questions focus specifically on the role of education and race/ethnicity in the link between health behaviors (physical activity and diet) and diabetes.

Section III. Research Focus and Questions

The central objective of this dissertation is to interrogate the social bases of the relationship between health behaviors and the prevalence of diabetes. In doing so, I intend to develop an argument concerning the way in which social factors not only provide segments of society with positions and resources that effectively reduce the risk of developing diabetes but bolster individuals' ability to capitalize on healthy behaviors. By examining the association between health behaviors such as physical activity and diet and diabetes at the population level, it may be possible to assess if engaging in physical activity or eating a particular diet is more strongly associated with risk of diabetes for those of different social groups.

Given what is known about diabetes both as a disease and social problem and because the majority of diabetes cases are related to lifestyle and particular behaviors, this research focuses specifically on physical activity and diet. Both physical activity and diet are well documented as being related to the development of diabetes (Whiting, Unwin, & Roglic, 2010). Addressing these two behavioral factors is appropriate because they are cornerstones of diabetes prevention and they are risk factors for diabetes that have shown to be influenced greatly by social factors. The theoretical framework argues that 1) social factors make it more or less likely that marginalized groups will have access to resources that allow them to engage in healthy behaviors and that 2) those in privileged positions experience a greater sense of personal control that increases their capacity to maximize the benefit of such healthy behaviors. Specifically, this research will address both educational attainment and race/ethnicity because both meet the aforementioned criteria related to the theoretical framework and both are associated with disparities in the prevalence of diabetes and prediabetes as well as the health behaviors of interest.

Both educational attainment and race/ethnicity greatly influence individuals' access to resources, health behaviors, and feelings of personal control. Educational attainment is generally associated with increased income, greater job security, and the accumulation of wealth. Educational attainment can also increase a person's sense of control by providing generally applicable capabilities, skills, knowledge, and power to govern their own lives (Becker, 1964; Mirowsky & Ross, 2003a). Race/ethnicity can manifest in a similar way. Rather than bolstering control over one's life, racial inequality, discrimination, and prejudice can result in reduced assess to income, education, and quality housing and can foster feelings of helplessness or loss of control (Ross & Mirowsky, 1989). While educational attainment and race/ethnicity are markedly different social factors, they are both characteristics that highlight current deficiencies in the way research addresses the relationship between health behaviors and health outcomes. Both are individual characteristics that are intimately tied to social hierarchy but both are also individual characteristics that are intimately tied to the psychosocial processes associated with health and diabetes in particular.

Two general questions guide this research. The first, "Does the association between behaviors and risk of diabetes or prediabetes vary between educational and racial groups?" This question addresses the degree to which educational and racial groups benefit from health behaviors in protecting against the risk of diabetes or prediabetes. This question addresses, for instance, whether the difference in risk of diabetes for those meeting activity recommendation compared to those who are not varies by education or race/ethnicity. For the sake of current health policy, it would be encouraging if, for all groups, being active or having a healthy diet resulted in a similar reduction in the risk of diabetes or prediabetes. If this were not the case, then the result would highlight potential issues currently being experienced by the population.

The second general research question is "Do educational and racial disparities persist when different groups engage in the same level of activity or consume the same quality of diet even after controlling for a host of confounding factors?" This question is important to address if educational attainment and race/ethnicity are associated with diabetes or prediabetes independently from physical activity and diet. It is also important to ask because the results may indicate just how much the two health behaviors contribute to or narrow the disparities in prevalence of diabetes and prediabetes. Given that diet and activity are foundational in the prevention of diabetes, it would be expected that the differences in behaviors between social groups explain a considerable amount of current disparities.

For each of the general research questions, specific questions were formulated for each behavior-social factors pairing. To clarify, each of the specific research questions are listed below. Each pairing includes two questions, as previously described. The research questions are intended to address different dimensions of the interaction between a behavior and a social factor. The first question in each pairing represents the first general research question and addresses whether or not the association between behavior and diabetes status is equal among different social groups. This is the primary purpose of the dissertation and of central interest both empirically and theoretically. The second question for each pairing is related more to the distribution of diabetes and prediabetes. This question addresses the more general trend associated with a behavior across groups and can be used to identify trends in the social disparities of diabetes according to behaviors.

Educational Attainment and Physical Activity

1. Does the association between physical activity and risk of diabetes or prediabetes vary by educational attainment?
2. Do educational disparities persist when different groups engage in the same level of physical activity even after controlling for a host of confounding factors?

Educational Attainment and Diet Quality

1. Does the association between diet quality and risk of diabetes or prediabetes vary by educational attainment?
2. Do educational disparities persist when different groups consume the same quality of diet even after controlling for a host of confounding factors?

Race/Ethnicity and Physical Activity

1. Does the association between physical activity and risk of diabetes or prediabetes vary by race/ethnicity?
2. Do racial disparities persist when different groups engage in the same level of activity even after controlling for a host of confounding factors?

Race/Ethnicity and Diet Quality

1. Does the association between diet quality and risk of diabetes or prediabetes vary by race/ethnicity?
2. Do racial disparities persist when different groups consume the same quality of diet even after controlling for a host of confounding factors?

Now that the research questions have been described, the next step is to introduce the data used to answer the questions. Chapter 2 “Data and Methodology” describes in detail the data, sample, and analytical approach taken. Because the research questions focus on trends within the population and the differential risk of diabetes and prediabetes, a large national dataset was required. To answer these questions, detailed health and demographic information must be included for a larger number of individuals with diabetes and prediabetes as well as those without diabetes. The advantage of using a largely national representative dataset is of course, the generalizability of the results as well as the adequate sampling of subgroups. The disadvantage to using a data source such as this is that the answers to the research questions will be conditional to that of the data source. Given the purpose of this dissertation is to examine the social bases for which health behaviors are associated with the risk of diabetes and prediabetes at the population-level, the use of the National Health and Nutrition Examination Survey (NHANES) is appropriate. The next chapter, "Chapter 2: Data and Methodology," describes in detail the data, sample, and analytical approach taken to answer the research questions.

Chapter 2. Data and Methodology

Introduction

This chapter provides detailed information concerning the data and research methodology used to address the central research questions of this study. As previously outlined, the primary goal of this study is to examine if the highly educated and racial majority experience advantage over their less educated and minority counterparts in the way health behaviors (physical activity and diet) are associated with diabetes status.

This chapter consists of four sections. Section I provides detailed information about the source of data in order to provide the proper context to the findings. Section II provides detailed information concerning the measurement and utility of specific variables used in the analysis. Section III outlines the treatment of the data and explains who was included in the sample and why data from some respondents was not included. Finally, Section IV outlines the analytical procedure and explains, in detail, the steps taken to analyze the data. This section addresses the specific statistical techniques used in the analysis as well as the strengths and weaknesses of these techniques.

Section I. The National Health and Nutrition Examination Survey (NHANES)

All data come from the National Health and Nutrition Examination Survey (NHANES) (www.cdc.gov/nchs/nhanes/about_nhanes.htm). The NHANES is a large, nationally representative survey conducted by the National Center for Health Statistics (NCHS) in conjunction with the Centers for Disease Control and Prevention (CDC). The NHANES is a continuous survey with a design that allows for a single sampling frame of two years. For example, the NHANES 2011-2012 is one cross-sectional survey carried out over two years. The survey consists of questionnaires administered in the home which are followed by a standardized physical examination in a specially equipped Mobile Examination Center (MEC). The examination includes physical measurements, a dental examination, and the collection of specimens for laboratory testing. In addition, a subsample of respondents participated in a nutritional assessment which included a food dairy and a 24-hour dietary recall interview. Here participants recorded the foods they ate and with the assistance of NHANES interviewers determined the specific amount of foods consumed over the 24-hour period. Dietary recall interviews were conducted in a private room in the MEC. Each MEC dietary interview room contains a standard set of measuring guides (e.g., measuring cups, assorted sizes of plates, cartons, bowls and glasses, and rulers, grinds and a food modeling booklet). These tools were used to help the respondent report the volume and dimensions of the food items consumed. They were not intended to represent any one particular food, but rather were designed to help respondents estimate portion sizes.

The complex, multistage probability sample design allows the NHANES to be representative of the resident civilian non-institutionalized U.S. population. NHANES excludes all individuals in supervised care or custody in institutional settings, all active-duty military personnel, active-duty family members living overseas, and other U.S. citizens residing outside the 50 states and the District of Columbia. NHANES uses a four-stage sampling design. The first is the selection of the primary sampling units (PSU) which are mostly individual counties. Second is the selection of segments within the counties. Third is the selection of dwelling units or households within the segments. And fourth is the selection of individuals within a household. Beginning in 1999, the annual sample size has been approximately 5,000 individuals from 15 different locations selected from a sampling frame that includes all 50 states and the District of Columbia.

Sampling weights are provided for the NHANES by the CDC to account for the complex design including oversampling of specific groups, survey non-response, and post-stratification. When a sample is weighted in NHANES it is representative of the U.S. Census civilian non-institutionalized population. A sample weight is assigned to each sample person. It is a measure of the number of people in the population represented by that sample person. A sample weight is provided in NHANES for each survey population and subpopulation. For instance, the sampling weight is different for those who completed the 24-hour dietary recall than for those who only completed the physical examination because the composition of dietary sample may be different.

A major strength of the NHANES is the physical examination and clinical measurements (laboratory testing) of health data which are absent from other large, nationally representative surveys. This advantage coupled with the questionnaire and dietary data make the NHANES one of the most appropriate datasets for the study of health and diabetes in particular.

NHANES 2007-2012

In order to produce estimates with greater statistical reliability, survey cycles were combined to increase survey sample size. The data included in this study come from the public-use NHANES 2007-2008, 2009-2010, and 2011-2012 (three cycles total). Use of non-public data is only granted through Research Data Centers (RDC); however, such resources were not necessary for this project. For each survey cycle (e.g. survey 2011-2012), data are provided in partial data files containing data from select portions of the NHANES. For example, demographic information and body measurements are provided as separate data files; therefore if one requires the two files for analysis the user would need to merge the files together according the unique sequence number provided to all respondents. For this analysis, over 25 data files were required for each survey cycle. The process of building the finalized dataset included: downloading all needed data files for all three survey cycles, sorting and saving each data file according to the unique sequence number assigned to all observations, merging survey cycle-specific data files according to the unique sequence number into a single full-data file for each survey cycle, and finally merging the three full-data files into a single NHANES 2007-2012 dataset. Because survey cycles were combined, new sampling weights were required. New sample weights were calculated according the procedures suggested by the CDC and NCHS (CDC, 2013).

Section II. Variables and Measurement

This section describes all of the variables included in the analysis, provides specifications for the measurement of each variable, and outlines if and how the variables had to be recoded, calculated, or adjusted. In addition, this section provides explanations for why some variables were omitted from the analysis.

Dependent variable: diabetes status

The primary outcome variable for all analyses was diabetes status. Diabetes status was measured as a categorical variable consisting of "diabetes," "prediabetes," and "normal glycemia." The "diabetes" groups was defined as having the diabetes mellitus, whereas "prediabetes" was defined as having a significantly greater risk for developing diabetes mellitus than those with "normal glycemia" or normal blood sugar whom present no risk of diabetes. The variables included in determining diabetes status include: a HbA1c test, a physician's diagnosis of diabetes or prediabetes, the current use of insulin, and the current use oral diabetes medication.

During the medical examination portion of the NHANES, participants volunteered a range of biospecimens including blood. The HbA1c test (or hemoglobin A1c) is a laboratory test that measures the proportion of glycated hemoglobin in the bloodstream. The test measures the average plasma glucose during the previous 90-120 days and has been used to monitor diabetes for many years. The HbA1c is used as both a diagnostic tool and an indicator of diabetes control (American Diabetes Association, 2015b). Other methods to assess diabetes include fasting plasma glucose, a two-hour glucose tolerance test, and a measure of serum insulin. Though these other measures have varied clinical use they are also more easily affected by day-to-day fluctuations in glucose and insulin, whereas the HbA1c assesses diabetes according to the average blood glucose over the last three to four months. Clinical recommendations for diagnoses of diabetes categories include HbA1c scores of 6.5 percent or greater for diabetes, 5.7-6.4 percent for prediabetes, and less than 5.7 for normal glycemia (American Diabetes Association, 2015b).

In addition to the HbA1c classification, participants were asked questions concerning diabetes, one of which asked about a physician's diagnosis: "Other than during pregnancy, have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" Participants could answer "yes", "no", or "borderline". If participants responded "yes" they were categorized has having diabetes, and if they responded "borderline" they were categorized as having prediabetes. Similarly, respondents were asked about a diagnosis of prediabetes in the question "Have you ever been told by a doctor or health professional that you have any of the following: prediabetes, impaired fasting glucose, impaired glucose tolerance, borderline diabetes, or that your blood sugar is higher than normal but not high enough to be called diabetes or sugar diabetes?" Participants could answer "yes" or "no". Those who responded "yes" were considered to have prediabetes. Furthermore, those who responded positively to the questions "Are you now taking insulin?" or "are you now taking diabetic pills to lower your blood sugar?" were considered as having diabetes.

Classification of diabetes status drew from all of the aforementioned assessments. Table 1 shows a diabetes status classification matrix. A participant was considered to have diabetes if their HbA1c was 6.5 percent or higher. A respondent was also considered to have diabetes if they had received a diagnosis of diabetes from a doctor or healthcare professional, was currently taking insulin, or taking an oral diabetic medication. If a respondent answered “yes” to any of these questions they were considered to have diabetes regardless of their HbA1c test results. Classification of this sort is necessary because with proper control of diabetes through medication, weight management, diet, and physical activity individuals can reduce their HbA1c into lower ranges of the diabetes spectrum. In fact, that is the goal of diabetes management. Similarly, a respondent was considered as having prediabetes if their HbA1c was between 5.7 and 6.5 percent. A respondent was also considered to having prediabetes if they responded “borderline” to the question asking about receiving a diagnosis of diabetes from a doctor or healthcare professional or “yes” to the question of having been told they have prediabetes, impaired fasting glucose, impaired glucose tolerance, or higher blood sugar than normal but not high enough to be considered diabetes. Similar to the case of diabetes, a participant was considered to have prediabetes if they answered positively to these questions regardless of their HbA1c scores unless their scores fell into the diabetes range. In this case, they were considered to have diabetes. If individuals did not meet the criteria for either diabetes or prediabetes they were considered to have normal glycemia. Generally, a diagnosis of diabetes supersedes a HbA1c test in the prediabetes and normal glycemia range and a diagnosis of prediabetes supersedes a HbA1c test in the normal glycemia range.

Table 1. Categorization Matrix for Diabetes Status

Diabetes	Diagnosis of Diabetes	Diagnosis of Prediabetes	Taking insulin or medication	No diagnosis and not taking medication
HbA1c > 6.5%	✓	✓	✓	✓
HbA1c 5.7-6.4%	✓	*X*	✓	*X*
HbA1c < 5.7%	✓	*X*	✓	*X*
Prediabetes	Diagnosis of Diabetes	Diagnosis of Prediabetes	Taking insulin or medication	No diagnosis or not taking medication
HbA1c > 6.5%	*X*	*X*	*X*	*X*
HbA1c 5.7-6.4%	*X*	✓	*X*	✓
HbA1c < 5.7%	*X*	*X*	*X*	*X*
Normal Glycemia	Diagnosis of Diabetes	Diagnosis of Prediabetes	Taking insulin or medication	No diagnosis or not taking medication
HbA1c > 6.5%	*X*	*X*	*X*	*X*
HbA1c 5.7-6.4%	*X*	*X*	*X*	*X*
HbA1c < 5.7%	*X*	*X*	*X*	✓

Independent variables

The primary independent variables of interest include two behavioral variables, physical activity and diet, and two sociodemographic variables, education and race/ethnicity. Other variables included in the analyses are described under the subheading “Control Variables”.

Physical Activity

Physical activity has shown to reduce the risk of type 2 diabetes as much as 30 percent (Bassuk & Manson, 2005) and is a foundational in the prevention and management of diabetes (Morrato, Hill, Wyatt, Ghushchyan, & Sullivan, 2007). Questions concerning recent or current physical activity are asked in the NHANES questionnaire. Participants are asked to report the number of minutes they spend in moderate and vigorous activity at both work and in recreation per week. Moderate-intensity activity is defined as activities that cause a small increase in breathing or heart rate and is done for at least ten minutes such as brisk walking, bicycling, swimming, or golf. Vigorous-intensity is defined as activities that cause large increases in breathing or heart rate and is done for at least ten minutes such as running or basketball.

Participants were categorized into two groups, those meeting physical activity recommendations and those not meeting physical activity recommendations. According to the CDC *2008 Physical Activity Guidelines for Americans,* adults need at least 150 minutes of moderate to vigorous aerobic activity per week. Those meeting the recommendation were considered active while those not meeting the recommendations were consider inactive. Measurements related to the recommendation for strength training were not included.

Healthy Eating Index 2010

Dietary quality is a cornerstone of diabetes management and prevention (Sheard et al., 2004). Diet was assessed according to the Healthy Eating Index (HEI) 2010 which was developed by the United States Department of Agriculture Center for Nutritional Policy and Promotion. The NHANES includes a nutritional diary and a 24-hour dietary recall. These two items allow researchers to calculate the HEI-2010 based on USDA's food patterns and quantified dietary recommendations. The HEI-2010 includes scores for 12 dietary components that sum to a maximum total score of 100. The total component score indicates the percentage of achieved dietary recommendations. For example, a total component score of 50 indicates that a group or individual met 50% of the dietary recommendations.

The primary variable of interest is the total component score, a continuous variable ranging from zero to 100. However, a limited analysis of individual components is provided in Chapter 3. Because USDA food pattern recommendations for amounts of food groups, oils, and empty calories are couched in terms of absolute amounts that vary according to energy level, the HEI–2010 scores use standards that are expressed as either a percent of calories or per 1,000 calories. This "density" approach disaggregates diet quality from quantity. The one exception is fatty acids, which are expressed as a ratio of unsaturated fatty acids to saturated fatty acids. The HEI–2010 components and scoring standards are shown below in Table 2.

Table 2. HEI-2010 Component and Scoring Standards

Component	Maximum points	Standard for Maximum score	Standard for minimum score of zero
Adequacy:			
Total Fruit	5	≥0.8 cup equiv. per 1,000 kcal	No Fruit
Whole Fruit	5	≥0.4 cup equiv. per 1,000 kcal	No Whole Fruit
Total Vegetable	5	≥1.1 cup equiv. per 1,000 kcal	No Vegetables
Greens and Beans	5	≥.2 cup equiv. per 1,000 kcal	No Dark Green Vegetables or Beans and Peas
Whole Grains	10	≥1.5 oz equiv. per 1,000 kcal	No Whole Grains
Dairy	10	≥ 1.3 cup equiv. per 1,000 kcal	No Dairy
Total Protein Foods	5	≥2.5 oz equiv. per 1,000 kcal	No Protein Foods
Seafood and Plant Proteins	5	≥.8 oz equiv. per 1,000 kcal	No Seafood or Plant Proteins
Fatty Acids	10	(PUFAs + MUFAs)/SFAs >2.5	(PUFAs + MUFAs)/SFAs
Moderation:			
Refined Grains	10	≤1.8 oz equiv. per 1,000 kcal	≥4.3 oz equiv. per 1,000 kcal
Sodium	10	≤1.1 gram per 1,000 kcal	≥2.0 grams per 1,000
Empty Calories	20	≤19% of energy	≥50% of energy

Source: USDA

Dietary component scores were calculated with the use of the MyPyramid Equivalents Database (MPED) according to the methodology established by the US Department of Agriculture Center for Nutrition Policy and Promotion. The MPED links to the USDA's Food and Nutrition Database for Dietary Studies and has been used to evaluate the US diet in relation to dietary guidance. The MPED translates the amounts of foods, as eaten, into cup and ounce equivalents that are consistent with the units of measure used for the HEI scoring standards. The National Cancer Institute (NCI) provides SAS code for NHANES data that performs the preliminary steps for creating the requisite variables for measuring individual and population level HEI-2010 scores (http://epi.grants.cancer.gov/hei/tools.html). The NCI SAS code allocates the NHANES-measured components to the HEI-2010 algorithm. Because the HEI-2010 is a multidimensional construct involving 12 densities, a simple method for estimating standard errors was not available; therefore, the code includes a Monte Carlo simulations step in order to calculate stable standard errors. Modification of the NCI provided SAS code was necessary to appropriately estimate HEI-2010 scores for the individual NHANES datasets (2007-2008, 2009-2010, 2011-2012) before being merged with the full NHANES 2007-2012 dataset.

A measure of diet can not only be difficult to estimate, but may be subject to time period effects for which the cross-sectional design of NHANES cannot account. Individuals are at higher risk for diabetes when consuming an unhealthy diet (Ley, Hamdy, Mohan, & Hu, 2014); however dietary habits may change after diagnosis due to encouragement from healthcare providers, increased nutritional education, and family support (Gerstle, Varenne, & Contento, 2001). Those diagnosed with diabetes are often provided with detailed dietary education to help them improve their diets and manage their disease. Likewise, those with prediabetes are often advised to make changes to their diets to reduce the chances of developing diabetes in the future (American Diabetes Association, 2015b). Therefore, the interpretation of the relationship between diet and diabetes must be mindful of the potential for reverse causality associated with a diagnosis.

Educational Attainment

Educational attainment was included in all analyses given the specific interest in education as a social factor and the documented disparities in diabetes related to educational attainment (Beckles & Chou, 2013; Borrell, Dallo, & White, 2006). NHANES measures educational attainment for adults older than 20 years old as less than 9th grade, 9th-11th grade (with no diploma), High School graduate/GED or equivalent, some college or associates degree, college graduate or above. The variable of educational attainment was recoded into four categories: less than high school, high school, some college, and college. The original categories of less than 9th grade and 9-11th grade (with no diploma) were collapsed due to sample size and the lack of evidence indicating meaningful differences in diabetes outcomes and lifestyle factors.

Race/Ethnicity

Race and ethnicity was also included in all analysis due to the known racial disparities in the prevalence of diabetes (Selvin, Parrinello, Sacks, & Coresh, 2014) as well as the differences in both diet and physical activity among race/ethnicity groups (Kirkpatrick, Dodd, Reedy, & Krebs-Smith, 2012; Troiano et al., 2008). NHANES measures race and ethnicity as non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, and other race including multi-racial. For the purposes of this study, Mexican and other Hispanic categories were collapsed in one Hispanic category. Although meaningful differences have been observed between specific groups (i.e., Puerto Ricans vs Cubans) in terms of health outcomes (Fuentes-Afflick & Lurie, 1997) and health behaviors (Alegría et al., 2007; Loria et al., 1995), the differences related specifically to physical activity, diet, and diabetes between Mexican Americans and other Hispanics in this study were marginal.

Control Variables

Several additional control variables were included in the analysis due to either the association between control variables and diabetes or the association between control variables and health behaviors and sociodemographic factors. First a measure of weight status in the form of body mass index (BMI) was included in all analyses. Overweight and obesity are well documented risk factors for diabetes (Leong & Wilding, 1999; Mokdad, Ford, Bowman, & et al., 2003; Nguyen, Nguyen, Lane, & Wang, 2010) and weight management is at the foundation of diabetes prevention and management (Inzucchi et al., 2012). BMI was included in the NHANES medical examination. BMI, expressed as weight in kilograms divided by height in meters squared (kg/m^2) is commonly used to classify weight status. NHANES classifies BMI into four categories underweight (BMI > 18.5), normal or health weight (BMI 1.5-24.9), overweight (BMI 25.0-29.9), and obese (BMI <30.0). Due to the small sample size among those who are underweight, underweight and normal weight categories were combined. Although BMI is useful for assessing general risk of diabetes, the measure is not without flaws. BMI is not a measure of body fat and the cut points, from normal to overweight or overweight to obese, were largely developed from assessing the weight and height of Non-Hispanic white individuals (Jackson, Ellis, McFarlin, Sailors, & Bray, 2009). However, a large body of evidence suggests that being overweight and obese, according to measures of BMI, is associated with increased risk of diabetes and prediabetes among all race/ethnicity groups (Narayan, Boyle, Thompson, Gregg, & Williamson, 2007).

The next variable included as a control was age category. Diabetes is most prevalent among those age 65 and older (Morley, 2008). Additionally, physical activity and diet vary by age. Levels of physical activity tend to decrease with age (Caspersen, Pereira, & Curran, 2000; Troiano et al., 2008) and diet quality is typical highest among children and older adults (Hiza, Casavale, Guenther, & Davis, 2013). To account for the fact that older adults are more likely to have both diabetes and prediabetes and behave differently than their younger counterparts, age category as measured as adults 24-34, 35-54, 55-64, and 65 and older was included in all analyses.

Gender was also included in the analyses. Although the prevalence of diabetes is approximately 1 percent higher among male adults than female adults, gender was also included in all analyses due to the differences in levels of physical activity and diet among men and women (Troiano et al., 2008).

A measure of income and poverty was included in the analyses to account for differences in financial resources and exposure to poverty that may be associated with diabetes, health behaviors, and sociodemographic characteristics such as education and race/ethnicity. An income-to-poverty ratio was calculated from year-specific poverty thresholds and reported family income levels. Family income was measured as categorical variables ranging from 1-15, each unit representing $4,999 with the exception of the final category which represents income of $100,000 or more. Respondents who did not provide total income were asked whether their family income was below or above $20,000 or to select one of the income categories. The National Center for Health Statistics used the midpoint of each category to calculate the income-to-poverty ratio. The income-to-poverty ratio was calculated by dividing the midpoint family income by the established U.S. poverty threshold for the given year. The values range from 0-4.9 and 5 for values greater than or equal to 5 times the poverty threshold. The income-to-poverty ratio measure was preferred because it reflects family income relative to poverty and has been used extensively in publication (Freedman et al., 2007; Merikangas et al., 2010; Seligman, Laraia, & Kushel, 2010).

Section III. Analytic Sample

The original sample of adults over the age of 24 was 17,713. This was the total number of adults over the age of 24 from NHANES 2007-2008, 2009-2010, and 2011-2012. Because the variables used in the analysis come various subsamples within the NHANES (i.e., medical examination, laboratory testing, dietary recall), the sample used in the analysis was considerably smaller. For each stage of the NHANES, specific sample weights were calculated for those who complete the stage. For instance, if one were to analyze data collected from the medical exam (e.g. body measurements) then the appropriate sample weights would apply only to those having completed the exam and therefore observations not included in that subsample cannot be included for analysis. In this case, data were used from several subsamples; only those who had a physical exam, had laboratory test completed, and participated in the dietary recall were eligible for inclusion. Table 3 presents a list of exclusions from the sample. Specifically, 628 observations were deleted for having not had a physical examination, 958 were deleted for not having had laboratory test completed, and 872 observations did not complete the dietary recall.

Table 3. Number and Type of Exclusions to the Sample, NHANES 2007-2012

	Exclusions	Sample Total
Adults over age 24		17,713
Subsamples		
No Physical Exam	628	17,085
No Laboratory Tests	958	16,127
No Dietary Recall	872	15,255
Missing Data		
BMI	216	15,039
Age	228	14,811
Family Income	1,265	13,546
Education	10	13,536
Pregnancy	136	13,400
Totals	*4,331*	*13,400*

After subsample exclusions the eligible subsample was 15,255. Even though the sample was smaller than original, the NHANES sampling weights ensure the sample is representative of the non-institutional, civil U.S. population. Missing data in the independent and control variables also reduced the size of the original sample. Specifically, 1,719 observations were deleted due to missing data for BMI (216), age (228), poverty-to-income ratio (1,265), and educational attainment (10). Additionally, 136 pregnant women were excluded from sample because blood glucose during pregnancy can vary greatly, BMI is not appropriate for pregnant women, and diet and physical activity are irregular. These exclusions brought the sample to a total of 13,400 adults over the age of 24. All analyses conducted in this study use this sample. Moving forward, the next section details the step taken to analyze the data including a detailed description of the statistical approach.

Section IV. Analytical Procedures

All of the statistical analysis was conducted in STATA 13 (Stata Corp 2013). The only exception was the use of SAS for calculating the Health Eating Index scores as described in Section III of this chapter. First, a univariate analysis was completed for all variables of interest using the *svy* command in STATA to ensure all descriptive information for the variables were weighted to reflect the adult population of the U.S. The univariate analysis provided frequency and percentage distributions for all the variables of interest. Next, a bivariate analysis was conducted for the outcome variable of diabetes status and all of the independent and control variables. The bivariate distribution was presented to highlight the association between independent variables and diabetes status. For example, to call attention to the age distribution within diabetes statuses or to provide the percentage of those with diabetes across levels of educational attainment. Additionally, a bivariate analysis was conducted between each behavior-sociodemographic pairing of interest (i.e. physical activity-education, physical activity-race/ethnicity, diet-education, and diet-race/ethnicity). This was necessary to identify how levels of physical activity and diet quality vary among those with different levels of education and race/ethnicities. Differences were evaluated based on two-sample tests of proportions and *t*-tests and statistical significance was evaluated at the .05 alpha level.

A multivariate analysis was then conducted to highlight the behavior-sociodemographic relationships within diabetes statuses. All percentage distributions and differences were evaluated by calculating 95% confidence intervals (CI) for each percentage as well as a two-sample test of proportions and two-sample *t*-tests. To illustrate, the complex survey design of the NHANES provides estimates of population frequencies such that the proportion of those with diabetes and a high school education is representative of the U.S. adult population. From those estimates, a 95% CI was calculated and a two-sample test of proportions or a two-sample *t*-test was performed to determine if the difference between two or more proportions or means was equal to zero. Although conducting an ANOVA would provide the same information, this procedure is only appropriate when one of the variables is continuous. Additionally, because the HEI-2010 is the only continuous variable and the mean HEI score is essentially a proportion of dietary recommendation, the test of proportions and the *t*-test calculate the same statistic. A 95% CI was calculated for all percentage and mean estimates and additional tests of significance were performed to evaluate the differences between groups. For example, to evaluate if the percentage of those with diabetes who were active was higher among those with a college degree than those with a high school degree, a two-sample test of proportions was conducted. Whereas, to evaluate whether the mean diet score of those with diabetes, was higher among those with a college degree than a high school degree, a two-sample *t*-test was performed.

Multinomial logistic regression

After preliminary analysis and surveying the descriptive statistics of the sample, inferential statistical procedures were performed. While the descriptive statistics can provide information on the general association between diabetes, health behaviors, and social factors, further statistical analysis allowed the given associations to be viewed within the contexts of the control variables. To proceed, four separate sets of models were estimated using multinomial logistic regression.

Multinomial logistic regression allows researchers to estimate the odds and probabilities of a specific outcomes related to a categorical variable. In this case, multinomial logistic regression was used to predict the probability of having normal glycemia, prediabetes, or diabetes. One of the advantages of using a multinomial logistic model is that the assumptions of the statistical technique are less stringent than other models (Long & Freese, 2006). Multinomial logistic regression, as opposed to ordered logistic regression, makes no assumptions concerning order among the dependent or outcome variable. This is important for the outcome variable diabetes status because one of the assumptions underlying ordered logistic regression is that the relationship between each pair of outcomes (normal glycemia vs prediabetes and prediabetes vs diabetes) is the same. Ordered logistic regression assumes that the coefficients that describe the relationship between, say, the lowest versus all higher categories of the response variable are the same as those that describe the relationship between the next lowest category and all higher categories. This assumption is called the proportional odds assumption or the parallel regression assumption. Because the relationship between all pairs of groups is the same in ordinal regression, there is only one set of coefficients (only one model). If this was not the case, it would require different models to describe the relationship between each pair of outcome groups.

To determine whether ordinal or multinomial logistic regression was most appropriate, the parallel regression or proportional odds assumption were tested. This assumption can be tested by using the *oparrallel* command in STATA which performs five tests of the parallel regression or proportional odds assumption. Here, the null hypothesis asserts that there is no difference in coefficients between models. A significant test statistic in the form of a chi-square indicates evidence that the parallel or proportional odds regression assumption has been violated. When performed on this data, the results of all tests indicated the proportional odds regression assumption had indeed been violated (See Table 4).

Table 4. Tests of Parallel Regression or Proportional Odds Assumption

	χ^2	df	p>χ^2
Likelihood Ratio	64.14	8	.001
Brant	58.58	8	.001
Wolfe-Gould	64.14	8	.001
Wald	63.05	8	.001
Score	62.8	8	.001

p<.05 indicates a violation of the parallel regression assumption

While a natural ordering of the variable, diabetes status, appears to be present in that individuals can progress from a state of normal glycemia to a prediabetes and then to diabetes, the outcome variable, in this case, is neither intended to be a marker of severity, nor is diabetes status measured in unidirectional manner. Take for instance those with diabetes. An individual was considered to have diabetes if the individual had a diagnosis of diabetes even if the person had an HbA1c score in the prediabetes range. It is the diagnosis that takes precedent making a natural order inapplicable. The categorization of respondents into diabetes statuses was not simply a reflection of severity of the disease but a gauge of current physical status (HbA1c score) and examination history (diagnosis). Furthermore, the intention of the study was not to analyze the association between physical activity or diet and diabetes in progressive iterations or to assume that independent variables are equally associated with individual diabetes statuses. The intention was to estimate the degree to which the independent variables are associated with the probability of a single outcome (normal glycemia, prediabetes, or diabetes). Therefore, multinomial logistic regression was the most appropriate statistical technique for the data and research questions.

Multinomial logistic regression is an extension of what is referred to as a logit model. Logit models and multinomial logistic models are designed for categorical dependent variables. A multinomial logit model (MNLM) can be thought of as a simultaneously estimating binary logits for all possible comparisons among the outcome categories. In the case of diabetes status, the MNLM essentially runs three models at the same time: normal glycemia vs prediabetes, normal glycemia vs diabetes, and prediabetes vs diabetes. While the MNLM is a relatively simple extension of a binary logit model, the multiple comparisons involved can complicate interpretation quickly (Long, 1997).

Odds and probabilities

Each set of comparisons in multinomial logistic regression (i.e. normal glycemia vs prediabetes) provides a set of logit coefficients which can be converted into odds ratios or relative risk ratios. Odds ratios, as used in multinomial logistic regression, are a value that expresses the likelihood an event will occur relative to the likelihood an event will not occur. Those odds ratios indicate the logged odds of having one outcome (normal glycemia) versus another outcome (diabetes) for a given independent variable. If the independent variable is continuous, say the total component score from the Healthy Eating Index, the odds of having prediabetes compared to normal glycemia can be interpreted as follows: for each one unit increase in HEI-2010, a change in the logged odds of having prediabetes compared to normal glycemia can be expected by *x*. For categorical independent variables such as education or physical activity the interpretation becomes more complicated. In this instance, an odds ratio may be provided for high school education. The odds ratio for high school indicates that the odds of having prediabetes compared to having normal glycemia is *x* amount higher or lower than the reference group (in this case that would be less than high school education). Here the interpretation of the odds of having prediabetes for those with a high school education is solely reported as a number in reference to an education group (less than high school) and relative to the odds of having normal glycemia.

Interpretations such as these are required for all variables in all models. The comparison of odds are made across three diabetes statuses, four education groups, four race/ethnicity groups, two activity groups, and across a continuous diet score. Furthermore, to assess how the relationship between physical activity and diet vary by sociodemographic variables (education and race/ethnicity) an interaction, or cross-product, term must be added to each model. Adding a cross-product to the model produces an additional 8 to 12 variables to interpret for each outcome comparison. Summarizing and interpreting the results, given the high number of relative odds, can be more effective by calculating and presenting the predicted probabilities for each outcome, independently from one another as opposed to relative to one another, at each level of activity or diet score for each education or race/ethnicity group (Long, 1997; Long & Freese, 2006). A probability of diabetes status, as opposed to an odd, is simply an estimate of prevalence that indicates the likelihood of having diabetes or prediabetes. Presenting probabilities simplifies the interpretation of meaningful differences between groups and allows for direct comparison to be made between and within diabetes statues.

By first calculating the logged odds or relative risk of having normal glycemia vs prediabetes, normal glycemia vs diabetes prediabetes, and prediabetes vs diabetes, the *margins* command in STATA can use the model's logit coefficients to estimate the predicted probability of each outcome (diabetes) independent from the other two (prediabetes and normal glycemia). This is particularly helpful because then, for example, the probability of having diabetes among those who are active and high school education can be compared and tested statistically with the probability of having diabetes among those who are inactive with a college education.

Providing the predicted probability of each outcome at a given level of activity and education level, for example, not only makes the relationship more clear, but allows for the model calculations to be tested using the sample survey weights. Model testing using conventional methods of a likelihood ratio test are not supported with the complex design of the NHANES; therefore evaluating the differences between groups is most beneficial through evaluating the predicted probabilities of the model and using a Wald test to determine if adding a variable to the model results in a greater model fit. Not only is this step necessary given the design of the study, but the interpretation of probabilities as opposed to odds and risks are generally more easily understood.

Model estimation and evaluation

For each MNLM, three sets of predicted probabilities were calculated, one for normal glycemia, one for prediabetes, and one for diabetes. In total there were four MNLMs estimated:

- Model A: Physical activity and education interaction
- Model B: Diet and education interaction
- Model C: Physical activity and race/ethnicity interaction
- Model D: Diet and race/ethnicity interaction

To illustrate, a MNLM was estimated to examine if the relationship between physical activity and diabetes status varied by race/ethnicity (Model C). First, the model was estimated without an interaction term to determine the main effects of physical activity and race/ethnicity on diabetes status. Next, an interaction term was added and the model was estimated again. This model produced seven additional variables as the results of the two-category variable physical activity being multiplied by the four-category race/ethnicity. The model produced one fewer variables than 2*4 because one of the race/ethnicity categories, in this case non-Hispanic whites, remained in the model as the reference group.

The MNLM estimated logit coefficients for each variable in the model as well as a test of significance. The logits were then converted to relative risk ratios for interpretation. The interaction was evaluated by both the main effect of each variable multiplied by the interaction effect. However, this can be tedious and inconclusive given that both physical activity and race/ethnicity are categorical variables meaning that each interaction terms is relative to both the reference groups of physical activity and the reference groups of race/ethnicity in addition to all of the estimates being the relative odds of having either prediabetes compared to normal glycemia, diabetes compared to normal glycemia, or prediabetes compared to diabetes. To remedy this conflation of reference groups and base outcomes (which do not provide statistical evaluation of all possible combinations), the predicted probability of each outcome was calculated. The probability of having diabetes, independent from normal glycemia or prediabetes, was then calculated specifically for those who were active or inactive for all race/ethnicity groups after controlling for all the other confounding independent variables.

After the predicted probabilities were calculated, differences in the probabilities of having diabetes, prediabetes, or normal glycemia were evaluated *between* race/ethnicity groups (i.e. differences between non-Hispanic blacks and Hispanics at both active and inactive levels), for example, and *within* race/ethnicity groups (i.e. the difference in the probability of diabetes status between being inactive compared to active for all racial groups). Differences between predicted probabilities were evaluated in two ways: 1) using a pairwise comparison Wald tests to determine if the difference between any two given probabilities was significantly greater than 0 and 2) the use of 95% CIs which provide a more conservative estimate of the predicted probability of a specific group (e.g. those who are active and college educated) having diabetes, prediabetes, or normal glycemia in the U.S. population based on the sample survey weights. This process was conducted for all four models producing four separate analysis. Slightly different procedures were required for models addressing diet given that HEI-2010 scores were a continuous variable. Rather than calculating the probability of diabetes status for every unit increase in diet, the probability of diabetes status was calculated at HEI-2010 scores considered to be low (HEI=0), average (HEI=50), and high (HEI=100). These point estimates, though extreme, were found within the data. The purpose of displaying HEI scores at varying levels was to highlight areas where differences are most pronounced. Predicted probabilities of each diabetes status were presented in tables as well as displayed graphically to aid in the interpretation and evaluation process.

The analytical method described here provides the basis to address the central research questions concerning the role education and race/ethnicity plays in the association between health behaviors, such as physical activity or diet, and diabetes status. The next chapter presents all results from the univariate, bivariate, multivariate, and multinomial logistic regression analyses.

Chapter 3. Findings

Introduction

Recall the general research questions of this dissertation. These questions address two primary topics: 1) whether or not the relationship between health behaviors and diabetes status is consistent for those of different social groups and 2) whether or not engaging in similar health behaviors resulted in parity, of diabetes risk, among those of different social groups. To address these questions, several analyses were performed. The purpose of this chapter is to detail the findings of those analyses.

This chapter is comprised of four sections followed by a summary section. These sections provide (1) descriptive statistics of the sample by diabetes status; (2) descriptive statistics of health behaviors (physical activity and diet) by social characteristics (education and race/ethnicity); (3) descriptive statistics of health behaviors and social characteristics by diabetes status; and (4) a statistical analysis of the four relationships of interest (i.e., physical activity-education interaction, diet-education interaction, physical activity-race/ethnicity interaction, and diet-race/ethnicity interaction). In section one, a description of the general distribution of all variables of interest is provided to inform subsequent interpretation and offer a general sense and range of the data. Then, descriptive statistics are provided for all independent variables according to diabetes status. This highlights some of the major differences in social, behavioral, and physical characteristics between those with diabetes, prediabetes, and normal glycemia such as whether those with diabetes tend to have high or low body mass indexes, be younger or older, or have higher or lower incomes. In section two, the bivariate associations between the health behavior variables (physical activity and diet) and social characteristics (education and race/ethnicity) are examined. In this section, questions such as, “does the proportion of those who are physically active vary by education status?” are addressed. Section three examines the relationship between all three variables groups of interest: diabetes status, health behaviors, and social characteristics. Here questions such as “does the proportion of those who have diabetes, some college education, and are active differ from those who have diabetes, are active and have a four-year college education?” are addressed. Finally, section four presents the results from a set of multinomial regression models which were estimated to determine if, after controlling for social, behavioral, and physical characteristics, the association between health behaviors (physical activity and diet) and the likelihood of having diabetes, prediabetes, or normal glycemia varied by level of education and race/ethnicity.

Before examining how the association between health behaviors (i.e. physical activity and diet) and diabetes status varies according to social characteristics (i.e. education and race/ethnicity) it is necessary to describe the sample used for the analysis.

Section I: Descriptive Statistics of the Sample and Distribution of Independent Variables by Diabetes Status

Table 1 presents the sample's descriptive information for the variables of interest. The sample includes 13,400 adults aged 24 years and older. In terms of age, about two-thirds were under the age of 55 which is consistent with that of the U.S. adult population (Gerstle et al., 2001). Gender was evenly distributed with just over half of the sample identifying as female. The race/ethnicity distribution was consistent with the U.S. population in 2000, and has a slightly higher proportion of non-Hispanic whites than the 2012 population. The majority (69.1%) of the sample was Non-Hispanic white followed by Hispanic (13.8%), Non-Hispanic black (10.8%), and other races (6.3%).

Consistent with estimates of educational attainment from the Community Population Survey (2010), the majority of the sample had at least some college. Approximately 18 percent of the sample had less than a high school education and just over 20 percent had a high school education. The distribution of income was most concentrated among middle and high family-incomes according the ratio of poverty to income. Nearly two-thirds of the sample had poverty-to-income ratios of more than 200% indicating an income twice that of the poverty line.

The majority of the sample, over two-thirds, was considered overweight or obese. This is consistent with the most recent estimates of obesity among U.S. adults (Ogden, Carroll, Kit, & Flegal, 2014). With respect to physical activity, nearly two-thirds of the sample did not meet the aerobic activity recommendations of the CDC and were considered inactive. These figures are lower than estimates from recent reports on self-reported physical activity gathered from the National Health Interview Survey (NHIS) that estimated about half of U.S. adults meet the aerobic recommendation (National Center for Health Statistics CDC, 2015). Additionally, the average U.S. adult was only meeting about half of the dietary recommendations as measured by the Healthy Eating Index (HEI-2010). This figure is slightly higher than previous estimates using the HEI-2010 and the NHANES (2008) that include children and adolescents (Guenther et al., 2013).

Table 1. Descriptive Sample Statistics for U.S. adults ages 24 and older, 2007-2012 NHANES N=13,400

	%, Mean	95% CI
Sociodemographic Characteristics		
Age		
24-34	26.2	(24.4-28.1)
35-54	39.4	(38.1-40.8)
55-64	16.9	(15.8-18.1)
65+	17.46	(16.4-18.5)
Gender		
Female	52.1	(51.1-53.0)
Male	47.9	(46.9-48.8)
Race/Ethnicity		
Non-Hispanic White	69.1	(64.7-73.1)
Non-Hispanic Black	10.8	(8.9-13.1)
Hispanic	13.8	(11.1-16.9)
Other	6.3	(5.3-7.6)
Socioeconomic Status		
Education Categories		
Less than High School	18.1	(16.4-20.0)
High School	22.6	(20.9-24.3)
Some college	31.2	(29.7-32.7)
College degree	28.1	(25.6-30.6)
Poverty income ratio		
Poor <124%	21.4	(19.5-23.4)
Low income 124-199%	14.9	(13.7-16.2)
Middle income 200-399%	27.1	(25.1-29.1)
High income ≥400%	36.6	(33.9-39.4)
Physical Conditions		
Body Mass Index		
Normal Weight	30.9	(29.2-32.6)
Overweight	33.8	(32.3-35.4)
Obese	35.3	(33.9-36.7)
Physical Activity		
Inactive	60.8	(58.3-63.3)
Active	39.1	(36.7-41.7)
Healthy Eating Index (% of recommendation)		
Total Component Score (Mean)	50.9	(50.2-51.7)
N	**13,400**	

All data adjusted for complex sampling frame
95% CI indicate the range that can be expected in the U.S. population from 2007-2012

Distribution of Independent Variables by Diabetes Status

The central focus of this study is the variation in behaviors and social characteristics across diabetes statuses, but it is understood that other variables such as age and BMI are strongly related to diabetes status as well. Descriptive statistics for all independent variables by diabetes status are presented in Table 2. Overall, two-thirds of the sample had normal glycemia (did not have diabetes or prediabetes) (A1C <5.7 and never having receiving a diagnosis) leaving about 25 percent who had prediabetes (at risk for diabetes) (A1C 5.7-6.4 or having received a diagnosis of prediabetes) and about 9 percent who had diabetes (A1C ≥6.5 or having received a diagnosis of diabetes). The figures for those with diabetes were similar to the estimates of 9.3 percent from 2012 (CDC, 2014). However, the estimates of the CDC use pooled data from the NHANES which uses both fasting glucose measures and A1C levels to estimate diabetes prevalence whereas this study uses only A1C. Additionally, the CDC estimates include self-reported data collected from the NHIS.

As expected, a clear gradient was observed according to age group. The prevalence of prediabetes and diabetes was most concentrated among older adults. Just over 1 percent of those aged 20-35 had diabetes compared to 20 percent of those aged 65 and older. Larger age disparities were observed among those with prediabetes. Although over nine percent of those aged 20-35 had prediabetes, over 40 percent of those aged 65 and older had prediabetes. These age distributions are similar to those of the CDC in 2014. No significant gender differences were observed across diabetes categories. This is consistent with the findings of the CDC which estimated the proportion of men with diabetes to be greater than women by only 1 to 2 percent. (CDC, 2014).

Table 2. Demographic, Socioeconomic Status, and Body Mass Index Characteristics according to Diabetes Status, NHANES 2007-2012 N=13,400

	Normal Glycemia % (95% CI)	Prediabetes % (95% CI)	Diabetes % (95% CI)
Overall	66.0 (64.7-67.3)	25.4 (24.5-26.4)	8.6 (7.9-9.3)
Sociodemographic Characteristics			
Age			
24-34	89.6 (88.4-90.8)	9.1 (8.1-10.3)	1.3 (0.9-1.7)
35-54	69.1 (67.2-70.9)	24.6 (22.89-26.3)	6.3 (5.5-7.3)
55-64	49.3 (45.0-53.6)	37.0 (33.4-40.8)	13.7 (11.7-16.1)
65+	38.3 (35.7-41.0)	41.4 (38.5-43.4)	20.3 (18.5-22.1)
Gender			
Male	66.5 (65.1-67.8)	24.5 (23.3-25.8)	9.0 (8.3-9.8)
Female	65.6 (63.6-67.5)	26.2 (24.9-27.7)	8.2 (7.3-9.2)
Race/Ethnicity			
Non-Hispanic White	68.1 (66.2-70.0)	24.4 (23.1-25.8)	7.5 (6.6-8.5)
Non-Hispanic Black	53.7 (51.5-55.8)	33.0 (31.0-35.1)	13.3 (12.0-14.8)
Hispanic	65.7 (62.6-68.7)	24.9 (22.0-28.0)	9.4 (7.6-11.7)
Other	62.7 (58.5-66.7)	26.3 (22.7-30.3)	11.0 (8.3-14.5)
Socioeconomic Status			
Education Categories			
Less that High School	55.6 (53.3-58.0)	30.5 (28.4-32.6)	13.9 (12.6-15.3)
High School	61.2 (58.1-64.1)	29.2 (26.4-32.2)	9.6 (8.2-11.3)
Some college	67.9 (65.5-70.2)	24.4 (22.0-26.9)	7.7 (6.8-8.7)
College degree	74.5 (72.1-76.8)	20.2 (18.3-22.3)	5.3 (4.4-6.4)
Poverty income ratio			
Poor <124%	64.4 (61.3-67.3)	24.9 (22.7-27.3)	10.7 (9.3-12.3)
Low income 124-199%	61.3 (58.0-64.4)	27.7 (25.0-30.5)	11.0 (9.5-12.8)
Middle income 200-399%	66.2 (63.7-68.6)	25.2 (23.0-27.5)	8.6 (7.5-9.9)
High income ≥400%	70.3 (68.0-72.4)	23.8 (21.9-25.8)	5.9 (5.1-6.9)
Body Mass Index			
Normal Weight	78.3 (76.3-80.2)	18.1 (16.4-19.8)	3.6 (2.9-4.5)
Overweight	68.0 (66.1-69.8)	25.9 (24.1-27.8)	6.1 (5.5-6.8)
Obese	53.8 (51.9-55.7)	31.3 (29.8-32.9)	14.9 (13.6-16.3)
N	***8,898***	***3,374***	***1,128***

All data adjusted for complex sampling frame

Race/ethnicity differences were anticipated given significant racial and ethnic disparities in diabetes persist (CDC, 2014). Non-Hispanic blacks had the highest prevalence of diabetes and prediabetes of all race/ethnicity groups. Just over 50 percent of the non-Hispanic black population had normal glycemia (no diabetes) which was 12-15 percent less than their non-Hispanic white and Hispanic counterparts. The sample estimates for diabetes among non-Hispanic blacks were slightly lower than the estimates from the CDC (CDC, 2014); however, the overall trend was comparable to previous estimates (NHIS 2010). Although non-Hispanic whites had the lowest proportion of diabetes and prediabetes, differences between non-Hispanic whites, Hispanics, and other races were not statistically significant as indicated by 95% confidence intervals in Table 2.

A consistent gradient was observed across all diabetes categories with respect to education. Generally, the proportion of the population with diabetes was lower among groups with more education. This trend was consistent for prediabetes as well. As previously reported (Kanjilal, Gregg, Cheng, & et al., 2006), the largest differences were between those with less than a high school education and those with a college education for both diabetes and prediabetes. To illustrate, nearly 75 percent of those with a college education had normal glycemia (no diabetes) compared to just over half (55%) of those with less than a high school degree, a difference of 20 percentage points.

The patterns associated with income were less consistent. Although diabetes was more prevalent among those with poor incomes (<124% PIR) than high incomes (≥400%), differences were not observed between poor, low, and middle incomes. This is somewhat unexpected given previous research has found much more clear gradients with respect to the poverty income ratio and prevalence of diabetes (Kanjilal et al., 2006). However, even in previous studies the largest differences were between those with the lowest incomes and the highest incomes. The proportion of those with prediabetes was fairly even across income groups with the largest difference, of only 3.9 percent, being between those in the high income group (≥400%PIR) and those in the low income group (<124% PIR). This was not surprising given previous studies reported only small differences in the prevalence of prediabetes between those with high incomes and low incomes (Bullard et al., 2013).

Aside from social characteristics, BMI was also examined because the relationship between body composition and diabetes is so strong (Chen, Magliano, & Zimmet, 2012; Narayan et al., 2007). As expected, proportions of those with diabetes and prediabetes were lowest among those of normal weight. The proportion of those with normal glycemia lower among those who were overweight and obese. There were considerably fewer obese individuals with normal glycemia (53.8 [95% CI, 51.9-55.7]) than both overweight (68.0 [95% CI, 66.2-69.8]) and normal weight individuals (78.3 [95% CI, 76.3-80.2]). Alternatively, a much greater proportion of those who were obese had prediabetes and diabetes than those of normal weight and overweight. Likewise, a greater proportion of those who were overweight had diabetes and prediabetes than those of normal weight.

Physical Activity and Healthy Eating Index Scores According to Diabetes Status

Beyond social characteristics and body mass, physical activity and diet are the two independent variables of most interest. Table 3 presents summary statistics for both physical activity and diet according to diabetes status. The proportion of those who were active was lowest among those with diabetes and highest among those with normal glycemia. This is consistent with finding that those with self-reported diabetes tend to be active at considerably lower rates than those without self-reported diabetes (Morrato et al., 2007). The crude differences between these groups are likely due, in part, to the concentration of older adults in the diabetes group who typically engage in less physical activity than others. Specifically, 21 percent of those with diabetes were considered active compared to 32 percent of those with prediabetes and 44 percent of those with normal glycemia.

Table 3. Percentage of Active/Inactive and Mean HEI-2010 Scores for U.S. Adults by Diabetes Status, NHANES 2007-2012

	Overall (%, Mean) (95% CI)	Normal Glycemia (%, Mean) (95% CI)	Prediabetes (%, Mean) (95% CI)	Diabetes (Mean, %) (95% CI)
Physical Activity				
Active %	36.1 (36.7-41.7)	44.4 (41.7-7.0)	31.7 (28.7-35.0)	21.0 (18.1-24.4)
HEI_2010 Component (maximum score)				
Total Score (100)	50.9 (50.2-51.7)	50.7 (49.8-51.6)	51.1 (50.2-52.1)	52.5 (51.3-53.7)
Adequacy				
Total Vegetable (5)	3.0 (2.9-3.0)	2.9 (2.8-3.0)	3.0 (2.9-3.1)	3.1 (3.0-3.2)
Greens and Beans (5)	1.5 (1.4-1.6)	1.5 (1.4-1.6)	1.5 (1.4-1.6)	1.4 (1.3-1.6)
Total Fruit (5)	2.2 (2.1-2.3)	2.1 (2.0-2.2)	2.3 (2.1-2.4)	2.3 (2.1-2.5)
Whole Fruit (5)	2.1 (2.1-2.2)	2.1 (2.0-2.2)	2.3 (2.1-2.4)	2.3 (2.1-2.5)
Whole Grains (10)	2.5 (2.4-2.7)	2.4 (2.3-2.5)	2.6 (2.4-2.8)	3.1 (2.8-3.4)
Dairy (10)	5.2 (5.1-5.3)	5.3 (5.1-5.5)	5.1 (5.0-5.2)	5.0 (4.8-5.3)
Total Protein Foods (5)	4.1 (4.0-4.1)	4.0 (3.9-4.1)	4.1 (4.0-4.1)	4.3 (4.2-4.4)
Seafood and Plant Proteins (5)	2.3 (2.2-2.4)	2.3 (2.2-2.4)	2.3 (2.2-2.4)	2.3 (2.1-2.5)
Fatty Acids (10)	5.0 (4.9-5.1)	5.0 (4.9-5.1)	5.1 (4.9-5.3)	5.2 (4.9-5.4)
Moderation				
Sodium (10)	4.4 (4.3-4.4)	4.5 (4.4-4.6)	4.3 (4.2-4.5)	3.5 (3.2-3.7)
Refined Grains (10)	6.2 (6.1-6.3)	6.2 (6.1-6.3)	6.3 (6.1-6.4)	5.9 (5.6-6.1)
Empty Calories (20)	12.5 (12.2-6.3)	12.3 (12.0-2.6)	12.4 (12.0-12.7)	14.2 (13.8-14.7)
N	**13,400**	***8,898***	***3,374***	***1,128***

All data adjusted for complex sampling frame

Also shown in Table 3 are the HEI-2010 component scores. Overall, total scores did not vary significantly among diabetes statuses. As mentioned in the previous chapter "Methods and Data," predicting diet among those of different diabetes statuses can be difficult. Although poor diet is associated with the risk of diabetes, the management of diabetes requires individuals to be mindful of their dietary patterns.

To further illustrate, Figure 1 shows average percentage of the dietary recommendation achieved for each component and how these percentages differ by diabetes status (See Table 3 for estimates and confidence intervals). Briefly, those with diabetes had slightly higher scores for total component, total vegetable, whole grains, total protein, and empty calories and lower scores for dairy, sodium, and refined grains. Note, higher sodium, refined grain, and empty calorie scores reflect moderation and indicate greater adherence to recommendations. For example, a higher empty calorie score indicates that a *lower* proportion of one's diet comes from empty calories. Because the central focus is only with overall diet, individual components are only briefly described to clarify how the total component is calculated and will not be examined further. To supplement, additional figures and estimates are provided in the Appendix.

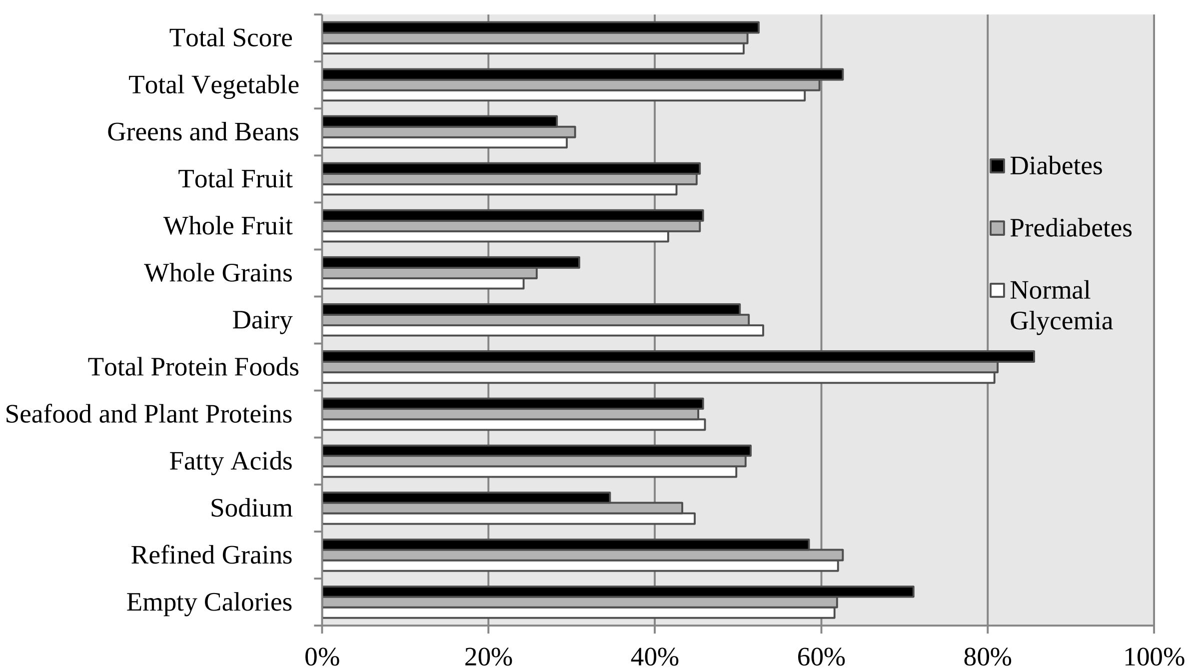


Figure 1. HEI-2010 Componet Scores as % of Recommendation, NHANES 2007-2012

Section II: Descriptive Statistics of Health Behaviors (Physical Activity and Diet) by Social Characteristics (Education and Race/Ethnicity)

Introduction

Now that the variation in health behaviors and social characteristics has been assessed in relation to diabetes status, it is necessary to describe how levels of physical activity and quality of diet vary according to educational attainment and race/ethnicity.

Physical Activity and HEI-2010 by Education

While physical activity and diet are central to the research questions, the project has a specific interest in how those behaviors vary according to educational attainment. Figure 2 shows the percentage of those who are active across education levels. Overall, a clear and consistent education gradient was observed with the percentage of those who were active increasing among each subsequent education level. Roughly 20 percent of those with less than a high school degree were considered active compared to 56 percent of those with a college degree. While the largest difference was between less than high school and college, the proportion of those with a college education who were active was also significantly higher than those with a high school education (-23.7, t=10.20, $p<.001$) and those with some college (-15.9, t=9.56, $p<.001$) according to a two-sample t-test of proportions.

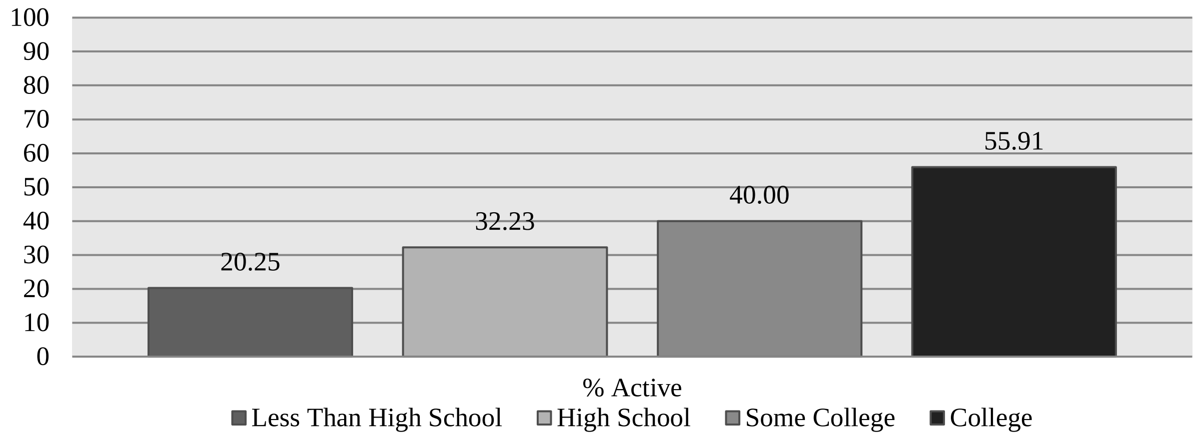


Figure 2. Percent Active U.S. adults According to Education Attainment, NHANES 2007-2012

In addition to the interest in physical activity, the possible variation in diet among those with different levels of education was examined. Even though previously reported crude differences in diet scores (HEI-2010) were generally minimal among diabetes statuses, differences were observed among individuals with different levels of education. Figure 3 presents these results. Generally, those with higher education fared better in terms of meeting dietary recommendations. Overall, those with less than a high school and a high school education had the lowest total component scores, and those with a college education had the highest total score. Those with a college education, on average, met 56 percent (95% CI, 55.0-57.1) of dietary recommendations which was significantly higher than those with less than a high school (+8.5 t=14.94, p<.001), high school (+7.8, t=13.01, p<.001), and some college (+5.7, t=9.36, p<.001) according to a two-sample t-test.

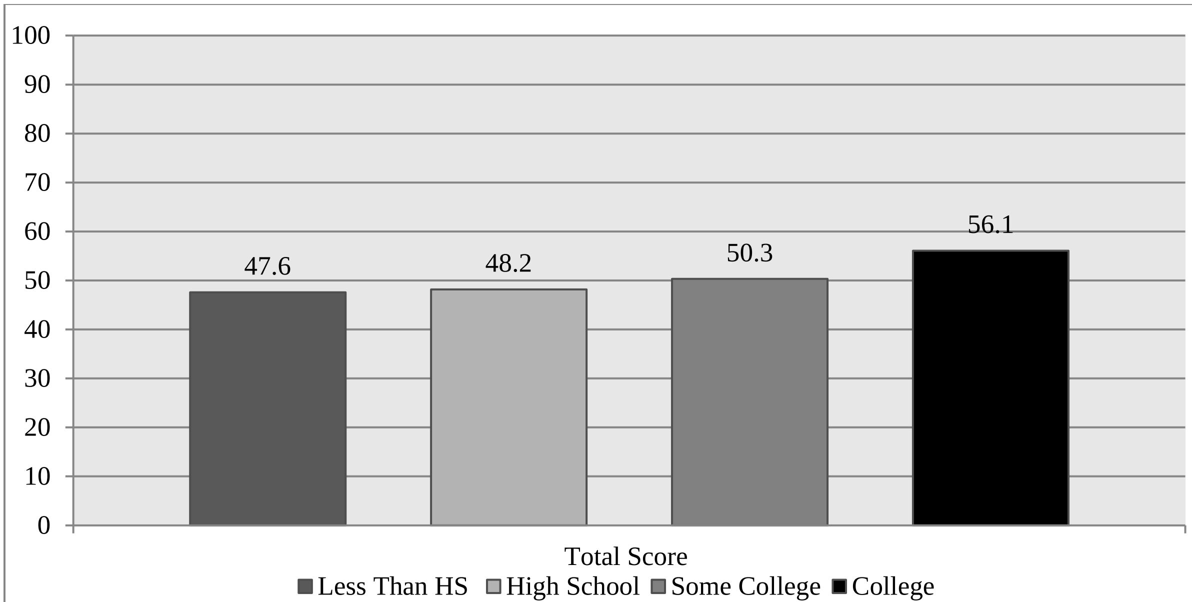


Figure 3. HEI-2010 Total Component Score as % of Recommendation by Educational Attainment, NHANES 2007-2012

Physical Activity and HEI-2010 by Race/Ethnicity

In addition to physical activity and diet patterns according to education level, differences in physical activity and diet among race/ethnicity groups are a focus of this study. The proportion of those considered active did vary between race/ethnicity groups as shown in Figure 4. Overall, non-Hispanic whites had a higher proportion who were active than non-Hispanic blacks (+7.2, *t*=7.11, p<.001) and Hispanics (+8.2, *t*=11.03, p<.001). These figures are consistent with other studies that have found self-reported leisure-time physical activity to be highest among non-Hispanic whites compared to their black and Hispanic counterparts (Berg et al., 2016; CDC, 2013).

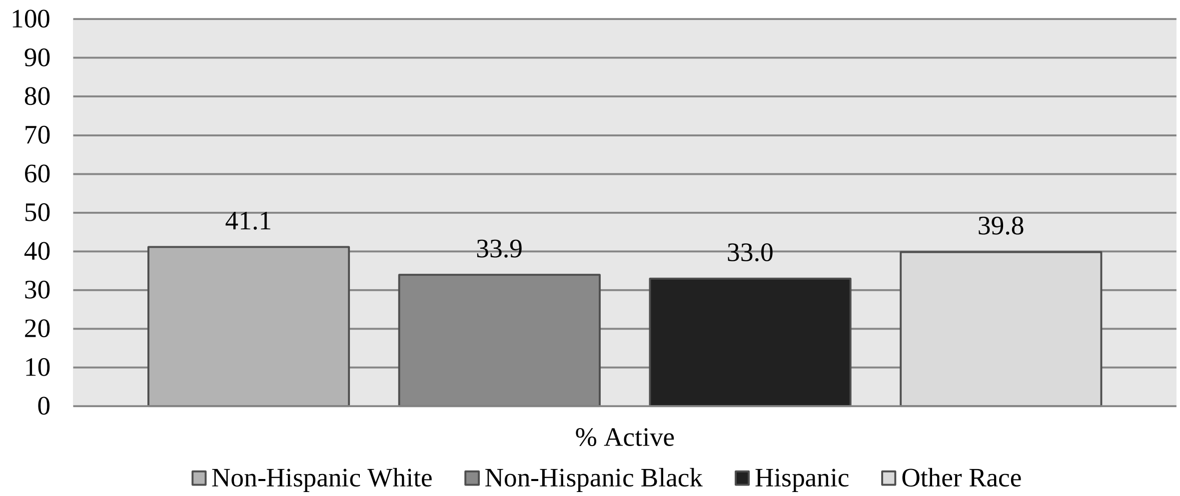


Figure 4. Percent Active U.S. Adults according to Race/Ethnicity, NHANES 2007-2012

While previous figures indicate at least some components of diet vary by diabetes status, it is important for this project to also highlight the dietary patterns that vary by race/ethnicity. Figure 5 shows the differences in total component scores which varied only slightly between race/ethnicity categories. The average total component score for non-Hispanic blacks was the lowest at 47.7 (95% CI, 46.8-48.5), 3.6 percent lower than non-Hispanic whites (t=5.58, p<.001), 2.6 percent lower than Hispanics (t=4.66, p<.001), and 6.5 percent lower than other races (t=9.99, p<.001).

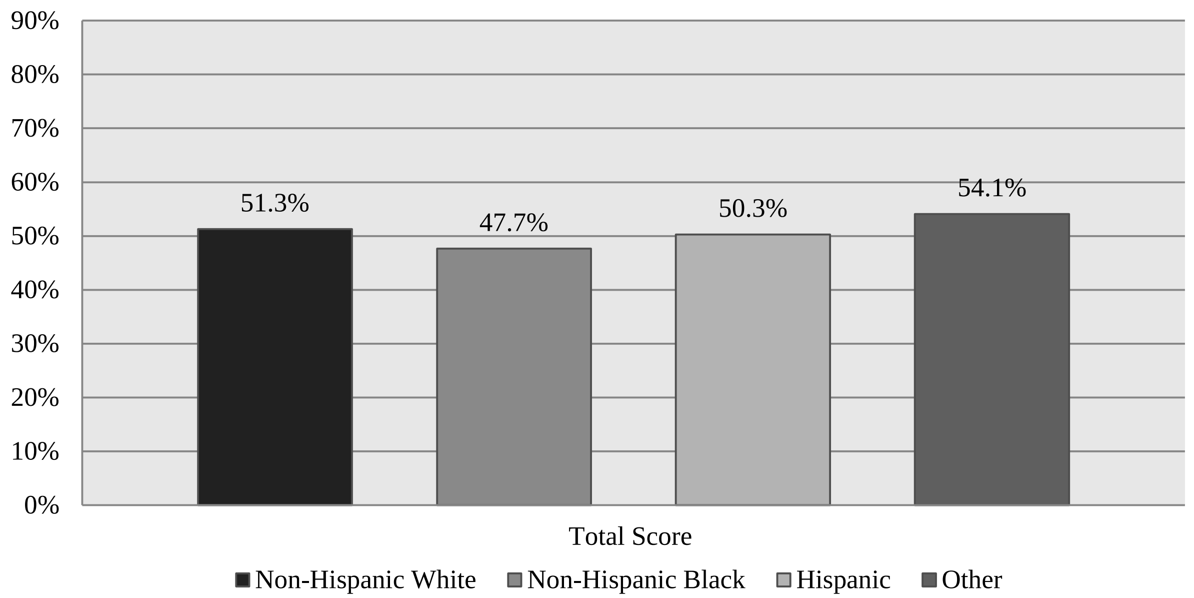


Figure 5. HEI-2010 Total Component Score as a % of Recommendation by Race/Ethnicity, NHANES 2007-2012

Summary

To summarize, generally an education gradient was present for both physical activity and diet. A higher proportion of those with a college degree met physical activity recommendation than those with less education. Likewise, on average those with a college degree had higher diet scores than those with less education. Racial differences were also observed with respect to physical activity and diet. A greater proportion of non-Hispanic whites met physical activity recommendations than non-Hispanic blacks and Hispanics. Diet scores were lowest among non-Hispanic blacks.

Section III: Descriptive Statistics of Health Behaviors (Physical Activity and Diet) and Social Characteristics (Education and Race/Ethnicity) by Diabetes Status

Introduction

Although levels of physical activity and quality of diet did vary across education and race/ethnicity groups, the focus remains on how health behaviors and social characteristics are related to diabetes status. In this section, descriptive statistics for each paring of health behavior and social characteristic according to diabetes status are examined. Below is a matrix that will guide subsequent descriptions and analyses. For each pairing, the differences according to education and race/ethnicity *within* and *between* diabetes groups are described.

	Educational Attainment	**Race/Ethnicity**
Physical Activity	A	C
Diet	B	D

A. Physical Activity and Educational Attainment by Diabetes Status

The proportion of individuals that met recommendations for physical activity varied both by diabetes status and education attainment. Similarly, the prevalence of diabetes and prediabetes varied by educational attainment. Because one of the goals of this project is to determine if the association between physical activity and diabetes is dependent on educational attainment, the next step is to explore physical activity and educational attainment by diabetes status.

Rates of diabetes and prediabetes differed for those of different activity levels and across educational categories. As Table 4 shows, just over 20 percent of those with diabetes were considered active. However, the proportions varied from 11.4 percent for those with less than a high school education to 34.5 percent for those with a college degree, a significant difference of 23.1 percentage points (*t*=4.76, p<.001). Similarly, the overall percentage of active adults with prediabetes was 31.7. However, the proportions ranged from 17.9 percent for those with a less than high school education to 43.4 percent of those with a college degree, a significant difference of 25.5 percentage points (*t*=9.27, p<.001). The trend was even more evident for those with normal glycemia where a significant difference of 37.0 percentage points (*t*=15.49, p<.001) was found between those with less than a high school degree and those with a college degree.

Table 4. Percent of Active U.S. Adults by Diabetes Status and Educational Attainment

	No Diabetes		**Prediabetes**		**Diabetes**	
	% Active (95% CI)		% Active (95% CI)		% Active (95% CI)	
Overall	44.3	(41.7-47.0)	31.7	(28.6-34.9)	21.1	(17.9-24.2)
Educational Attainment						
Less than High School	23.8	(20.5-27.0)	17.9	(14.8-20.9)	11.4	(8.8-13.9)
High School	35.2	(31.6-38.9)	31.0	(26.1-35.8)	17.3	(10.4-24.2)
Some college	43.9	(39.7-48.1)	33.6	(29.7-37.6)	26.3	(21.8-30.8)
College degree	60.8	(57.2-64.4)	43.4	(38.0-48.9)	34.5	(25.4-43.6)

All data adjusted for complex sampling frame

Among those with prediabetes who were active, a two-sample test of proportions indicated a significant difference between those with a college degree (43.4%) and those with a high school degree (31%, *t*=4.19, *p*>.001), those with less than a high school degree (17.9%, *t*=9.27, p>.01), and those with some college (33.8%, *t*=3.50, p<.01). The education gradient was somewhat consistent among those with diabetes. Over one-third of those with a college degree who had diabetes were considered active compared to 26 percent of those with some college; however the difference of 8.1 points was not statistically significant (*t*=1.57, p=.122). Those with a high school degree (17.3%) and those with less than a high school degree (8.2%) had significantly lower rates of activity than those with some college ($p<.05$) and college degrees (*p*<.001) according two-sample tests of proportions.

B. Diet and Educational Attainment by Diabetes Status

HEI-2010 total component scores varied by diabetes status and educational attainment independently, but it is necessary to examine the diet scores by educational attainment and diabetes status collectively. Table 5 presents mean total component scores by education and diabetes status. Call attention to the differences in total component scores by education level *within* diabetes groups. For those with normal glycemia, total component scores varied by educational attainment similarly to the overall average. Those with normal glycemia and less than a high school education had the lowest total HEI-2010 score at 46 (95% CI, 44.3-47.1), while those with a college degree had the highest at 56 (95% CI, 54.4-56.9). According to a two-sample test of proportions, total scores for those with less than high school and high school educations were not significantly different from one another (t=0.43, p=.670). However, the scores for those with some college and a college degree were significantly higher than those with a high school education or less ($p<.001$). Additionally, the total score for those with a college education were significantly higher than those with some college, a difference of 6.60 (t=10.45, $p<.001$). Educational differences in total component scores were less pronounced for those with prediabetes. Those with prediabetes and a college education had total scores 5-7 percentage points higher than others with prediabetes and less education ($p<.01$). The gradient was similar for those with diabetes. The college educated had progressively higher scores than other educational groups.

Table 5. Mean Total Component HEI-2010 Score by Diabetes Status and Education, max=100

	Overall (95% CI)		Normal Glycemia (95% CI)		Prediabetes (95% CI)		Diabetes (95% CI)	
Total Score (100)	50.4	(49.4-51.3)	50.0	(48.9-51.2)	50.9	(49.8-51.9)	51.9	(51.9-50.4)
Education								
Less than High School	47.1	(46.0-48.2)	45.7	(44.3-47.1)	48.8	(47.6-50.0)	49.2	(47.4-51.0)
High School	47.5	(46.3-48.7)	46.3	(44.9-47.8)	49.3	(47.7-50.9)	50.5	(48.4-52.6)
Some College	50.2	(49.4-51.1)	49.8	(48.7-50.8)	50.5	(49.2-51.9)	53.5	(51.5-55.7)
College	55.6	(54.5-56.8)	55.6	(54.4-56.9)	55.5	(53.4-57.7)	56.9	(53.2-59.4)

All data adjusted for complex sampling frame

To explore the relationship between diet, education, and diabetes status more fully, education-specific total component scores were examined *between* diabetes statuses. Among those with less than a high school education, those with prediabetes (t=2.59, p<.05) and diabetes (t=4.45, p<.001) had higher total scores than those with no diabetes. Similar trends were observed among those with a high school education and some college. Finally, no significant differences were found across diabetes statuses for those with a college education. However, it may be worth noting that those with diabetes and a college education had the highest overall score of 56.9 (95% CI, 53.2-59.4) while those normal glycemia and a less than high school education had the lowest overall scores at 45.7 (95% CI, 47.4-51.0). Additionally, those with a college education had the highest total scores regardless of diabetes status.

C. Physical Activity and Race/Ethnicity by Diabetes Status

Attention next turns to race/ethnicity and its role in the association between physical activity and diabetes status. As previously stated, the proportion of individuals meeting physical activity recommendations varied according to race/ethnicity. Likewise, the prevalence of diabetes, prediabetes, and normal glycemia varied according to race/ethnicity. Therefore, it is necessary to examine the degree to which physical activity varies by race/ethnicity *within* and *between* diabetes groups. As shown in Table 6, just over 20 percent (95% CI, 18.1-24.4) of individuals with diabetes were considered active with proportions ranging from 18 percent (95% CI 14.5-22.0) for non-Hispanic blacks to 31 percent (95% CI, 19.9-44.4) for those of other races. However, as indicated by the 95% confidence intervals the differences were not statistically significant. Similarly, proportion of individuals with prediabetes who were active did not differ among race/ethnicity groups. Finally, among those with normal glycemia, non-Hispanic blacks and Hispanics had a smaller proportion of active individuals than non-Hispanic white and those of other races by six to eight percent ($p<.001$).

Table 6. Percent of Active U.S. Adults by Race/Ethnicity and Diabetes Status

	Normal Glycemia		**Prediabetes**		**Diabetes**	
	% Active	(95% CI)	% Active	(95% CI)	% Active	(95% CI)
Overall	44.4	(41.7-47.0)	31.7	(28.6-34.9)	21.1	(18.1-24.4)
Race/Ethnicity						
Non-Hispanic White	46.7	(43.2-50.2)	31.9	(27.8-36.2)	21.0	(16.7-25.9)
Non-Hispanic Black	38.5	(34.9-42.2)	33.0	(29.0-37.0)	17.9	(14.5-22.0)
Hispanic	36.1	(32.9-39.4)	29.4	(25.4-33.8)	19.6	(15.5-24.4)
Other Race	44.5	(39.7-49.4)	32.5	(24.9-41.1)	30.8	(19.9-44.4)

All data adjusted for complex sampling frame

As observed among education groups, generally a greater proportion of those with normal glycemia were active than those with prediabetes and diabetes. Among non-Hispanic whites a consistent gradient was observed, nearly half of those with normal glycemia were active, compared to 32 and 21 percent for those with prediabetes and diabetes, respectively. While the difference in the proportion of active non-Hispanic black and Hispanic individuals was nearly 20 percent between those with normal glycemia and diabetes, the difference between those with normal glycemia and prediabetes was less pronounced than for non-Hispanic whites.

D. Diet and Race/Ethnicity by Diabetes Status

Similar to the previously reported information on diet, education, and diabetes status, race and ethnicity differences in diet were examined *within* and *between* diabetes statuses. Table 7 presents diet scores by race/ethnicity and diabetes status. Non-Hispanic blacks generally had lower diet scores than non-Hispanic whites, at least among those with normal glycemia and prediabetes. Total scores for non-Hispanic blacks were, on average, five to eight percent lower than non-Hispanic whites and those of other races. Generally, total scores did not vary by race/ethnicity *between* diabetes statuses. The exception was that of non-Hispanic blacks for which those with diabetes had slightly higher scores than their counterparts with prediabetes and normal glycemia. Among non-Hispanic blacks, the difference between those with diabetes and normal glycemia was 4.9 ($t=5.94$, $df=1$, $p<.001$) and difference between those with diabetes and prediabetes was 3.4 ($t=3.51$, $df=1$, $p<.001$). Both were statistically significant according to a two-sample *t* test and evidenced by the 95% CI.

Table 7. Total Component HEI-2010 Scores by Diabetes Status and Race/Ethnicity, NHANES 2007-2012

	Overall (95% CI)		**Normal Glycemia** (95% CI)		**Prediabetes** (95% CI)		**Diabetes** (95% CI)	
Total Score (100)	51.3	(50.2-52.3)	47.7	(46.7-48.5)	50.3	(49.5-51.0)	54.1	(52.9-55.3)
Race/Ethnicity								
Non-Hispanic white	51.3	(50.3-52.3)	51.1	(49.9-52.3)	51.6	(50.3-52.9)	52.4	(50.4-54.4)
Non-Hispanic black	47.7	(46.8-48.5)	46.5	(45.2-47.8)	48.0	(46.9-49.1)	51.4	(50.5-53.8)
Hispanic	50.3	49.6-51.0)	49.7	(48.8-50.6)	51.5	(50.2-52.7)	51.7	(50.0-53.5)
Other Race	54.1	(52.9-55.3)	54.1	(52.6-55.6)	52.4	(50.4-54.4)	58.3	(55.5-61.0)

All data adjusted for complex sampling frame

Summary

To summarize, an education gradient in the percentage of those meeting physical activity recommendations was found within diabetes groups. The educational variations were largest among those with normal glycemia and smallest among those with diabetes. Similarly, the percentage of those meeting physical activity recommendations varied across diabetes groups among those with different levels of education. Generally, diet scores were higher among those with more education within diabetes groups. Similarly, diet scores were higher among those with diabetes than those with normal glycemia across all levels of education with the exception of those with a college education for which the difference was not significant. With respect to physical activity and race/ethnicity, race/ethnicity differences were only found for those with normal glycemia. Generally, among all race/ethnicities a smaller proportion of those with diabetes were physically active than those with normal glycemia.

Among those with normal glycemia, non-Hispanic blacks had lower diet scores than non-Hispanic whites and those of other races. Finally, diet scores varied only slightly across diabetes groups according to education level. The only significant difference found was among non-Hispanic blacks where those with normal glycemia had lower diet scores than those with diabetes. Overall, those with diabetes had the highest mean diet scores and the lowest proportion considered active.

Section IV: Predicting Diabetes Status and the Roles of Physical Activity, Diet Quality, Educational Attainment, and Race/Ethnicity

Introduction

The major associations between diabetes status and behavioral and social characteristics have been explored. The descriptive statistics suggest that the patterns associated with physical activity and diet may differ to varying degrees across education and race/ethnicity groups. While this is important to know going forward, the central research questions remain unanswered. More appropriate and advanced statistical techniques are required to determine if physical activity and diet are predictive of diabetes status and whether or not the association is consistent among those with different levels of education and race/ethnicities. To this end, a series of statistical models, multinomial logistic regression models specifically, were estimated to analyze the degree to which social characteristics such as education and race/ethnicity moderate the relationship between physical activity and diet and the likelihood of having diabetes, prediabetes, and normal glycemia.

Consistent with the matrix in Section III, separate models were estimated for each pairing of physical activity-diet and education-race/ethnicity where the interaction term, as a cross-product of the two (i.e. diet*education), was calculated. After accounting for the variance attributable the health behavior-social characteristic interaction, the probability of having normal glycemia, prediabetes, or diabetes was estimated at varying levels of physical activity and diet across levels of educational attainment and for those of different races and ethnicities. Accordingly, the estimates were adjusted for age, BMI, and other social factors to ensure the relationship between behavioral-social characteristics and diabetes was not spurious. Analysis A examined education as a moderator of the relationship between the independent variable of physical activity and the dependent variable of diabetes status. Analysis B examined education as a moderator for the relationship between diet (HEI-2010 total component scores) and diabetes status. Analysis C examined race/ethnicity as the moderator for the physical activity-diabetes status relationship. Finally, analysis D examined race/ethnicity as a moderator for the relationship between diet and diabetes status.

A. Physical Activity, Educational Attainment and the Likelihood of Diabetes, Prediabetes and Normal Glycemia

The first pairing of a behavior and a social characteristic to be examined was physical activity and education. To begin, a model including activity level, education, and control variables was estimated. Table 8 presents the relative risk ratios (RRR) of each variable along with the corresponding p-value to indicate statistical significance. As indicated in Model 1, both activity level and education were associated with the likelihood of having diabetes. The risk of having diabetes for those who were active was .61 times that of those who were inactive ($p<.01$). Being active was not as strongly associated with prediabetes. The relative risk ratio of .88 ($p=.059$) suggests that the model expected those who were active to be less likely to have prediabetes than those who were not active, but certainty of the estimates fall just outside the conventional 95% confidence level. Regarding education, those with a college degree had .55 times the risk of diabetes ($p<.01$) of those with a less than high school education. Similarly those with some college had .66 times the risk of diabetes (RRR 0.66, $p<.001$) of those with less than a high school education. The difference between those with less than high school and high school were not significant.

Table 8. Relative Risk Ratios for Prediabetes and Diabetes vs. Normal Glycemia Education-PA Interaction, NHANES 2007-2012, N= 13,400

	Model 1		Model 2	
	Prediabetes	Diabetes	Prediabetes	Diabetes
Variables (referent)				
Body Mass Index (normal)				
Overweight	1.43***	1.61***	1.43***	1.61***
Obese	2.38***	5.89***	2.38***	5.89***
Healthy Eating Index 2010	0.99	1.01+	0.99	1.01+
Age (24-34)				
35-54	3.63***	7.08***	3.63***	7.08***
55-64	8.23***	24.72***	8.23***	24.72***
65+	12.93***	48.81***	12.93***	48.81***
Gender (female)				
Male	0.95	1.33**	0.95	1.33**
Income (Poor<124%)				
Low income 124-199%	1.02	0.9	1.02	0.9
Middle income 200-399%	0.88	0.69**	0.88	0.69**
High Income ≥400%	0.9	0.55***	0.9	0.55***
Race/Ethnicity (NH white)				
Non-Hispanic Black	2.11***	2.76***	2.11***	2.76***
Hispanic	1.24**	1.45**	1.24**	1.45**
Other race	1.90***	3.18***	1.90***	3.18***
Education Category (LSHS)				
High School	0.95	0.76*	0.9	0.78
Some college	0.82+	0.69**	0.81+	0.66***
College degree	1.90***	0.49***	0.73**	0.55**
Physical Activity (Inactive)				
Active	0.88+	0.61***	0.93	0.66*
Education X Activity				
LSHS-Active	-	-	1	1
HS-Active	-	-	1.16	0.79
Some college-Active	-	-	1.02	1.16
College-Active	-	-	.70+	0.76+

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Furthermore, those with a college education had .65 times the risk of diabetes of those with a high school education ($p<.01$) and .71 times the risk of diabetes (RRR .71, $p<.05$) of those with some college (not reported in Table 8). A similar trend was observed for prediabetes. Those with a college education had .62 times the risk of prediabetes ($p<.001$) of those with less than a high school education. The differences between those with less than a high school education and high school or some college were not statistically significant. In addition, those with a college education had .65 times the risk of prediabetes ($p<.001$) of those with a high school degree, and had .76 times the risk of prediabetes ($p<.05$) of those with some college (not reported in Table 8).

An interaction term was added in model 2 to determine if the observed relationship between activity level and diabetes status was consistent across different levels of education. Generally, being active resulted in a lower likelihood of having diabetes among the college educated, but only at the .10 level as shown in Table 8. However, interpretation of multinomial coefficients can be difficult and misleading because (1) each relative risk ratio is for a specified outcome in comparison to the base outcomes (normal glycemia), (2) risk ratios are also relative to the reference group for each variable, (3) the interaction effect is measured relative to those with less than high school education who are active which does not indicate difference from inactive to active within education groups. Rather than making the numerous distinctions and comparisons between three outcomes, two independent variables, and four moderating categorical groups, the estimates can be used to calculate the marginal effects of the independent variables and thus the predicted probability of having normal glycemia, prediabetes, and diabetes at different levels of activity and at different levels of education while holding other independent variables at their means (Long and Freese 2014).

Further analysis using this method indicated that while the direction of the relationship between physical activity and diabetes status was consistent across education categories, the strength of that relationship did vary. In other words, being active was generally associated with lower risk of diabetes, the difference in risk between those who were active compared to inactive varied by educational attainment. The interaction between physical activity and education was less uniform for predicting the likelihood of having prediabetes. It appears that being active was only associated with a lower likelihood of having prediabetes for those with a college education.

Table 9 provides predicted probabilities of having diabetes, prediabetes, or normal glycemia according to activity and educational level (also See Figure 6). Examining these probabilities allowed for a broader understanding of the relationship between education, activity, and diabetes status. First, direct attention to the diabetes category (also shown in Figure 6, panel 3). As previously mentioned those with less than a high school, a high school, and a college education, who were also active had a reduced likelihood of having diabetes compared to their inactive counterparts. The difference was largest, numerically, among those with a high school degree and least among those with some college.

Table 9. Predicted Probabilities of having Normal Glycemia, Prediabetes, and Diabetes by Activity and Education Level

	No Diabetes		**Prediabetes**		**Diabetes**	
	Inactive	Active	Inactive	Active	Inactive	Active
Less Than High School	**65.0**	**67.9**	**27.8**	**27.1**	**7.2**	**5.0**
	(62.0-68.0)	(62.0-73.9)	(25.1-30.4)	(21.8-32.4)	(5.9-8.5)	(3.3-6.7)
High School	**68**	**68.4**	**26.1**	**28.5**	**5.9**	**3.1**
	(64.7-71.3)	(63.2-73.7)	(23.2-29.0)	(23.5-33.4)	(4.4-7.4)	(1.7-4.5)
Some College	**70.6**	**72.3**	**24.3**	**23.6**	**5.1**	**4.0**
	(67.8-73.4)	(68.3-76.3)	(21.7-26.8)	(19.9-27.4)	(4.2-6.1)	(3.0-5.2)
College	**72.9**	**81.1**	**22.6**	**16.5**	**4.4**	**2.5**
	(69.4-76.5)	(78.4-83.8)	(19.4-25.9)	(13.9-19.0)	(3.4-5.5)	(1.5-3.4)

All data adjusted for complex sampling frame, sample year, BMI, age, gender, income, and race/ethnicity.

Overall, those with a college degree had the lowest probability of diabetes active or otherwise. The predicted probability of having diabetes for an active, college-educated individual was 2.5 percent (95% CI, 1.5-3.4) compared to 5.0 percent (95% CI, 3.4-6.7) for an active individual with a less than a high school education (a difference of 2.5, $z=2.30$, $p<.05$). Similarly, a difference of 2.8 in probability ($z=4.32$, $p<.001$) was found between those the most educated and the least educated who were inactive.

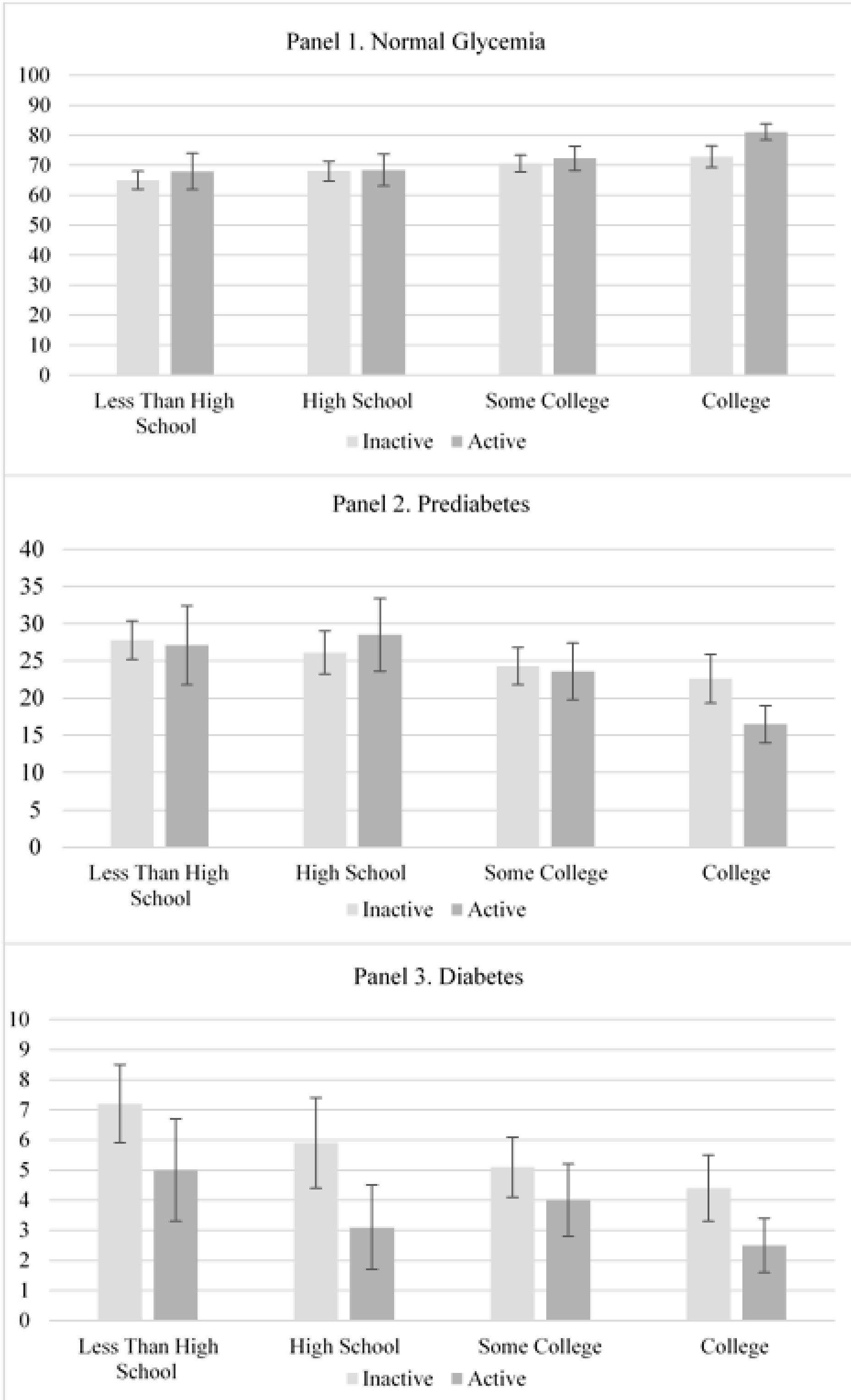


Figure 6. Predicted Probability of Diabetes Status by Physical Activity and Educational Attainment.

While the difference in the probability of diabetes from inactive to active among those with less than a high school education and college education were similar numerically, the change in proportion, from 7.2 to 5.0, for those with less than a high school education was 30.9 percent (z=2.70, p<.01) compared to a 44.0 percent (z=3.41, p<.001,) change in proportion from 4.4 to 2.5 for those with a college education. In other words, the difference in the rate of diabetes for those who were inactive compared to active was similar; however the percentage difference, with respect to the starting point, was larger for those with a college degree than those with a less than high school degree. Correspondingly, those with a high school education had the largest gap in risk for diabetes for those who inactive versus those who were active (2.8, z=2.59. p<.010). However, the change in proportion from 5.9 to 3.1, a difference of 47 percent, was only marginally greater than the change observed for those with a college education. Unsurprising, the largest difference in the likelihood of having diabetes was between active, college-educated individuals and inactive, less than high school educated individuals (2.5 vs 7.2).

Referring again to Table 9, the predicted probability of having prediabetes was largely unaffected by activity for those with less than a college degree (shown in Figure 6, panel 2). But among college, the likelihood of having prediabetes was lower by 6.2 (z=2.93, p<.01) percentage points for those who were active compared to those who were inactive. By comparison, the probability of having prediabetes for those who were active and had a college degree was 7.2 points lower than those with some college (z=2.84, p<.01) and more than 10 points lower than those with high school education or less (p<.001).

Overall, the substantial difference in the likelihood of having prediabetes for active individuals with a college education combined with the numerically small probability of active individuals with a college education having diabetes rendered a significantly greater probability of those with a college education having normal glycemia than their counterparts with less education. By comparison, the predicted probability of having normal glycemia among those who were inactive and had a college education was 72.9 percent (95% CI, 69.4-76.5) compared to their counterparts with less than a high school education, 65.0 percent (95% CI, 62.0-68.0). The differences were even greater for those with college and less than high school who are active, 81.1 vs 67.9.

To further elaborate, a comparison of mean differences in the predicted probability of having prediabetes and diabetes between those who are inactive compared to those who are active within education groups are shown in Table 10. The values in Table 10 indicate the numerical difference in the probability of prediabetes and diabetes for those who are inactive compared to those who are active (Inactive Probability-Active Probability). Positive numbers indicate how much higher the probability of diabetes status was for being inactive compared to active. The difference in the probability of having diabetes for those who had less than a high school education and were inactive compared to those who were active was approximately two percentage points ($z=2.53$, $p<.05$). To clarify, the likelihood of having diabetes refers to the predicted prevalence or probability of diabetes among a given population. A two percent difference as observed among those with a less than high school degree means that prevalence of diabetes is estimated to be two percentage points lower among those who are active. This estimate translates to a substantially lower number of individuals with diabetes given two percent of the U.S. adult population with less than a high school education from 2007-2012 is roughly 760,000 people. A similar trend was observed for those with a college education (1.9, $z=2.70$, $p<.01$). The largest difference was for those with a high school education. The likelihood of having diabetes was 2.8 percentage points (z=2.59, p<.01) lower for active individuals with a high school degree. Alternatively, those who were active and had some college were less likely to have diabetes by 1.1 percentage points; however the difference was not statistically significant (p=.065).

Although the mean differences in predicted probabilities indicate significant differences for all groups with the exception of those with some college, it should be noted that the Wald test of significance, as used in Table 10, conflicts somewhat with the significances test calculated by the 95% CI in Table 9. The confidence intervals are a more conservative estimate of what the predicted probability of diabetes should be in the U.S. adult population, whereas the Wald test of significance, as used to test the means differences in predicted probabilities (Table 10), is a hypothesis test that estimates the chance that the mean differences are equal to zero. Therefore, the latter estimates of mean differences should be interpreted carefully. Although we can be confident that for those with a less than high school and high school education the mean difference in probability of having diabetes for those who are active compared to those who are inactive were significantly different from zero at the .05 level, we cannot be certain at the .05 level that the probability estimates, as shown in Table 9, differ significantly in the U.S. adult population as indicated by the 95% CI. This can only be said for those with a college education.

Table 10. Mean Differences in Predicted Probabilities: Inactive Vs. Active (Educational Attainment)

	Prediabetes		Diabetes	
	Contrast (95% CI)	*p*	Contrast (95% CI)	*p*
Less Than High School				
Inactive vs. Active	0.7 (-4.4-5.8)	0.798	2.2 (0.5-4.0)	<.05
High School				
Inactive vs. Active	-2.4 (-7.3-2.5)	0.341	2.8 (0.7-4.9)	<.01
Some College				
Inactive vs. Active	0.62 (-3.2-4.4)	0.751	1.1 (-0.06-2.3)	0.065
College				
Inactive vs. Active	6.2 (2.0-10.3)	<.01	1.9 (0.5-3.4)	<.01

p-values result from Wald tests of significance (z-statistics)

All data adjusted for complex sample design

Summary

Overall, being active resulted in a lower risk of diabetes. Across education levels, the probability of having diabetes was at least somewhat lower for those who were active. However, those with the least education not only had the highest probability of having diabetes, active or otherwise, but had a less dramatic difference between being active compared to being inactive. The probability of having diabetes for those who are active and a less than high school education (5.0) was twice as high as the probability of having diabetes for those who are active and college educated (2.5). Conversely, for those not meeting the aerobic activity recommendations the likelihood of having diabetes was higher among those for those with less than a high school education (7.2) than those with at least a high school education (5.9).

With respect to prediabetes, being physically active was not associated with a lower probability of having prediabetes for those with less than a college education. For those with a college education, the probability of having prediabetes was six percentage points lower for those who met physical activity recommendation compared to those who did not. In addition, those with a college education who were active were 12 percentage points less likely to have prediabetes than those who were active with a high school education and 11 percentage points less likely to have prediabetes than those who were active with less than a high school education. Overall, the likelihood of having normal glycemia was, on average, 10 percentage points greater for those with a college degree than their counterparts with less education, even when meeting the same physical activity recommendations. Being physically active did not eliminate educational disparities in the risk of diabetes.

B. Diet, Educational Attainment and the Likelihood of Diabetes, Prediabetes and Normal Glycemia

Now that the role of education in the physical activity-diabetes relationship has been examined, attention is turned to role of education in the diet-diabetes relationship. To begin, a multinomial logistic regression model including education, total component scores, and control variables was estimated to determine the likelihood of having diabetes, prediabetes, and normal glycemia. Table 11 presents the relative risk ratios (RRR) of each variable along with the corresponding tests of statistical significance, or p-values. As shown in Model 1, the RRR for total component score of 1.008 (p=.057) for diabetes and .99 (p=.747) for prediabetes indicate that total scores did not differ significantly across diabetes categories. However, as previously reported the likelihood of diabetes and prediabetes did vary by education.

To determine if the overall trend in total scores held constant across education groups, an interaction term, the cross-product of Education*Total Component score, was added in Model 2. On average, the interaction between total component scores and education was not statistically significant in predicting the likelihood of having diabetes, as indicated by p-values in Table 11. However, the association between total component score and the likelihood of having prediabetes was slightly less positive among those with a college education (RRR=.99, $p<.05$) compared to those with less than a high school education. To more broadly understand the relationship between diet, education, and diabetes status, post-estimation procedures were performed to the convert the relative risk ratios into predicted probabilities that take into account the interaction between diet score and education. Doing this depicted whether the likelihood of diabetes and prediabetes was consistent across education levels at diet scores considered to be low (0), average (50), and high (100).

Table 11. Relative Risk Ratios For Prediabetes and Diabetes vs. Normal Glycemia: Education and Diet, NHANES 2007-2012, N= 13,400

	Model 1		Model 2	
	Prediabetes	Diabetes	Prediabetes	Diabetes
Variables (referent)				
Body Mass Index (normal)				
Overweight	1.43***	1.61***	1.43***	1.61***
Obese	2.38***	5.89***	2.38***	5.89***
Age (18-34)				
35-54	3.63***	7.08***	3.63***	7.08***
55-64	8.23***	24.72***	8.23***	24.72***
65+	12.93***	48.81***	12.93***	48.81***
Gender (female)				
Male	0.95	1.33**	0.95	1.33**
Income (Poor<124%)				
Low income 124-199%	1.02	0.90	1.02	0.90
Middle income 200-399%	0.88	0.69**	0.88	0.69**
High Income ≥400%	0.9	0.55***	0.9	0.55***
Race/Ethnicity (NH white)				
Non-Hispanic Black	2.11***	2.76***	2.11***	2.76***
Hispanic	1.24**	1.45**	1.24**	1.45**
Other race	1.90***	3.18***	1.90***	3.18***
Education Category (LSHS)				
High School	0.95	0.76*	0.96	0.76*
Some college	0.82+	0.69**	0.82*	0.69***
College degree	1.90***	0.49***	0.65***	0.53***
Physical Activity (Inactive)				
Active	0.88+	0.61***	0.88+	0.61***
HEI 2010 Score				
Total Component=50	0.99	1.01+	1.00	1.01
Education at HEI=50				
LSHS	-	-	1	1
HS	-	-	1.004	1.01
Some College	-	-	1.001	1.01
College	-	-	0.99**	0.99

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Predicted probabilities are shown in Table 12. Generally, the likelihood of having diabetes did not vary between educational groups with low diet scores (diet=0). However, those with a college education and a diet score of 50 had a lower probability of having diabetes compared to their less educated counterparts. Specifically, the probability for a college educated individual with a diet score of 50 was 3.7 percent (95% CI, 2.9-4.5) compared to 6.1 percent (95% CI, 5.1-7.2) for those with less than a high school education with the same diet score, the difference of 2.4 percentage points was statistically significant (z=3.95, df=1, p<.001). Similarly, the difference between those with a college education and a high school education with diets scores of 50 was statistically significant (1.1, z=1.99, df=1, p<.05). The differences were even larger for diet scores of 100. The probability of having diabetes for a less than high school education and diet score of 100 was 8.1 percent (95% CI, 4.7-11.5) compared to 3.2 percent (95% CI, 0.9-5.6) for those with a college education, the difference of 4.9 percentage points was significant according to a Wald test (z=2.40, df=1, p<.05) however the confidence intervals which estimate the distribution of diabetes in the population did not differ significantly as evident by the overlapping confidence intervals. Similar differences were observed between those with a college education and those with high school (6.5 [z=—1.60, df=1, p=.10]) and some college (4.6 [z=—2.18 df=1, p<.05).

Table 12. Predicted Probability of Normal Glycemia, Prediabetes, and Diabetes by Diet and Education

	Normal Glycemia			**Prediabetes**			**Diabetes**		
	HEI=0	HEI=50	HEI=100	HEI=0	HEI=50	HEI=100	HEI =0	HEI=50	HEI=100
Less Than High School	**68.9**	**66.4**	**63.6**	**26.5**	**27.5**	**28.3**	**4.6**	**6.1**	**8.1**
	59.6-78.3	63.3-69.5	54.3-72.8	18.6-34.3	24.7-30.2	20.6-36.1	2.3-7.0	5.1-7.2	4.7-11.5
High School	**75**	**68.2**	**59.5**	**22.7**	**27**	**30.8**	**2.3**	**4.8**	**9.7**
	68.1-81.9	65.1-71.3	48.1-71.0	16.0-29.4	24.0-29.9	20.5-41.1	0.6-3.9	3.8-5.8	2.8-16.6
Some College	**75.7**	**71.3**	**66**	**21.7**	**24.1**	**26.3**	**2.6**	**4.6**	**7.8**
	68.7-82.7	68.7-74.0	57.3-74.7	15.3-28.0	21.6-26.5	18.7-33.8	1.2-4.1	3.8-5.4	3.7-11.9
College	**65**	**75.9**	**84**	**30.9**	**20.4**	**12.8**	**4**	**3.7**	**3.2**
	54.6-75.5	73.8-78.0	77.9-90.0	20.5-41.1	18.3-22.5	7.9-17.6	0.7-7.3	2.9-4.5	0.9-5.6

All data adjusted for complex sampling frame, sample year, BMI, age, gender, income, and race/ethnicity.

Notably, the trends in the likelihood of diabetes increased as diet scores increased for those with less than a college education. This was expected because the descriptive statistics indicated that those with diabetes had higher diet scores than those with prediabetes or normal glycemia, but as observed here the likelihood of diabetes was higher at better diet scores only among those with less than a college education. For instance, for those with a high school education and a diet score of zero, the predicted probability of having diabetes was 2.3 percent (95% CI, 0.6-3.9). The probability of having diabetes was 4.8 percent (95% CI, 3.8-5.8) at a diet score of 50. The difference of 2.5 was statistically significant (z=2.77, df=1, p<.01). A similar pattern was observed for those with some college. However, for those with a college education the probability of having diabetes at a diet score zero (4.0 [95% CI, 0.7-7.3]) was not significantly different from the probability at a diet score of 100 (3.2 [95% CI, 0.9-5.6]).

The predicted probability of prediabetes at varying diet scores differed somewhat from the patterns of diabetes. Among those with less than a college education, the probability of prediabetes was only marginally lower (not significantly) at higher diet scores; whereas, the predicted probability of prediabetes for those with a college education was significantly higher at a diet score of zero (30.9% [95% CI, 20.5-41.1]) than at a diet score of 100 (12.8% [95% CI, 7.9-17.6]) at a diet score of 100. The difference in the probability from a diet score of zero to 100 was a contrast of nearly 60 percent or 18.2 percentage points (z=2.77, df=1, p<.01). Conversely, the differences between education groups were not significant when diet scores equaled zero. However, at a diet score of 50, those with a college education had the lowest probability of prediabetes at 20.4 (95% CI, 18.3-22.5), whereas diet scores for those with less education remained relatively unchanged. This divergent trend was even more pronounced at a diet score of 100 largely due to continued decrease in probability of prediabetes among those with a college education and the unchanged probability of prediabetes among those with less education.

Overall, the patterns in diabetes and prediabetes, with respect to education, contributed to oppositional trends in normal glycemia. At a diet score of zero, little difference is was observed in the probability of having normal glycemia. At higher diet scores, the probability of having normal glycemia was stable for those with a less than high school education, was somewhat lower for those with high school or some college, and was higher for those with a college education. Specifically, the difference in the probability of having normal glycemia between a diet score of zero and 100 was −15.5 percentage points ($z = -1.74$, $df=1$, $p=.08$) for those with a high school education compared to 19.0 percentage points ($z=2.33$, $df=1$, $p<.05$) for those with a college education.

Summary

In general, the patterns associated with diabetes status and diet score were unique among those with a college degree. Although overall trends indicate those with diabetes met a higher percentage of dietary recommendation than their counterparts with prediabetes and normal glycemia suggesting being at risk for or having diabetes makes healthier dietary patterns more likely, it appears this phenomenon was not observed among those with a college education. First, the probability of having prediabetes and diabetes was lower among those with a college education at average and high diet scores than those with less education. Second, the higher diet scores were actually associated with a lower probability of diabetes and prediabetes among those with a college education, whereas the probability of diabetes and prediabetes was highest at higher diet scores among those with less than a college education. Somewhat similar to the findings related to physical activity and diabetes status, the relationship between diet quality and diabetes seems to be different for those with a college education than their less educated counterparts.

C. Physical Activity, Race/Ethnicity and the Likelihood of Diabetes, Prediabetes and Normal Glycemia

Next, the relationship between physical activity and diabetes was reexamined by focusing on race/ethnicity. As previously stated physical activity varied both by race/ethnicity and diabetes status. Additionally, the prevalence of diabetes was disproportionately high among some racial minorities. To investigate whether or not being active resulted in a lower likelihood of diabetes uniformly across race/ethnicity groups, a set of multinomial regression models and a series of post-estimation procedures were performed. First, a model (Model 1) with physical activity and race/ethnicity, along with other covariates, was estimated and results (RRR's and p-values) are shown in Table 13. Initial model estimates (without interaction terms) were the same for physical activity (RRR .61 [95% CI, 49.8-73.9]) as in previous models. As expected, the relative risk of having diabetes was significantly higher among minority groups. Specifically, non-Hispanic blacks were 2.8 (95% CI, 2.2-3.5) times as likely to have diabetes than non-Hispanic whites. In addition, Hispanics were 1.5 (95% CI, 1.1-1.8) times as likely to have diabetes as non-Hispanic whites. Similar trends in the risk of prediabetes were observed. Non-Hispanics blacks were twice as likely to have prediabetes as non-Hispanic whites (RRR 2.1, $p<.001$) and Hispanics were 1.2 times as likely to have prediabetes as non-Hispanic whites (RRR 1.2, $P<.01$).

Table 13. Relative Risk Ratios For Prediabetes and Diabetes vs. Normal Glycemia: Race/Ethnicity-PA Interaction, NHANES 2007-2012, N= 13,400

	Model 1		Model 2	
Variables (referent)	Prediabetes	Diabetes	Prediabetes	Diabetes
Body Mass Index (normal)				
Overweight	1.43***	1.61***	1.43***	1.61***
Obese	2.38***	5.89***	2.38***	5.89***
Healthy Eating Index 2010				
Total Component	0.99	1.01+	0.99	1.01+
Age (24-34)				
35-54	3.63***	7.08***	3.63***	7.08***
55-64	8.23***	24.72***	8.23***	24.72***
65+	12.93***	48.81***	12.93***	48.81***
Gender (female)				
Male	0.95	1.33**	0.95	1.33**
Income (Poor<124%)				
Low income 124-199%	1.02	0.9	1.02	0.9
Middle income 200-399%	0.88	0.69**	0.88	0.69**
High Income ≥400%	0.9	0.55***	0.9	0.55***
Education Category (LSHS)				
High School	0.95	0.76*	0.9	0.78
Some college	0.82+	0.69**	0.81+	0.66***
College degree	1.90***	0.49***	0.73**	0.55**
Race/Ethnicity (NH white)				
Non-Hispanic Black	2.11***	2.76***	2.11***	2.76***
Hispanic	1.24**	1.45**	1.24**	1.45**
Other race	1.90***	3.18***	1.90***	3.18***
Physical Activity (Inactive)				
Active	0.88+	0.61***	0.93	0.66*
Race/Ethnicity X Activity				
NHW-Active	-	-	0.93	0.66
NHB-Active	-	-	1.16	0.79
Hispanic-Active	-	-	1.02	1.16
Other-Active	-	-	.70+	0.76

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

The next step was to determine if the association between physical activity and diabetes and prediabetes varied among racial groups. Accordingly, an interaction term for physical activity and race/ethnicity was added in Model 2 and predicted probabilities of each outcome were calculated. Results are present in Table 14 (also see Figure 7). Overall, the predicted probability of having diabetes was lowest among non-Hispanic whites who were active. For active whites, the probability of having diabetes was 2.7 percent (95% CI, 2.1-3.4) which, according to Wald tests, was significantly lower than the 5.9 percent of active-blacks (z=4.36, p<.001), the 4.5 percent for active-Hispanics (z=2.11p<.05), and the 8.7 percent of active-other races (z=3.12, p<.001). Note, according to Table 14, the 95% CI for the predicted probability of diabetes indicates a possible range of 2.1-3.4 for active-whites compared to 2.9-6.1 for Hispanics in the population; however, a hypothesis test in the form of a Wald test indicated the probability of diabetes for active-whites and active-Hispanics being equal was less than .05. A similar trend was observed for being inactive across racial groups. The probability of having diabetes for inactive-whites of 4.6 percent was, according to Wald tests, significantly lower than the 9.3 percent for inactive-blacks, the 5.8 percent for inactive-Hispanics, and 10.3 percent for inactive-other races (p<.05).

Table 14. Predicted Probabilities of Having Normal Glycemia, Prediabetes, and Diabetes by Activity Level and Race/Ethnicity

	No Diabetes		Prediabetes		Diabetes	
	Inactive	Active	Inactive	Active	Inactive	Active
Non-Hispanic white	**73.3**	**76.8**	**22.7**	**19.3**	**4.6**	**2.7**
	(71.9-74.7)	(74.7-78.9)	(21.3-24.3)	(17.2-21.5)	(3.8-5.4)	(2.1-3.4)
Non-Hispanic black	**55.3**[a]	**60.1**[a]	**32.2**[a]	**40.3**[a]	**9.3**[a]	**5.9**[a]
	(52.4-63.3)	(56.9-63.3)	(29.4-35.0)	(36.3-44.2)	(7.6-10.9)	(4.5-7.3)
Hispanic	**68.4**	**72.4**[a]	**24.4**	**26.3**[a]	**5.8**[a]	**4.5**[a]
	(65.9-70.9)	(69.9-74.9)	(21.6-27.2)	(23.0-29.6)	(4.7-6.9)	(2.9-6.1)
Other race	**56.5**[a]	**61.6**[a]	**33.1**[a]	**29.8**[a]	**10.3**[a]	**8.7**[a]
	(51.4-61.5)	(56.5-66.7)	(26.7-39.5)	(23.2-36.4)	(7.1-13.5)	(5.2-12.2)

[a] indicates significant difference from whites, Wald test p<.05.
All data adjusted for complex sampling frame, sample year, BMI, diet score, age, gender, income, and education.

The patterns of racial difference and activity level were somewhat different for predicting prediabetes. While active-whites had the lowest probability of prediabetes, the next lowest probability of having prediabetes was for inactive-whites. As presented in Table 14 and Figure 7, the overall prevalence of prediabetes among non-Hispanic blacks, active or inactive, was much higher than among non-Hispanic whites. The probability of having prediabetes for the inactive was nearly 10 percent points higher for non-Hispanic blacks than non-Hispanic whites and over 20 percentage points higher for those who were active. The probability of having prediabetes was also significantly lower for active-non-Hispanic whites than active-Hispanics and active-other races. Lastly, the probability of having normal glycemia was highest among active non-Hispanic whites and lowest among inactive non-Hispanic blacks. The differences were most substantial between whites and blacks, active or otherwise.

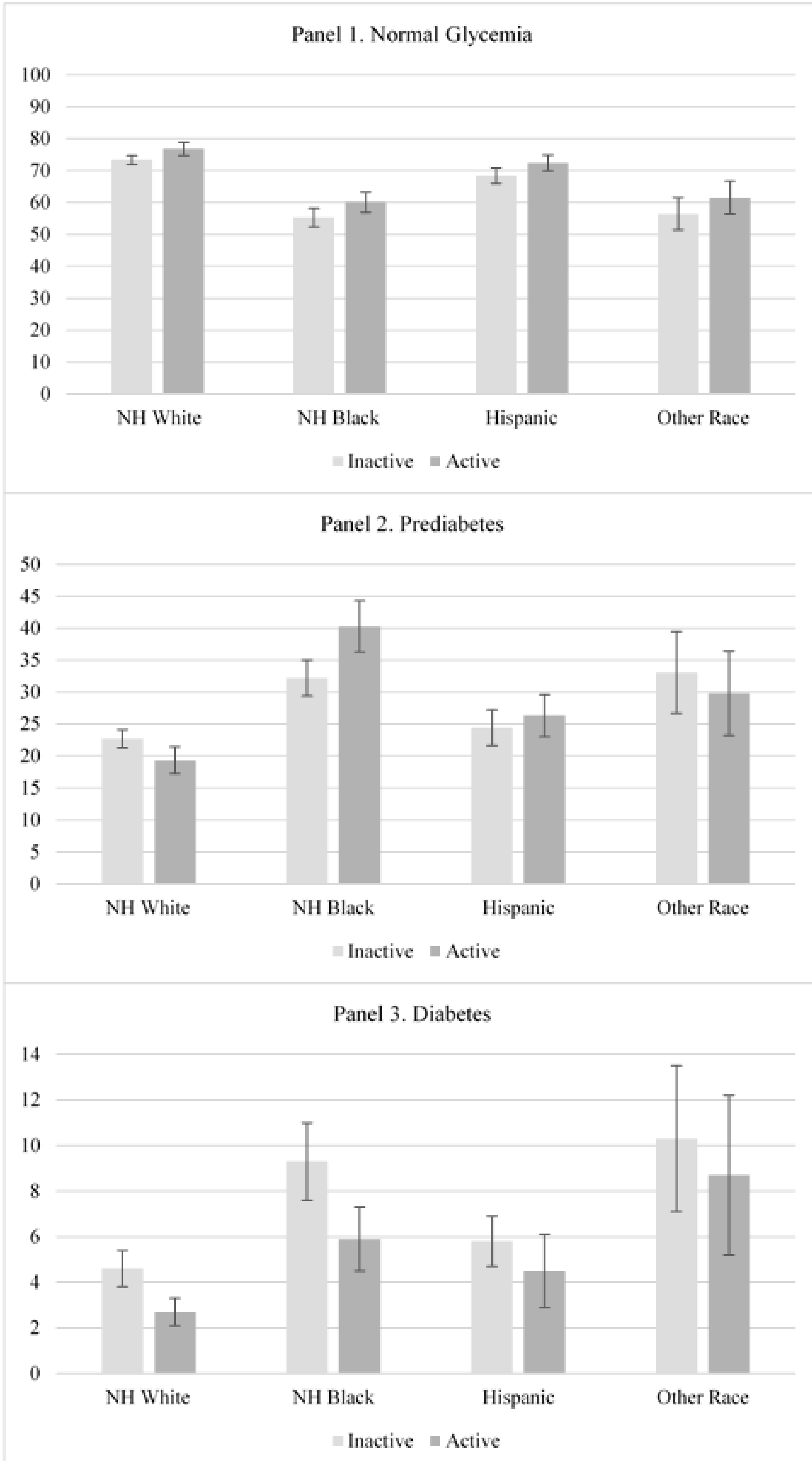


Figure 7. Predicted Probability of Diabetes Status by Physical Activity and Race/Ethnicity.

Differences in the probability of normal glycemia, prediabetes, and diabetes within diabetes status and according to level of activity, suggest persistent disparities between racial groups. Generally, being active, as opposed to being inactive, resulted in a lower risk of having diabetes within race/ethnicity groups. However, a statistically significant advantage of activity was only found among non-Hispanic whites and non-Hispanic blacks. A comparison of mean differences in the probability of diabetes and prediabetes between being active and inactive within race/ethnicity groups are shown in Table 15. Again positive values indicate a higher probability of diabetes or prediabetes for those who are inactive. Among non-Hispanic whites, the risk of diabetes was 1.9 percentage points ($p<.001$) higher for those who were inactive than for those who were active. A larger percentage point difference was observed among Non-Hispanic blacks who had a difference of 3.4 points ($p<.001$). Furthermore, the difference in the probability of diabetes from 4.6 for inactive whites to 2.7 for active whites is a difference of 40.5 percent compared to a difference from 9.3 to 5.9, or 36.3 percent, among blacks. Effectively, the proportional inactive-to-active difference in the probability of having diabetes was similar between whites and blacks even though the numerical difference was largest for blacks and unobserved for Hispanics and those of other races.

Table 15. Mean Differences in Predicted Probabilities: Inactive Vs. Active (Race/Ethnicity)

	Prediabetes		Diabetes	
	Contrast (95% CI)	*p*	Contrast (95% CI)	*p*
Non-Hispanic white				
Inactive vs. Active	3.4 (0.8-6.2)	0.01	1.9 (0.9-2.8)	<.001
Non-Hispanic black				
Inactive vs. Active	-8.1 (-12.5--3.7)	<.001	3.4 (1.3-5.4)	<.001
Hispanic				
Inactive vs. Active	-1.9 (-5.9--2.2)	0.372	1.3 (-0.3-2.9)	0.101
Other Race				
Inactive vs. Active	-3.2 (-6.3-1.3)	0.502	1.6 (-3.2-6.4)	0.518

p-values result from Wald tests of significance (z-statistics)

All data adjusted for complex sample design

With respect to prediabetes, the inactive-active difference was positive only for non-Hispanic whites. In other words, the probability of having prediabetes was lower among those who were active than those who were inactive, but only for non-Hispanic whites. For non-Hispanic blacks, being inactive was actually associated with a lower risk of prediabetes than being active. In fact, the probability of having prediabetes was actually higher among active non-Hispanic blacks than inactive non-Hispanic blacks, a difference of 8.1 percentage points (p<.001).The inactive-active differences for Hispanics and other races were not statistically significant. As shown in Figure 7: Panel 2, the overall prevalence of prediabetes among non-Hispanic blacks, active or inactive, was much higher than among non-Hispanic whites. The probability of having prediabetes was nearly 10 percentage points greater among non-Hispanic blacks than non-Hispanic whites who were inactive. The difference was twice that for those who were active. The probability of having prediabetes for active non-Hispanic whites was also lower than that of active Hispanics and active other races.

Summary

Overall, the risk of diabetes was lowest for non-Hispanic whites even when racial/ethnic minorities met recommendations for physical activity and all other variables were held constant. All things including physical activity being equal, racial disparities persist with the largest gaps being between non-Hispanic whites and non-Hispanic blacks. Another significant finding from this model was that probability of having diabetes for non-Hispanic whites and non-Hispanic blacks was lower when meeting physical activity recommendations, but a difference was not found for Hispanics and those of other races. Furthermore, even though the difference in the probability of diabetes between being active or inactive was largest numerically among non-Hispanic blacks, indicating a stronger relationship between meeting activity recommendations and diabetes for non-Hispanic blacks, the proportional difference between the probability of diabetes being active compared to inactive was slightly lower for non-Hispanic blacks than non-Hispanic whites. Finally, the risk of prediabetes was much lower for non-Hispanic whites than other groups and only among non-Hispanic whites did being active result in a significantly lower risk of prediabetes than being inactive. For non-Hispanic blacks, being active actually resulted in a higher risk of prediabetes than being inactive which may suggest, among other things, non-Hispanic blacks may engage in physical activity after they have progressed to the stage of prediabetes.

D. Diet, Race/Ethnicity and the Likelihood of Diabetes, Prediabetes and Normal Glycemia

The final set of models estimated the association between diet score and race/ethnicity in predicting the likelihood of having diabetes, prediabetes, and normal glycemia. Similar to the model analyzing diet and education, this analysis first examined the association of diet score and race/ethnicity with diabetes status independently, then examined the interaction between the two to determine if the association between diet and diabetes status varied across race and ethnicity groups. As shown in Table 16 and previously reported, race/ethnicity was differentially associated with both having diabetes and prediabetes. The association between diet score was statistically significant for diabetes but not for prediabetes. To determine if the relationship between diet score and diabetes status was similar among those of different race/ethnicities, an interaction term (dietXrace) was added in model 2 and predicted probabilities for normal glycemia, prediabetes, and diabetes were calculated for each race/ethnicity group according to specific diet scores.

Table 16. Relative Risk Ratios for Prediabetes and Diabetes vs. Normal Glycemia: Race/Ethnicity and Diet, NHANES 2007-2012, N= 13,400

	Model 1		Model 2	
	Prediabetes	Diabetes	Prediabetes	Diabetes
Variables (referent)				
Body Mass Index (normal)				
Overweight	1.43***	1.61***	1.43***	1.61***
Obese	2.38***	5.89***	2.38***	5.89***
Age (18-34)				
35-54	3.63***	7.08***	3.63***	7.08***
55-64	8.23***	24.72***	8.23***	24.72***
65+	12.93***	48.81***	12.93***	48.81***
Gender (female)				
Male	0.95	1.33**	0.95	1.33**
Income (Poor<124%)				
Low income 124-199%	1.02	0.90	1.02	0.90
Middle income 200-399%	0.88	0.69**	0.88	0.69**
High Income ≥400%	0.90	0.55***	0.90	0.55***
Race/Ethnicity (NH white)				
Non-Hispanic Black	2.11***	2.76***	2.16***	2.83***
Hispanic	1.23**	1.44**	1.24**	1.45**
Other race	1.90***	3.18***	1.95***	2.84***
Education Category (LSHS)				
High School	0.95	0.76*	0.95	0.76*
Some college	0.82+	0.69**	0.82+	0.70**
College degree	0.62***	0.49***	0.62***	0.49***
Physical Activity (Inactive)				
Active	0.88+	0.61***	0.88+	0.61***
HEI 2010				
Total Component=50	0.99	1.01+	0.99	1.00
Race at HEI=50				
NH white	-	-	1.00	1.00
NH black	-	-	1.01	1.02*
Hispanic	-	-	1.01	0.99
Other race	-	-	0.99	1.02*

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Calculating the predicted probability of each diabetes status allows for the differential association between diet and race/ethnicity to be clarified and tested within and between diabetes statuses. Additionally, this allows for the relationship between to race/ethnicity and diabetes status to be evaluated at low, average, and high diet scores to determine if higher or lower diet scores were differentially associated with diabetes status and if the relationship was consistent across race/ethnicity groups. Results are shown in Table 17. Beginning with the diabetes category, at a diet score of zero, the likelihood of having diabetes did not differ by race/ethnicity; however, at a diet score of 50 the likelihood of having diabetes was significantly higher than at zero for non-Hispanic blacks (3.2 HEI=0 to 8.1 HEI=50), a difference of 4.9 percentage points ($z=5.81$, $df=1$, $p<.001$). The likelihood of having diabetes was even higher at a diet score of 100 for non-Hispanic blacks (18.9 [95% CI, 11.1-26.8]). Only those of other races had a higher risk of diabetes at a diet score of 100. By contrast, the risk of diabetes was not significantly different at low, average, and high HEI scores for non-Hispanic whites and Hispanics. Furthermore, at an average diet score (diet=50) the probability of non-Hispanic blacks having diabetes was 4.3 points higher than non-Hispanic whites ($z=6.84$, $df=1$ $p<.001$) and 3.0 points higher than Hispanics ($z=4.33$, $df=1$, $p<.001$). Disparities were even greater at a diet score of 100. The probability of non-Hispanic blacks with a diet score of 100 having diabetes was 14.3 points higher than non-Hispanic whites ($z=3.64$, $df=1$, $p<.001$) and 13.8 points higher than Hispanics ($z=3.33$, $df=1$, $p<.001$).

With respect to the risk of prediabetes, variation was quite low among non-Hispanic whites and blacks from low to high diet scores. The probability of having prediabetes was greater for Hispanics at both a diet score of 50 and 100; however, the difference of 11.8 between diet scores of zero and 100 was not statistically significant ($z=1.60$, $df=1$, $p=.10$). At a diet score of zero, only those of other races had a significantly different probability of prediabetes (47.8) than other race/ethnicity groups. However, at a diet score of 50 non-Hispanic whites had a lower probability of prediabetes than all groups that was statistically significant (p<.05). Additionally, Hispanics had a significantly lower probability of prediabetes than non-Hispanic blacks and other races. Finally, at a diet score of 100, non-Hispanic whites had a probability of 19.9 (95% CI, 14.8-25.1) which was 15.3 percentage points lower than non-Hispanic blacks (z=2.37, df=1, p<.05) and 11.3 percentage points lower than Hispanics (z=2.1, df=1, p<.05).

Table 17. Predicted Probability of Normal Glycemia, Prediabetes, and Diabetes by Race/Ethnicity and Diet, NHANES 2007-2012

	Normal Glycemia			Prediabetes			Diabetes		
	HEI = 0	HEI= 50	HEI=100	HEI = 0	HEI= 50	HEI=100	HEI = 0	HEI= 50	HEI=100
NH white	**73.9**	**74.8**	**75.5**	**23.1**	**21.5**	**19.9**	**3.1**	**3.8**	**4.6**
	67.4-80.3	69.5-81.5	69.5-71.5	17.3-28.8	20.3-22.7	14.8-25.1	1.6-4.6	3.15-4.4	2.6-6.6
NH black	**64.5**	**56.7**	**45.9**	**32.3**	**35.2**	**35.2**	**3.2**	**8.1**	**18.9**
	54.2-74.8	54.0-59.5	34.8-56.9	22.1-42.6	32.6-37.8	24.9-45.5	1.6-4.8	6.8-9.3	11.1-26.8
Hispanic	**75.5**	**70**	**63.7**	**19.5**	**24.9**	**31.2**	**5**	**5.1**	**5.1**
	68.0-83.0	67.9-72.1	54.6-72.7	13.2-25.8	22.6-27.2	22.4-40.0	1.5-8.6	4.1-6.1	2.2-7.9
Other race	**50.4**	**58.7**	**52.7**	**47.8**	**32.9**	**17.4**	**1.8**	**4.6**	**29.8**
	33.8-67.0	54.0-63.5	33.3-72.1	30.9-64.8	28.1	8.5-26.2	-0.1-3.7	2.6-6.6	7.7-52.3

All data adjusted for complex sampling frame, sample year, BMI, age, gender, diet, income, and education.
[a] indicates significant difference from NH white, Wald test p<.05

Lastly, the probability of having normal glycemia was examined. Again at a diet score of zero, the probability of having normal glycemia varied between race/ethnicity groups, but were not statistically significant. Significant differences were only observed at diet scores of 50 and further differences were observed at scores of 100. Generally, non-Hispanics blacks at a lower probability of having normal glycemia at diet score of 50 and 100 than non-Hispanic whites and Hispanics. Similar differences were observed between non-Hispanic whites and Hispanics. At a diet score of 50, the probability of having normal glycemia for non-Hispanic whites was 74.8 percent (95% CI, 69.5-81.5) compared to 70.0 percent (95% CI, 6.9-72.1) for Hispanics, a statistically significant difference of 4.8 percentage points ($z=3.73$, $df=1$, $p<.001$). Differences between non-Hispanic whites and other groups were even greater at a diet score of 100. The probability of having normal glycemia for non-Hispanic whites with a diet score of 100 was 29.6 percentage points higher than non-Hispanic blacks ($z=4.23$, $df=1$, $p<.001$) and 11.8 percentage points higher than Hispanics ($z=2.07$, $df=1$, $p<.05$). Overall, the probability of having diabetes and was higher for non-Hispanic blacks with each incremental increase in diet score. Specifically, non-Hispanic blacks had a higher risk of diabetes at average and high diet scores than their white and Hispanic counterparts. Alternatively, the probability of having diabetes, prediabetes, or normal glycemia remained relatively steady for non-Hispanic whites and to a lesser degree for Hispanics.

Summary

The association between diet scores and diabetes status was only apparent for those non-Hispanic blacks and those of other races. For both of these groups, the probability of having diabetes was much higher at diet scores of 100 than at diet scores of 0. However, a divergent pattern emerged related to prediabetes. The probability of having prediabetes was relatively stable across low, average, and high diet scores for non-Hispanic blacks, whereas the probability of having prediabetes was significantly lower at high diet score than low diet score for those of other races.

Section V: Summary of Findings

In summation, the role of education and race/ethnicity in the link between the health behaviors of physical activity and diet and diabetes proved important. Physical activity predicted risk of diabetes differently across education and race/ethnicity groups whereas the relationship between diet and diabetes was less clear. Being active was clearly associated with a lower likelihood of having diabetes within the population. In reference to the two central research questions: 1) the relationship between physical activity and diabetes status did vary by educational attainment and 2) physical activity level did not produce parity in the likelihood of having diabetes and prediabetes among those of different levels of educational attainment. Across education levels, the likelihood of having diabetes was lower for those who were active. However, those with the least education not only had the highest likelihood of diabetes, active or otherwise, but had the least dramatic benefit as a result of being active. In other words, meeting aerobic activity recommendations reduced the likelihood of diabetes more for those with a high school and college education than those with less than a high school education and interestingly those with some college.

Conversely, not meeting the aerobic activity recommendations increased the likelihood of having diabetes more for those with less than a high school education than those with at least a high school education. With respect to prediabetes, being physically active did not reduce the likelihood of having prediabetes for those with less than a college education. Furthermore, those with a college education who were active were 12 percentage points less likely to have prediabetes than those with a high school education and 11 percentage points less likely to have prediabetes than those with less than a high school education. Overall, the likelihood of having normal glycemia was, on average, 10 percentage points greater for those with a college degree than their counterparts with less education, even when meeting the same physical activity recommendations. Being physically active did not lower the risk of diabetes equally and did not eliminate educational disparities in the risk of diabetes.

The probability of having diabetes was higher at better diet scores for those with a less than a college education. This may indicate that the diet among those with a less than a college education is generally reactive to diabetes as opposed to proactive. Similarly, the risk of prediabetes was lowest among those with a college education and high diet scores. The probability of having prediabetes was less than half for those with a college degree and a high diet score, while the probability of having prediabetes among those with less education trended slightly upward with diet scores. Overall, the probability of having normal glycemia changed marginally at higher diet scores among those with a less than high school education. Whereas the probability of having normal glycemia trended downward at higher diet scores among those with high school or some college, and the probability of having normal glycemia was higher at high diet scores increased among those with a college education.

The role of race/ethnicity also proved important in the health behaviors-diabetes relationship. Being physically active significantly reduced the likelihood of having diabetes among non-Hispanic whites and blacks, but not among Hispanics and other races. Meeting activity recommendations reduced the likelihood of having diabetes most dramatically for non-Hispanic blacks, numerically; however, the proportional change in risk from inactive to active was equal between whites and blacks. Being active was equally beneficial to both blacks and whites, but did not give even active blacks parity with their white counterparts. The likelihood of having diabetes was more than double for non-Hispanic blacks compared to whites, even for those who were active. Being physically active did not result in equal risk of diabetes among race/ethnicity groups. Even so, the likelihood of having diabetes was lower for non-Hispanic whites who were inactive, than non-Hispanic blacks who were active. Meeting physical activity recommendations resulted in a lower risk of prediabetes, but only for non-Hispanic whites. Active, non-Hispanic whites were at half the risk of prediabetes as non-Hispanic blacks and a quarter of the risk of Hispanics. Overall, the likelihood of having normal glycemia was 16 percentage points higher for non-Hispanic whites than non-Hispanic blacks. In reference to the research questions, the relationship between physical activity and diabetes status was not the same for all race/ethnicity groups and meeting physical activity recommendations did not eliminate or even reduce racial/ethnic disparities in the risk of diabetes or prediabetes.

Similar to what was observed among those with low levels of education, non-Hispanic blacks were more likely to have diabetes if their diet was healthier. Because the probability of having diabetes or prediabetes was relatively even for non-Hispanic whites, black/white disparities were largest at high diet scores. The probability of diabetes was highest among non-Hispanic blacks even when diet scores were the same and confounding factors were controlled. These results do not indicate that healthier diets cause diabetes among non-Hispanic blacks, but they do suggest that healthier diets are more closely associated with diabetes among non-Hispanic blacks. Alternatively, dietary differences were much lower across diabetes statues among non-Hispanic whites and Hispanics. One exception was the elevated likelihood of prediabetes among Hispanics with high diet scores. This observation is similar to the case of diabetes and non-Hispanic blacks, where better diet actually predicted an increased likelihood of prediabetes for Hispanics.

The results presented in this chapter largely suggest that the association between health behaviors and diabetes status are not the same across education and race/ethnicity groups, and that even when behaviors are the same the risk of diabetes and prediabetes vary across groups of different levels of educational attainment and race/ethnicities. As reported, education and race/ethnicity, to varying degrees, moderate the relationship between health behaviors (physical activity and diet) and diabetes status, in that physical activity and diet are not uniformly related to diabetes status across education and race/ethnicity groups. In other words, there is a relationship between physical activity, diet and diabetes status but it depends on education and race/ethnicity. While physical activity was generally beneficial in reducing the likelihood of diabetes and prediabetes, the strength of the relationship was weakest among those with the least amount of education. Similarly, adhering to dietary recommendations resulted in a higher probability of diabetes only among those with low levels of education and non-Hispanic blacks. The following chapter will explore possible explanations for the observed phenomena by drawing on theories of health, education, and race and suggest ways in which diabetes, health behaviors, and social characteristics can be reconceptualized to address problems facing population health.

Chapter 4. Discussion

Introduction

The preceding analysis examined the role of education and race/ethnicity in the link between health behaviors, physical activity and diet, and diabetes status. Generally, the results suggested that the relationship between health behaviors and diabetes status was not consistent for all education and race/ethnicity groups. Most notably the relationship between physical activity and diabetes varied by both education level and race/ethnicity. For the most part, those with the least education and non-Hispanic blacks were more likely to have diabetes and prediabetes than other groups even when meeting recommendations for physical activity. The relationship between diet quality and diabetes status was less clear. The probability of having diabetes was relatively consistent across low, average, and high diet scores for those with higher levels of education, non-Hispanic whites, and Hispanics. Whereas, the probability of having diabetes was actually higher at improved diet scores for those with lower levels of education and non-Hispanic blacks.

Moving forward, a discussion of each of the models' results is presented. The findings are discussed in the same order for which they were presented in Chapter 4. The discussion first addresses the role of education in the relationship between physical activity and diabetes status followed by education in the relationship between diet and diabetes status. Then, the discussion turns toward that of race/ethnicity in the relationship between physical activity and diabetes status followed by diet and diabetes status. Finally, the findings, as a whole, are oriented under the established theoretical framework outlined in Chapter 1.

Education, Physical Activity, and Diabetes Status

Three general observations were found concerning the role of education in the relationship between physical activity and diabetes status: 1) Being active, compared to inactive, did not result in a lower probability of having diabetes for those with less than a high school education and those with some college; 2) Being active, compared to inactive, lowered the risk of prediabetes for those with a college education while no differences were observed among other education groups, and 3) Significant disparities of diabetes persisted between those with a college education and those with less than high education even after controlling for activity level and other variables.

Educational attainment and physical activity have shown to be negatively associated with type 2 diabetes (Borrell et al., 2006; Morrato et al., 2007), but the findings here suggest education may also play a role in the association between physical activity and diabetes. Generally, education level seemed to moderate the relationship between a known risk factor for diabetes, physical inactivity, and diabetes status. This observation is similar to that of Liu and colleagues (2015) who found education moderated the relationship between genetic vulnerability and diabetes. After controlling for a host of variables, the probability of having diabetes was substantially lower, approximately half, among those with a college education than those with less than a high school education even among those who were meeting physical activity recommendations. This suggests that education may play a role in diabetes prevalence beyond simply increasing the likelihood of engaging in a healthy behavior.

The prevailing view regarding the social determinants of health is that social factors grant or restrict individuals' access to resources that can be used to engage in healthy lifestyles. Those in higher social strata have more money for quality food, safer environments for physical activity, and greater access to health care and health knowledge that deters smoking, alcohol abuse, and weight gain. However, the findings here suggest that social determinants of health such as educational attainment not only impact the probability of engaging in healthy behavior but may be associated with conditions that allow the relationship between behavior and health to be positive. The current findings compliment other research suggesting that as a fundamental cause of diabetes disparities, educational attainment affects health and disease risk related to resource access and exposure to differentially impactful life circumstances (Cutler, Lleras-Muney, & Vogl, 2008; Johnson et al., 2010; Link & Phelan, 1995b; Phelan, Link, & Tehranifar, 2010). Educational attainment can also increase a person's sense of control by providing generally applicable capabilities, skills, knowledge, money and power to govern their own lives (Becker, 1964; Mirowsky & Ross, 2003a) while increasing one's ability to access social resources such as healthy built environments and medical care. Access to general resources such as money and power can be used not only to better individual's quality of life, but to minimize the consequence of disease risk, avoid disease all together, and maximize the protective factors associated with health.

Public health and social science research consistently show that greater educational attainment, either through increased skills or resources, enables individuals to engage in activities that benefit their health and avoid activities that confer negative health consequences (Mirowsky & Ross, 2015; Phelan et al., 2010). The general assumption regarding educational attainment and its relationship to health is that educational attainment activates mechanisms such as increased income and psychosocial skills that bolster individuals' capacity to choose healthy behaviors. It is then the high level of participation in those beneficial activities such as physical activity, diet, and weight management that result in educational disparities in health outcomes such as diabetes. And in fact, those with high levels of education do tend to engage in more physical activity (Hootman, Macera, Ham, Helmick, & Sniezek, 2003), eat healthier diets (Turrell, Hewitt, Patterson, & Oldenburg, 2003; Turrell & Kavanagh, 2006), and have slightly lower rates of obesity (Ogden, Lamb, Carroll, & Flegal, 2010). What this body of literature concludes is that education acts as a fundamental cause of disparities in diabetes by determining a pathway for some to engage in healthier behavior more often than others.

Research on the social determinants of health also suggests that not only is education a mechanism that increases the likelihood of engaging in healthy behaviors, but it contributes to overall life circumstances that allow healthy behaviors to have a positive effect. For example, those with high levels of education may be able to offset genetic risk factors for type 2 diabetes, in that individuals with education-provided skills and higher social status are more often placed into circumstances were mechanisms that activate genetic markers are less likely to occur (e.g., high BMI, eating foods associated with a Western diet) (Liu et al 2015). Healthy behavior among those in higher social strata, particularly the highly educated, is structurally embedded meaning the process of making choices or engaging in particular healthy behaviors is less restricted by material resources or social and cultural expectations. The social factors such as education and social class that make healthy lifestyles more readily available also protect against poverty, job instability, neighborhood safety, and the resulting distress of such living conditions. Healthy behavior among those with higher education is less likely to be mitigated by circumstances that confer opposing health risks. In other words, education is not only associated with healthy behavior, but it is associated with circumstances in which the benefits of healthy behavior can be actualized and the effects of damaging behaviors can be reduced.

The finding that those with a college education were the only group to have observable differences in the probability of prediabetes based on activity level is justification for such claims. This findings is particularly important given the risk of having prediabetes was not only lower for those with a college education after controlling for physical activity, but that those who are active and college educated were six percentage points less likely to have prediabetes than those who were college educated and inactive. The difference in risk for being physically active was only observed for those with the highest levels of education. This is problematic for the potential growing disparities of diabetes given those with prediabetes are much more likely to develop diabetes in the future (CDC, 2014). As Williams and colleagues (2010) suggest, the current patterns of findings related to social inequality and health shed light on the importance of examining the variations in the exposure individuals have to risk factors but to the variations in the vulnerability to risk factors evident by varying levels of preparedness for coping with adversity and differential ability to recover.

While physical activity and other behaviors are closely related to diabetes, generally health behaviors explain some, but not all of differences in health. In the famous Whitehall study of British civil servants, smoking, drinking, and other behaviors explained just one-third of the difference in mortality between those of higher rank and those of lower rank (Marmot, 1994). Similarly, Culter, Lleras-Muney (2006) found that the effect of education on mortality was reduced by just 30 percent when controlling for exercise, smoking, drinking, seat belt use, and use of preventive care. In addition, they found that the relationship between education and health was not consistent across health outcomes. The relationship between education and outcomes such as mortality and cancer screening were linear, but for outcomes such as obesity and smoking the relationship was not linear with an increased effect of education for only people with 12 years of schooling or more. This research suggests that those with more education might be healthier due to reasons concerning education as social structure and mechanisms not yet shown to be health-improving, or at least undetermined empirically.

Consistent with the previous proposition that education may be associated with healthy behavior and associated with circumstances in which the benefits of healthy behavior can be maximized, is the finding related specifically to those with less than a high school education and some college. The proportional difference in the probability of having diabetes between being inactive and being active was lowest among those with the less than a high school education and those with only some college. Among those with less than a high school education, the probability of having diabetes was approximately 30 percent lower for those who were active compared to those who were inactive. Alternatively, the same difference of 47 percent and 43 percent was observed for those with high school and college educations, respectively. In this case, the association between physical activity and diabetes was stronger for those with a high school or college degree than those with less than a high school degree. This finding adds to the litany of known disadvantages experienced by those without a high school education. Having less than a high school degree has been associated with many social disadvantages known to confer negative health outcomes including: unemployment, low wages, limited access to healthcare, negative environmental exposure (Bird & Bogart, 2000; Carnevale, Rose, & Cheah, 2011; Lopez & Hynes, 2006). The restricted access to material and societal resources that produce positive health outcomes acts as "double jeopardy" for those with less than a high school education. Not only are the opportunities to engage in physical activity restricted, but the life circumstances and potential for life course instability may negate the positive effects of physical activity on diabetes.

The findings regarding to those with less than a high school education illustrate what has been referred to as social vulnerability. The social vulnerability hypothesis suggests that the combination of unhealthy behaviors and taxing life circumstances (i.e. stressful environment and unstable working, housing, and family circumstances) may be particularly risky among individuals of low socioeconomic status (SES) (Krueger & Chang, 2008; Williams, 1997; Williams et al., 2010). These individuals may be more vulnerable, or less resilient, to accumulating health risks. Krueger and Chang (2008) found that negative behaviors such as former smoking and physical inactivity increased the effect of stress on mortality among those with low SES but not those with middle and high SES. Essentially, those in lower social strata experience various health threats where each threat makes the next more severe (Pampel & Rogers, 2004) or in the case of education and diabetes each threat to health weakens the benefit of otherwise health protecting behaviors such as physical activity.

Alternatively, some researchers argue that because those in lower social strata experience a variety of circumstances that pose a health risk such as working and living conditions and neighborhood environments, unhealthy behaviors may in fact be less harmful at least incrementally (Blaxter, 1990). Similarly, the variety of health risks may make positive health behaviors less beneficial. Improving unhealthy behaviors (i.e. increasing activity/reducing inactivity) without improving socioeconomic disadvantage may produce limited health benefits compared to those not experiencing such life circumstances (Link & Phelan, 1995b; Sterling & Weinkam, 1990). This perspective could help explain why the active-inactive difference in the probability of having diabetes was less pronounced among those with less than a high school education and those with only some college as well as the active-inactive difference in the probability of having prediabetes for all groups with less than a college degree.

The case of those with some college is particularly interesting given the uniform gradient of education was inapplicable to this group. Consistent with the argues of Blaxter concerning multiple threats to health as a result of social conditions (Blaxter, 1990), those with only some college may indeed find themselves in a social position that does not provide them with the resources to gain benefit from otherwise healthy behaviors. Those with only some college perhaps encounter more obstacles in the pursuit of higher education and experience a sense of lifestyle inconsistency as a reflection of inconsistent social status. Lin and Vogt (1996) show that those with two-year degrees tend to experience greater occupational status variation than income variation. Status stratification appeared more open to the influence of some college than income stratification. Those with some college tend to hold occupations with greater status which in terms of physical activity likely entails reduced occupational activity, in that occupational status is typically inversely related to the workplace activity (Brownson, Boehmer, & Luke, 2005).

The social orientation of those with a college education differs from those with less educational attainment. They occupy a different social space – they work different jobs, they have different incomes, and they live in different places. Those with only some college are likely to occupy an inconsistent social space where they are exposed to the positive and negative components of lifestyle associated with educational attainment and SES in general. For example, an individual with a two-year degree may assume a leadership role in a blue collar, service, or paraprofessional occupational setting with increased pay and responsibilities. The increased income may allow the individual to buy a home, live in a more affluent neighborhood, and more easily buffer financial stress. However, they may more disconnected from those that share similar histories and lifestyles. They may also be living a more sedentary lifestyle at work and in leisure, unable to engage in work that requires standing and movement or to afford or be uninterested in the pursuit of active leisurely activities of those with even more income and education. The ascription of lifestyle is greatly governed by a person's social status. For individuals in-between more clearly defined status groups, the benefits of increased socioeconomic position may not be enough overcome the disadvantages of inconsistent lifestyles as well as the negative consequences related to occupation, leisure, and potential loss of social integration.

Having some college may also provide individuals with occupational-specific expertise rather than widely applicable skills more closely associated with a traditional liberal arts education. For example, formal education allows individuals to develop the skills to understand why certain actions are beneficial to health and have a sense of control to engage those actions as opposed to feeling less control over their own health and needing specific instruction regarding health such as following doctor's orders. While adhering to the directions given by a health care professional is important to maintaining health, the direction seldom involves strategies to overcome the structural barriers to healthy behavior and the resulting effectiveness of said behavior. It is the generalizability of education that provides some with the capacity to navigate seemingly unmanageable conditions, find alternative avenues by which to access resources, and in a sociological context, enact human agency over structural barriers. Those with more education may be able to more effectively integrate the selective knowledge related to lifestyle and diabetes into a larger body of knowledge and use existing skills to apply that knowledge in a meaningful way. This is not to say that those with less education are unequivocally without the capacity to enact such agency, but often skills are acquired through technical, applied, and task-specific forms of education. The different forms of education and resulting influencing over sense of control, as argued by Mirowsky and Ross (2003), are also compounded by the external forces of education as a social institution of inequality that distinguishes class barriers based on cultural expectations related to lifestyle.

Overall, the relationship between physical activity and educational attainment in relation to diabetes status is representative of the current knowledge on educational disparities in health. The findings of this study extend current perspectives regarding the social determinants of health that largely relate disparities in diabetes to disproportionate behavior among some groups. The findings not only show that those with more education are likely to engage in physical activity which translates to reduced prevalence of diabetes, but that the relationship between meeting physical activity recommendations and having or being at risk for diabetes was stronger among those with a college education and markedly weaker among those with less than a high school education. The findings suggest that those at the top of the educational ladder may benefit more from a positive health behavior than those at the bottom and those with less clearly defined social statuses.

Education, Diet, and Diabetes Status

Dietary quality is an important factor in the prevention and management of type 2 diabetes. High quality diet has been associated with reduced risk of diabetes and optimal management of diabetes (de Koning et al., 2011; Fung, McCullough, van Dam, & Hu, 2007). The findings of this study suggest that education may also play a role in that relationship. Most notably was the distinction in patterns between those with a college degree and those with less than a college degree. Generally, the direction of the association between diet and diabetes status was oppositional between the college educated and other groups. For those with a college education the probability of having diabetes was consistent at all diet scores and the probability of having prediabetes lower at higher diet scores. Alternatively, for those with less education, the probability of having diabetes was higher at average and higher diet scores and the probability of having prediabetes was even at average and high scores.

Overall, the observed trends highlight the limitations in cross-sectional measurement of diet and diabetes status. Measuring diet at one point in time along with diabetes make an analysis vulnerable to reverse causality where diabetes status influences dietary habits. Rather than measuring the effect of having a poor diet and the development of diabetes, the results may actually reflect an endpoint of dietary change. While generally those with a diagnosis of diabetes do not dramatically change their physical activity patterns (Cooper et al., 2012), there is some evidence that dietary patterns may change. Fung and colleagues (2007) found that among women, recent changes in diet may have a substantial influence on diabetes development and that women may respond to detection of hyperglycemia by adopting a healthier diet. This research is consistent with the findings regarding diet and diabetes status among those with less than a college degree. For example, the probability of having diabetes for those with a high school education was 4.8 at an average diet score of 50. Whereas, the probability of having diabetes for the same group was nearly twice as high, 9.7, at a diet score of 100. Two conclusions can be drawn from this observation: 1) among those with a high school education, higher quality diet results in a greater probability of diabetes or 2) among those with a high school education, having diabetes results in a higher quality diet. It is more likely that those with diabetes have better diets than those without diabetes because it is required for the management of diabetes and other comorbid conditions such as overweight and obesity. This observation suggests diet quality may be a reactive mechanism related to diabetes, at least for those with less than a college education.

Interestingly, the trend of reaction specifically related to diet and having diabetes was not observed among those with a college education. Rather, the probability of having diabetes was relatively consistent at low, average, and high diet scores. This findings suggests that those with a college education and diabetes have different dietary patterns than their counterparts with less education. The need for reactive dietary change in the face of diabetes may not be as necessary for those with a college education. Rather, it may suggest that existing dietary habits among those with an increased education proactively reduces the likelihood of having diabetes. If diet among those with a college degree has a weaker association to diabetes, this may indicate less need to change the quality of their diet, in light of diabetes, to the same degree as those with less education. For instance, those with a college education were the only group for which the probability of having prediabetes was lower at a high diet score compared to an average or low diet score. This suggests that the trends in dietary habits among this group are associated with reduced probability of prediabetes; in that, those with better diets are less likely to have prediabetes as opposed to those with less education where the relationship is either even across dietary scores or in the opposite direction. Together, these findings suggest that the relationship between diet and diabetes status is not the same among those with different levels of education. However, the findings do not clearly illustrate how dietary quality is related to diabetes. For the purposes of this study, the findings do provide evidence that education plays a role in the relationship between diet and diabetes however unclear that relationship appears.

Assuming there is some sort of reactive versus proactive trend occurring, the literature related to education and health could help explain these observations. First, the human capital perspective of Becker (1964) and Mirowsky and Ross (2003a) argues that a critical link between education and health is a sense of control, sometimes referred to as personal control or perceived control. Education allows people to develop the skills required to understand their own position, evaluate their social surroundings, and use a variety skills to accomplish tasks that might otherwise seem beyond their reach. A large part of the reason the well-educated experience good health is that they engage in a lifestyle that includes walking, exercising, drinking moderately, and avoiding overweight and smoking (Mirowsky & Ross, 2003a). Their ability to integrate such behaviors into their lifestyles is related to the high levels of personal control they possess.

Research has consistently found that because education helps develop the ability to gather and interpret information and to solve problems on many levels, it increases personal control over events and outcomes in life (Ross & Mirowsky, 1989). Furthermore, education raises a sense of personal control because it enables people to act proactively by successfully preventing problems, solve problems when prevention fails, and achieve goals (Mirowsky & Ross, 2003b; Pearlin, Menaghan, Lieberman, & Mullan, 1981; Wheaton, 1980). Indeed, high levels of control have been positively associated with many dimensions of health including: cardiometabolic risk

(Infurna & Gerstorf, 2013), better physical functioning (Caplan & Schooler, 2003; Infurna, Gerstorf, & Zarit, 2011; Lachman & Agrigoroaei, 2010), decreased risk for cardiovascular disease incidence (Surtees et al., 2010), health behaviors (Lachman & Firth, 2004; White, Wojcicki, & McAuley, 2012), and lower mortality risks (Infurna, Ram, & Gerstorf, 2013; Penninx et al., 1997).

The skills learned in school increase effective agency or as Mirowsky and Ross refer to it "learned effectiveness". The theory of learned effectiveness argues that educational attainment increases personal control and decreases helplessness. As Mirowsky and Ross (2003a) argue, people who feel helpless tend to see little connection between their actions and important outcomes in their lives. They feel there is little they can do to improve their situation and are less prepared to take the steps needed to ensure favorable circumstances in the future. This argument would explain the need for reactive measures among those with less than a college education. A feeling of helplessness may be associated with a reduced capability to overcome personal and structure constraints that result in unhealthy diets before the development of diabetes. The need for dietary change is most necessary among those with a history of low quality diets who happen to have the least amount of education and thus a lower sense of control. Even so, changing dietary habits as a result of diabetes requires some degree of personal control and social circumstances that provide individuals with the skills and resources needed to overcome the restricted opportunities for change. The interjection of a physician's diagnosis or a diabetes education program may supply those with less education with an increased level of learned effectiveness or sense of control required to make such changes in dietary habits. However, the timing related to the increased control requires that an individual react by making major changes to an existing set of behaviors that would otherwise confer negative health outcomes.

Gaining a sense of control by seeking information concerning an illness may be particularly effective for those in socially disadvantaged positions. Lachman and Weaver (1998) found that among individuals from low-income groups, those with higher control beliefs had better self-rated health, fewer poor health symptoms, and greater physical functioning than those with lower control beliefs. Additionally, Turiano and colleagues (2014) found perceived control was associated with decreased mortality among those with low levels of education, but not among those with high levels of education. These findings suggest that while those with higher levels of education do have the high levels of perceived control, the greatest benefit of perceived control may be seen among the most vulnerable in terms of social disadvantage. In other words, the ability to reactively adjust dietary patterns may be more important for those with less education and lower levels of control. The social advantages experienced by those with higher levels of education provide a security structure that fosters personal control but may reduce the need to enact such control. Rather, the lifestyle and social advantages of those with high levels of education in combination with the high levels of control they experience engage health risks proactively which reduces the need to change lifestyle patterns even after developing a disease such as diabetes, at least not to the degree of their less educated counterparts.

Individuals with greater education are able to maximize their agency and minimize feelings of helplessness. So rather than having to respond to a health crisis, those with greater education have the skills to safe guard against the health crisis. In the event those with higher education develop diabetes, they may not have to change their diet as dramatically as those with less education in order to manage the disease. Psychological literature on adaptation in old age emphasizes the importance of a personal sense of control among older adults. A sense of control reduces the rate and amount of biological decline by counteracting the downward spiral (Phelan et al., 2010) of comorbid health complications and the long-run impact of social conditions not conducive to healthy aging (Rodin 1986). Those with higher levels of education are less likely to experience social conditions not conductive to healthy aging which effectively reduces the volume of threats to counteract. Those with more education are situated in a favorable social position where structural threats to health are less likely to make an impact. For example, the observation that those with a college education are as likely to have diabetes at a diet score of 50 as they are at a diet score of 100, whereas those with a high school education are nearly twice as likely to have diabetes at a diet score of 100 compared to a score of 50 suggests just that.

Clearly, educational attainment is associated with a varied relationship between diet and diabetes status. This observation is clearly evident by the distribution of probabilities of having normal glycemia. The probability of having normal glycemia, or normal blood sugar, for those with a college education and a low diet score was 65 percent. The probability of normal glycemia was 10 percentage points higher at an average score and an additional 10 percentage points higher at the high diet score. Essentially, the relationship between diet score and having normal glycemia was positive. For all other groups, the inverse was observed, and the differences for those with a high school education were almost an inverse reflection of their college educated counterparts.

Overall, the association between diet quality and diabetes appears to be different for those with a college education compared to those with less education. While the nature of the relationship between diet and diabetes status remains unexplained, theories of social stratification and a sense of personal control related to educational attainment can support an argument for the divergent observations among those with a college degree and those with less education.

Specifically, the theories of education and health are consistent with the possibility that the relationship between diet and diabetes may be a reflection of reactive behavioral practices for those with less education and proactive behavioral practices for those with a college education. In essence, the health lifestyle of those with a college education may be more consistent with a lifestyle that prevents or manages diabetes through diet. Similarly, the health lifestyle of those with a less than college education may be more consistent with a lifestyle that requires change to reduce the risk of diabetes and diabetes complications. In both cases, personal control and structural barriers related to educational attainment are important factors in the observed patterns of dietary quality and diabetes status.

Race/Ethnicity, Physical Activity, and Diabetes

Race/ethnicity is powerful social factor that influences health and behavior. Generally, the findings concerning the role of race/ethnicity in the relationship between physical activity and diabetes reveal several patterns: 1) The probability of having prediabetes and diabetes among non-Hispanic blacks was disproportionately high regardless of physical activity level, 2) Only limited evidence for a Hispanic paradox in the relationship between physical activity and diabetes status was observed, and 3) The probability of having diabetes for inactive, non-Hispanic whites was equal to or lower than the probability of having diabetes among active minorities.

Generally, being active did not eliminate or reduce race and ethnic disparities in diabetes and prediabetes. While being active was generally associated with a lower probability of diabetes compared to being inactive, those who were non-Hispanic white were at a much lower risk, active or otherwise, than their minority counterparts. This is consistent with findings that reveal some risk factors to have more adverse impacts on blacks than on whites even when their overall behaviors are lower than or similar to those of whites (Williams et al., 2010). For instance, the risk of lung cancer was found to be disproportionately higher among African Americans and Native Americans than whites given the trends in smoking behavior (Geronimus, Hicken, Keene, & Bound, 2006). Similarly, alcohol-related mortality was found to be nearly twice as high among black men than their white counterparts, and compared to whites, blacks have higher levels of common biomarkers for liver damage at every level of alcohol consumption (Stinson, Nephew, Dufour, & Grant, 1996; Stranges et al., 2004).

In the current study, meeting activity recommendations reduced the likelihood of having diabetes most dramatically for non-Hispanic blacks, at least numerically. However, the proportional difference in risk between inactive and active was equal between whites and blacks. Even so, the likelihood of having diabetes was lower for non-Hispanic whites who were inactive, than non-Hispanic blacks who were active. The likelihood of having diabetes was twice that for non-Hispanic blacks compared to whites, even for those who were active. These findings suggest that race/ethnicity may act as a fundamental cause of health disparities related to diabetes. As Hatzenbuehler, Phelan, and Link (2013) argue, racial inequalities in health endure partly because racism is a fundamental cause of racial differences in SES and because SES is a fundamental cause of health inequalities. In addition to these powerful connections, there is evidence that racism, largely via inequalities in power, prestige, freedom, neighborhood context, and health care, also has a fundamental association with health independent of SES (Williams et al., 2010).

The association between racism and health largely relates to the stigma attached to minority status and the structural impediments associated with discrimination and prejudice that restrict individuals' opportunities and behaviors. As a result, minority status has been associated with a reduced sense of control (Mirowsky & Ross, 1983, 1984, 1986), partly but not fully due to generally lower education, income, and employment. Partly, though, it reflects the fact that any given level of achievement requires greater effort and provides fewer opportunities for members of the minority groups. This is reflected in a lower sense of control and consequent distress. Undesirable events, such as discrimination, decrease a sense of control (Pearlin et al., 1981). Their occurrence implies powerlessness to avoid them because undesirable events are unwanted. Many people are caught in self-reproducing spiral of undesirable events that lead to difficult situations, both of which undermine the sense of control, which undermines attentive, active, and proactive problems-solving, and leads to more undesirable events and difficult situations (Hiroto, 1974; Kohn & Schooler, 1982; Pearlin, 1980; Pearlin et al., 1981; Wheaton, 1980, 1983). The consequent distress experienced by these social-oriented living conditions establish vary different starting points for health and very different experiences of behavior. Perceived stress or distress caused by racial discrimination can breed feelings of helplessness and manifest physically in the form of metabolic abnormalities that result in frequent increases in blood glucose and increased risk for developing diabetes (Björntorp, 1997; Lovallo, 2015).

Again, those of the racial majority, non-Hispanic whites, enjoyed lower rates of diabetes at the inactive level than non-Hispanic blacks did at the active level. This finding suggests that the effect of a negative health behavior (inactivity) is largely buffered for whites, providing this groups with an advantage. Meanwhile, the positive behavior of physical activity was not beneficial enough for non-Hispanic blacks resulting in disadvantage and disparities between the groups that are not easily remedied by the equalization of protective behaviors. Current recommendations for diabetes prevention and one of the goals of Healthy People 2020 is to achieve health equity. Healthy People 2020 defines *health equity* as the "attainment of the highest level of health for all people." Achieving health equity requires valuing everyone equally with focused and ongoing societal efforts to address avoidable inequalities, historical and contemporary injustices, and the elimination of health and health care disparities. However, the findings here suggest that even if those of minority status achieve the recommendations that "address avoidable inequalities," inequalities will persist because the causal mechanisms associated with preventing diabetes (i.e. physical activity, obesity) are but just a few of many causal mechanisms of health disparities. In other words, the currently understood causes of diabetes are not solely the causes of diabetes disparities.

As Pampel and Rogers (2004) suggest those in socially marginalized positions, such as racial minorities, experience various health threats where each threat makes the next more severe. Each threat to health can weaken the benefit of otherwise health protecting behaviors such as physical activity. Similar to the disadvantage experienced by those with low levels of education, racial minorities, particularly non-Hispanic blacks, experience disadvantages lives where the realistic opportunity for physical activity is reduced, and where the distress of racism and loss of control over their own lives may mitigate otherwise beneficial health behaviors. It is unclear whether encouraging levels of physical activity beyond the recommendation would be sufficient to overcome the disproportionate burden of diabetes among disadvantaged minorities. However, an approach such as this would only address the behavior rather than broader social inequalities. Improving healthy or unhealthy behaviors (i.e. increasing activity/reducing inactivity) without improving social disadvantage may produce limited health benefits compared to those not experiencing such life circumstances (Link & Phelan, 1995b; Sterling & Weinkam, 1990).

In a similar vein, the advantage of living without minority status and the resulting decrease of distress and increased sense of control experienced by non-Hispanic whites was evident in the association between physical activity and prediabetes. The probability of having prediabetes among inactive, non-Hispanic whites was nearly 10 percentage points lower than the probability of prediabetes for inactive non-Hispanic blacks which translates to a staggering number of individuals. The difference of 10 percentage points is larger than the estimated population of inactive, non-Hispanic blacks with diabetes. Unlike their non-Hispanic black counterparts, Hispanics who were inactive had a similar probability of prediabetes to whites.

However, the non-Hispanic whites were the only group in which being active resulted in a decrease in the probability of prediabetes.

For Hispanics, being active resulted in a non-significant increase in the probability of prediabetes, whereas their black counterparts had an increase of eight percentage points from inactive to active. This unusual occurrence may indicate a limitation in the measurement and/or variance of physical activity. While ample evidence exists that harmful behaviors may be even more harmful for racial minorities and that beneficial behaviors may be less beneficial for racial minorities, there is a lack of complimentary evidence for a finding in which a positive behavior such as being physically active is more risky for diabetes or prediabetes than inactivity. Although, one such finding has been reported for moderate alcohol consumption. While moderate alcohol consumption has been positively associated with health, it has been shown to have negative effects for black men (Jackson et al., 2015).

Rather, two other explanations are more viable. The first is the relationship to income, life course stability, and aging as a motivator of health improvement. Even though the analysis controls for income, age, and body mass, it is possible that as non-Hispanic blacks age, and become more likely to have prediabetes regardless of activity level, they become more proactive about weight management and prioritize physical activity. The result would be that those with prediabetes have improved their physical activity patterns and thus a higher proportion of those with prediabetes are currently active. Examining age specifically may provide further insight. While data shows that individuals tend not to change their physical activity patterns after having received a diagnosis of diabetes (Cooper et al., 2012), research is limited in relation to prediabetes. This may be due, in part, to the fact that prediabetes most often occurs in mid-life, a point at which many individuals have more available resources, greater access to health care, and additional concerns for health that may provide incentive for lifestyle change. Given the limitations of cross-sectional data, there is no method to estimate whether or not this is the case. An alternative but less likely explanation is that individuals change their behavior after having received a diagnosis of prediabetes. This is alternative explanation may apply to some, but given the CDC (2014) estimates that 90 percent of individuals with prediabetes are not aware they have it, this explanation is less likely.

Beyond the disadvantages experienced by non-Hispanic blacks are the findings regarding Hispanics. The findings of this study support only in part the hypothesis of a "Hispanic Paradox". The Hispanic Paradox refers to the observation that Hispanics have lower all-cause mortality or better health despite increased diabetes, obesity, lower SES, and access to health care (Hunt et al., 2002). More recently, the concept has been extended to other health outcomes such as the health benefits of Hispanic communities for mother and infants (Shaw & Pickett, 2013) and childhood asthma (Camacho-Rivera, Kawachi, Bennett, & Subramanian, 2015). The findings of this study indicate that Hispanics experience a higher probability of diabetes than non-Hispanic whites whether they are meeting physical activity recommendation or not. However, the probability of having diabetes for inactive Hispanics was approximately 3.5 percentage points lower than their non-Hispanic black counterparts and approximately 1.5 percentage points lower than their active non-Hispanic black counterparts. Even so, the probability of having diabetes for Hispanics who were active was equal to that of non-Hispanic whites who were inactive. Consistent with estimates from the CDC (2014), this finding indicates that while Hispanics may experience overall lower risk of diabetes than non-Hispanic blacks, their level of risk is not comparable to that of the racial majority. They too experience the disadvantage of minority status just not to the degree of non-Hispanic blacks. The advantage of Hispanics over non-Hispanic blacks was also evident in the findings regarding prediabetes where prevalence among Hispanics was more comparable to non-Hispanic whites.

Lastly, the findings regarding the Other Race group were most consistent with those of non-Hispanic blacks. However, the diversity of this group makes drawing conclusions difficult. Those of other races had the highest probability of diabetes across activity levels. This findings may be in part due to the increase prevalence of diabetes among American Indigenous and those of multiple races and in part due to the much smaller sample size of the group compared to the others.

Overall the findings indicate that race/ethnicity does play a role in the relationship between physical activity and diabetes. Consistent with the social determinants of health perspective, those in the racial majority have lower rates of diabetes and are more likely to engage in physical activity. However, racial minorities remain at a considerable disadvantage even when meeting physical activity recommendations. On the population level, remedying disparities in health behaviors is not likely to sufficiently eliminate racial and ethnic disparities in diabetes. The social circumstances faced by racial minorities (low SES, racism, reduced sense of control) restrict their access to resources that benefit health and undermine the benefit of healthy behaviors. For this reason, race acts as fundamental cause of disparities in diabetes by reducing human agency and fortifying discriminatory social structures.

Race/ethnicity, Diet, and Diabetes Status

Similar to the role of education in the diet and diabetes status relationship, the findings related to race/ethnicity were rather inconsistent. The patterns among non-Hispanic whites and Hispanics were markedly different from non-Hispanic blacks and those of other races. Differences in diet quality between various races and ethnicities have been noted (Hiza et al., 2013). Generally, non-Hispanic blacks tend to have poorer diets than their white counterparts (August & Sorkin, 2010) and adherence to diets have been shown to lower risk of diabetes have a stronger effect for non-Hispanic whites than non-Hispanic blacks and Hispanics (Liese, Nichols, Sun, D'Agostino, & Haffner, 2009). However, the focus of this study was not to determine if some groups had higher quality diets than others. Rather, the intention was to understand how the relationship between diet and diabetes status differed among those of varying race/ethnicity groups.

Consistent with the findings related to the highly educated, the patterns of diet and diabetes were relatively stable for non-Hispanic whites. The probability of having diabetes did not significantly change as diet quality increased. Alternatively, non-Hispanic blacks and those of other races were much more likely to have diabetes when diet scores were average or high compared to low. The most dramatic difference was observed among those of other races. The probability of having diabetes was 1.8 at a low score and a probability of 29.8 at a high diet score. However, the 95% CI for the high diet score ranged from 7.7 to 52.3 indicating the estimate was quite unreliable. The unknown ethnic composition of other races and the unreliable estimates makes generalizations concerning this group problematic. Alternatively, the estimates for non-Hispanic blacks were much more reliable. The probability of having diabetes was 10 percentage points higher at a high diet score than at an average diet score. This observation was similar to the findings related to diet and education, in that for non-Hispanic blacks the measurement may reflect reactive behavior resulting from the influence of diabetes status on diet quality. Previous research on the relationship between race and health could help explain why the probability of having diabetes was more than twice as high at a high diet score than at an average diet score.

Compared to their non-Hispanic white counterparts, non-Hispanic blacks tend to have diets that, on average, are less healthy which presents higher risk for diabetes (Hiza et al., 2013). This is in large part due to the restrictions both economically and environmentally that black Americans are faced with on a daily basis (Wang & Chen, 2011). Non-Hispanic blacks disproportionately experience food insecurity and food scarcity which has been associated diabetes among adults (Horowitz, Colson, Hebert, & Lancaster, 2004; Seligman et al., 2010). Additionally, marketing of high-calorie foods and beverages to minority populations, such as non-Hispanic blacks, has been reported as a barrier to making healthy choices (Grier & Kumanyika, 2008; Powell, Szczypka, & Chaloupka, 2010). Minority status is associated with the previously mentioned reduced access to resources that promote healthy diet and a reduced sense of control or increased sense of helplessness resulting from distress of socioeconomic disadvantage, racism, and discrimination (Mirowsky & Ross, 2003b). Individuals with a reduced sense of control may be less prepared to overcome the social obstacles that deter healthy practices including healthy diet (Mirowsky & Ross, 2003a, 2003b; Ross & Mirowsky, 1989).

The combination of limited resources for healthy lifestyles, economic and environmental conditions not conducive to health, and reduced sense of control result in a greater probability of developing diabetes. Additionally, these conditions and circumstances may create the need to reactively alter dietary habits in light of a metabolic condition such as diabetes which is likely to affect a higher proportion of non-Hispanic blacks. Structural constraints and reduced human agency (i.e. sense of control and helplessness) effectively shape dietary patterns and eventually dictate the need for dietary change as a result of the existing dietary patterns. Years of social circumstances that shape poor dietary habits through both reduced access to quality foods and reduced control to overcome financial and environmental barriers to such foods result in a higher disease risk and a greater need to alter diet to avoid diabetes-related complications including mortality. In accordance with the vulnerability hypothesis (Krueger et al., 2011; Williams, 1997) and cumulative advantage theory (Shuey & Willson, 2008), the effect of each threat to health (resources, environment, sense of control) acts cumulatively to reduce the overall health of individuals over the life course. Reducing the number of threats to health is more necessary among these groups than their less threatened counterparts. Halting the accumulation of disadvantage through behavioral change may be more necessary for those whom have already accumulated significant disadvantage, in terms of disease risk, even though equalizing behavior may not result in the equalization of risk.

As Blaxter (1990) argues, the totality of behaviors and socially disadvantageous positions make the proportional impact of behavioral change less effective for those in marginalized groups; however, the need for these groups to engage in healthy lifestyles is absolutely necessary to reduce risk of disease complication and mortality even if inequality as a result of socio-economic conditions and systems of racial discrimination persist. For example, Shuey and Wilson (2008) found that not only do blacks suffer from reduced access to resources that result in poorer health over the life course, but that whites receive a higher return from resources such as education that compounds over time. In order to survive a disease such as diabetes, non-

Hispanic blacks must engage in any and all behaviors that may benefit their health even though the benefit of such behaviors is likely to be less effective than it would be for the racial majority.

Alternatively, the observations associated with non-Hispanic whites and Hispanics suggests a reduced need for reactive change in dietary patterns. Among both groups the probability of having diabetes was relatively equal across low, average, and high diet scores. The absence of minority status for non-Hispanic whites may provide both socioeconomic and individual resources that, compared to their non-Hispanic black counterparts, reduce the need to reactively improve diet quality in light of diabetes. Even at average diet scores, non-Hispanic whites had a significantly lower probability of diabetes than non-Hispanic blacks and Hispanics. A similar occurrence was observed for the risk of prediabetes. While the pattern was relatively similar among non-Hispanic whites and blacks, the probability of having prediabetes was approximately 40 percent lower for whites than blacks at average and high diet scores. The marker of majority status acts as an advantage rather than a disadvantage. It provides greater opportunity for dietary patterns to proactively reduce the risk of diabetes and reduces the need for reactive dietary change, at least compared to non-Hispanic blacks. The advantage of control for the racial majority is accompanied by an environment that makes access to healthy foods more likely. Literature on food availability has reported that predominately white neighborhoods tend to have as many as four times the number of supermarkets as predominantly black neighborhoods (Morland, Wing, Diez Roux, & Poole, 2002; Raja, Changxing Ma, & Yadav, 2008), lower food prices (Chung & Myers, 1999), and fewer fast-food establishments in both urban and rural communities (Dunn, Sharkey, & Horel, 2012; Powell, Chaloupka, & Bao, 2007).

The observations related to Hispanics were relatively consistent with those of physical activity and diabetes. The relationship between diet quality and diabetes was similar at varying levels of diet quality just as for non-Hispanic whites. This observation may support the idea of a Hispanic paradox where Hispanics tend to experience health better or on par with non-Hispanic whites even when their life circumstances are similar to non-Hispanic blacks and as an ethnic minority are more likely to experience a reduced sense of control (Franzini, Ribble, & Keddie, 2001; Guinote, Brown, & Fiske, 2006). Hispanics, compared to non-Hispanic blacks, may not need to engage in drastic dietary changes to manage their disease. Hispanics are more likely than others to spend more money on food (Paulin, 1998) and shop specifically for fresh and traditional fruits and vegetables in supermarkets (Heise, 2002). Hispanics are also more likely to prepare and serve meals at home (Heise, 2002) which have been shown to more nutritious than food eaten away from home (Lin, Guthrie, & Frazao, 1999). Results from a supplemental analysis of the HEI-2010 dietary components (see Appendix) indicate Hispanics do tend to consume fewer empty calories and more vegetables than their non-Hispanic black counterparts. The importance of consuming empty calories in moderation is heavily stressed to those with diabetes by physicians and diabetes education programs (Evert et al., 2014). Because of this pattern, Hispanics may require less dietary change to manage diabetes and avoid diabetes complications.

The disadvantage of minority status was not observed for Hispanics and the probability of having diabetes; however, the patterns associated with diet quality and prediabetes were not consistent between non-Hispanic whites and Hispanics. While the probability of having prediabetes was slightly lower at a high diet score compared to a lower diet score for non-Hispanic whites, the probability of having prediabetes for Hispanics was 19.5 at a low diet score compared to 31.2 at a high diet score. This observation suggests that the association between diet and prediabetes maybe not be the same for Hispanics as it is for non-Hispanic whites.

An argument concerning reactive versus proactive behaviors in relation to prediabetes is more problematic than that of diabetes because the proportion of those with prediabetes who have received a diagnosis is quite low (CDC, 2014). Rather, the high probability of prediabetes at higher levels of dietary quality may reflect the co-occurring physical and social conditions for those at risk for diabetes. The probability of having prediabetes increases with age and weight status. While the analysis controls for those variables, the impact general association between age, weight, and prediabetes being related to diet may be important. Reactive improvement in diet may be the result of other conditions for which age and weight contribute. For example, those with prediabetes are more likely to develop other diseases that can also be managed with diet such as high blood pressure and high cholesterol (Graudal, Hubeck-Graudal, & Jürgens, 2012; Sacks et al., 2001).

Lastly, divergent patterns in the probability of normal glycemia were observed between non-Hispanic whites and their black and Hispanic counterparts. Non-Hispanic blacks and Hispanics were less likely to have normal glycemia at high diet scores than low diet scores, whereas relatively little change was observed for non-Hispanic whites. Examining the distribution of normal glycemia provides a robust depiction of the varied association between diet and diabetes status according to race/ethnicity. The observation that among non-Hispanic blacks and Hispanics an increase in diet quality resulted in a decrease in the probability of having normal glycemia supports the argument that racial and ethnicity minorities may be required to alter their diets as a result of diabetes risk. The structural and individual constraints of non-

Hispanic whites are different from other groups. They experience a greater sense of control, at least on average, because they are not consistently confronted with individual and institutional forms of discrimination and racism.

While segments of the non-Hispanic white population certainly experience socioeconomic disadvantage that confers negative health outcomes, they do not experience the additional stress of racial discrimination and prejudice. A higher proportion of blacks and Hispanics live in environments that make achieving a high quality diet less likely (Raja et al., 2008), and due to their disadvantage the need to undertake alternative dietary patterns may be even more essential to the management of diabetes (Liese et al., 2009). This reactive behavior is not likely to be performed to prevent diabetes but to prevent diabetes complications. The threat of the disease can be underestimated or overwhelming for those with a reduced sense of control, thus the need for reactive measures may be needed to reduce the threat of what the disease can do if it is developed.

For instance, the risk of diabetic retinopathy is greater among non-Hispanic blacks and Mexican Americans than non-Hispanic whites (Harris, Klein, Cowie, Rowland, & Byrd-Holt, 1998). Those in disadvantaged populations also experience barriers that undermine self-management performance, including comorbid conditions such as depression and chronic pain (Jerant, von Friederichs-Fitzwater, & Moore, 2005; Krein, Heisler, Piette, Makki, & Kerr, 2005), patient-physician communication problems (Heisler et al., 2003; Lutfey & Freese, 2005; Piette, Schillinger, Potter, & Heisler, 2003), economic barriers such as the cost for medication and glucose monitoring equipment (Jerant et al., 2005; Karter, Ferrara, Darbinian, Ackerson, & Selby, 2000; Piette, Wagner, Potter, & Schillinger, 2004; Zgibor & Simmons, 2002), and environmental barriers that may limit individuals' ability benefit from lifestyle changes and follow recommendations (Dutton, Johnson, Whitehead, Bodenlos, & Brantley, 2005; Horowitz et al., 2004; Rose & Richards, 2004; Sarkar, Fisher, & Schillinger, 2006).

Overall, the patterns associated with diet and diabetes status suggest that the relationship is different for all race/ethnicity groups. High diet scores among non-Hispanic blacks were associated with a higher probability of diabetes, but not among non-Hispanic white and Hispanics. High diet scores among Hispanics were associated with a higher probability of prediabetes, but not among non-Hispanic blacks or whites. Theories that address race as a fundamental cause of health disparities (Hatzenbuehler et al., 2013; Lutfey & Freese, 2005; Phelan et al., 2010), the vulnerability and cumulative disadvantages of minority statuses (Krueger et al., 2011; Shuey & Willson, 2008), and the diminished levels of personal control experienced by those of racial and ethnic minority groups (Guinote et al., 2006; Mirowsky & Ross, 1986; Ross & Mirowsky, 1989) suggest that systems of discrimination and inequality produce circumstances in which diet among minorities with diabetes and prediabetes may actually be more healthy than diet among minorities without such illnesses.

Social Inequality, Health Behaviors, and Diabetes Status

Explaining why the relationship between health behaviors and diabetes differs across educational and race/ethnicity lines requires a specific theoretical framework. This framework must take into account the complex workings of social structure and social inequality in the way individuals make decisions and account for the differential impact of said decisions on health. A classic starting place is with Weber's work on life chances and life choices ([1992] 1978). Weber's notions of life chances and life choices are in line with deeply embedded debate over the role of social structure and human agency in lives of individuals. Individuals are able to enact human agency to varied degrees based on the skills they have acquired. This agency is also subject to structural constraints that enable or constrict an individual's ability to make choices. Together, an individual's potential for human agency, or life choices, and their relative social location, or life chances, provides the basis for types of behaviors that occur over time. This collection of behaviors, as a reflection of social location, constitutes a lifestyle.

Weber argues that the lifestyle that individuals lead is a manifestation of the opportunities they have and the choices they make. Weber also argued that an individual's lifestyle is determined by the general way of life of one's status group. A status group provides individuals with specific ways of living. Being part of a status group, means that people within the group are much more likely to be exposed to certain norms that regulate behavior, jobs, and living conditions. These conditions influence behavior and health outcomes, and resources in the form of money, education, and social connections that enable or constrict their ability to make positive health-related decisions and deflect exposure to elements that confer negative health outcomes. This perspective on health is central to Cockerham's health lifestyles theory (Cockerham, 2005). Cockerham integrated Weber's ideas on status groups with Bourdieu's concept of the habitus to detail how lifestyles are related to social location. In health lifestyles theory, the interplay between class circumstances and the socialization process shapes the durable schemas or habitus by which individuals go about making lifestyle choices. The ways of living are reflective of our experiences, cultural norms, and capacity to act in our best interest. For some, health lifestyles protect health by design, but for others health lifestyles explicitly undermine health.

These theories compliment prevailing ideas in medical sociology that argue that social inequality acts a fundamental cause of health disparities (Hatzenbuehler et al., 2013; Link & Phelan, 1995a; Lutfey & Freese, 2005; Phelan et al., 2010) and others that address specific privileges and resources afforded to varying groups based on education, race, or income. Specifically, Mirowsky and Ross's (2003a) theory of learned effectiveness argues that education provides individuals with human capital that can be used to manipulate their social conditions. Education provides individuals with more effective human agency and a sense of control over their lives which allows them to think critically about their behavior, change elements of their lifestyle that are not conducive to health, and seek out protective behaviors and circumstances. Having an education provides individuals with the skills that benefit their lives but also places them in a status group that improves the chances of making healthy decisions. Education can protect individuals from the ill-effects of poverty, job loss, and the stress of everyday life. Established social patterns of stress and distress point to a sense of control as a critical link. The patterns of distress reflect the patterns of autonomy, opportunity, and achievement in the US (Mirowsky & Ross, 2003b). Education acts both as an individual trait and a structural characteristic that influences health and the effect of specific behaviors.

Similarly, race and ethnicity within the context of the United States acts a damaging factor for racial minorities. The effects of positive behaviors can be negated by the psychological and physiological responses to racism, discrimination, and the accumulation of disadvantage over the life course. Unlike education, race/ethnicity is a structural force that bares down on individuals with little alleviation as a result of acquired skills and knowledge. The restricted life chances and life choices of racial minorities not only make living a healthy life less likely due to disproportionate levels of poverty, reduced quality of housing, and faltering education systems, but act as a catalyst for stress that can lead to ineffective positive health behaviors and poor health outcomes. Minority status is associated with stigma, a reduced sense of control, and increased levels of distress due to fewer opportunities related to education, income, and employment as well as discrimination and prejudice. This type of distress has real physiological consequences particularly for metabolic health (Lovallo, 2015). It reflects the fact that any given level of achievement requires greater effort and provides fewer opportunities (Mirowsky & Ross, 1983, 1984, 1986). Free of such barriers, racial majorities may be more likely to engage in behaviors that benefit their health as well as buffer the ill-effects of social inequality that negate otherwise positive health behaviors.

Both education and race/ethnicity serve as systems that produce advantages and disadvantages. Both social institutions shape the structural barriers that either impede or foster good health. At the same time, both social institutions influence individuals' capacity to overcome or capitalize on their social position. Education and race/ethnicity influence the resources individuals can access and the sense of control individuals' experience. The ability to control one's life is a valuable health-related asset. However, having a sense of control can have distinctly different properties given one's social location and corresponding resources. Those with less favorable social positions and low levels of control are subject to structural disadvantages with little to no ability to manipulate their circumstance in a way that benefits health. Even those with a greater sense of control in similar positions are only able to overcome disadvantage to the degree of improving behavior. They are not able to buffer the distress of their social location and each effort to overcome social disadvantage must come from a greater effort.

The assumption that individuals can be given the ability to combat such an array of socially disadvantaged circumstances is improbable. While education seems to be the most effective tool at combatting such disadvantages, the system of education and the effect it has on one's sense of control are stratified by race, gender, income, and wealth among others. This is why we see a difference in relationship between health behaviors and diabetes across education and race/ethnicity groups. If the goal of public health is to create health equity, then focusing soley on behaviors will not suffice. As evident from this study, even if factors associated with diabetes are equal, disparities continue to persist because the health behaviors related to diabetes are differentially influential among those in disparate social positions. In the next chapter, these implications for health policy are further discussed along with the limitations and contributions of the current study.

Chapter 5. Conclusions

The purpose of this dissertation was to develop an argument concerning the relationship between social factors, health behaviors, and diabetes. I argue that educational attainment and race/ethnicity play a role in the link between health behaviors, specifically physical activity and diet, and diabetes. It is widely acknowledged that educational attainment and race/ethnicity act as social determinants of health because they are associated with health behaviors and access to resources or environments that are positively or negatively related to health. However, in this dissertation, I argue that educational attainment and race/ethnicity do more than determine behavior. They play a role in how behavior is associated with diabetes and prediabetes.

Yes, rates of diabetes and prediabetes are highest among those with the few social advantages (i.e. those with less than a high school education and non-Hispanic blacks). And yes, this is related to the fact that those with less advantage engage in less physical activity and consume poorer diets. However, the point of this dissertation was to move past the traditional social determinants paradigm in which the primary interest in social factors is intimately tied to corresponding distribution of health behaviors. The focus here was to examine if the relationship between health behaviors and diabetes status was social factor-specific. Indeed, I found that it was only for those with the most social advantages (i.e. those with college education and non-Hispanic whites) that risk of diabetes and prediabetes was significantly and consistently lower when meeting physical activity recommendations. Meeting physical activity recommendations resulted in a lower risk of diabetes and prediabetes for those with a college education and non-Hispanic whites, but not uniformly for other groups. For instance, those with a high school degree, like their college educated counterparts, who were active had a significantly lower risk of diabetes than those who were inactive, but unlike those with a college education this trend was not observed for prediabetes. The same was found for non-Hispanic blacks. Overall, this dissertation uses these findings to argue that, in the adult population, the association between physical activity, diet quality, and diabetes status is not consistent for all education and race/ethnicity groups.

There are elements of social factors that determine health beyond determining behavior. The way in which behavior is engaged and experienced can be differentially associated with an individual's exposure to factors that negate the benefit of healthy behaviors (i.e. lacking a sense of personal control as a result discrimination or increased levels of helplessness). Currently public health policy addresses the diabetes epidemic through behavior and lifestyle modification. The potential for overall improvement in health is great. Improving behavior through increased physical activity, healthy eating, and corresponding weight reduction has the potential significantly reduce the burden of prediabetes and T2DM. However, addressing behavioral change alone will not reduce the unequal distribution of diabetes and risk of diabetes. If healthy behaviors are increased in the population, but the association between behaviors and diabetes status are more favorable for some groups than others, inequality will persist.

Behavioral change alone will not create health equity. The best-case scenario for a behavioral-oriented approach is that overall prevalence of diabetes would decrease across the population while a gradient across social groups would remain consistent. However, the observations of recent history suggest that reduction in the prevalence of diabetes is most likely to occur among those with the greatest social advantage. For instance, the prevalence of diabetes among those with less than a high school education increased from 9.1 percent in 2006 to 11.6

percent in 2010. During the same time period the prevalence of diabetes among those with a college degree went from 4.6 percent to 5.8 percent (Beckles & Chou, 2013). While the difference may seem small, this is a time frame of only four years. Additionally, recent reports indicate that the overall prevalence of diabetes is plateauing, but not for racial minorities and those of lower SES (Geiss et al., 2014; Menke et al., 2015).

Growing disparities combined with a plateauing of rates for groups with social advantage are major problems that current health policy is not adequately addressing. The orientation of current health policy toward the behavioral model of prevention certainly has its advantages, but it also has the potential to increase health inequality and further stigmatize marginalized groups. By assuming that all behaviors result in the same the risk of diabetes, regardless of social location, a lack of improvement among those with less advantage can be attributed to personal deficiency, individual fault, and result in stigmatized identities.

I do not assume that the results of this dissertation are definitive. They do not speak to the causal relationship between health behaviors and diabetes. They do not address the biophysical components of metabolic health. The findings do, however, address the patterns of behavior and their association with diabetes status across education and race/ethnicity groups at the population level. At the very least, the findings indicate the relationship between physical activity, dietary quality, and diabetes status is not consistent for varying social groups and suggest greater attention be paid to the role social factors play in the relationship between health behaviors and diabetes status.

Further examination of confounding social, behavioral, and physiological factors should be undertaken. First, the association between physical activity and diabetes could be examined in an age-specific context. The risk of diabetes varies with age and rates of physical activity vary with age. To more clearly understand the role educational attainment plays, factors such as occupations, health care access and utilization, and marital status could be examined. Similarly with regard to race/ethnicity, examining racial differences in light of foreign-born status may be fruitful. It is also possible that gender differences, particularly for black men may be important. Further examination of gender could be helpful given many behaviors are gender-specific. Finally, other behavioral and physiological characteristics such as smoking and obesity may be future avenues by which to examine the observed phenomena.

At the population level, those with favorable social positions appear to be benefitting from healthy behaviors in a way that their less advantaged counterparts are not. A major strength of this dissertation is the quality of the data. The population-level estimates provide a snapshot of how meeting physical activity and dietary recommendations is associated with diabetes statuses. The use of large, nationally representative data provides a strong and reliable estimation of the prevalence of diabetes and prediabetes, rates of physical activity, and general dietary patterns. Reliable estimation of diabetes and health behaviors can be made for range of groups and allow researchers to make comparisons across those groups. The NHANES is unique to other large nationally representative datasets in that the survey includes clinical measurements of health. Having detailed self-reported data and clinical assessments of health conditions is advantageous. The objective measures of diabetes allow those without a diagnosis to be counted among the diabetes and prediabetes categories. This is particularly important because nearly one in four adults do not know they have diabetes and nearly nine out of 10 adults do not know they have prediabetes (CDC, 2014). The findings related to prediabetes would be nearly impossible without the clinical measurements.

Although the data used here allow for reliable analysis across social groups and includes necessary clinical assessments of health conditions, the data and subsequent analysis are limited in several ways. First, the cross-sectional design of the NHANES only allows a very short period of assessment. With the exception of the dietary recall data, all of the assessments and questionnaires were conducted at one time point. Even the dietary recall data was only collected at two time points and are not intended for comparison. The use of cross-sectional data limits the capability to provide causal explanation for findings. Analyzing physical activity over time or dietary patterns over a longer period of two days would be beneficial to the study of diabetes. While the findings here indicate that meeting physical activity recommendation was associated with a lower risk of diabetes and prediabetes for those with a college education compared to those with less education, it is unknown if those with higher education have been meeting physical activity recommendation for longer period of time. Additionally, the measurement of behaviors in this study is entirely by self-report. Issues regarding the self-report of physical activity have been well-documented. Individuals tend to overestimate their physical activity (Sallis & Saelens, 2000; Troiano et al., 2008) due to issues of interpretation, memory process, judgment formation, and social desirability (Warnecke et al., 1997). Some studies have found the discrepancies between social groups tend remain consistent whether based on objective or self-reported measures (Troiano et al., 2008), but others have reported some social groups such as racial minorities tend to express socially desirable attitudes when reporting health behaviors (Warnecke et al., 1997).

In addition, the current study is unable to address the possibility of genetic predispositions to diabetes and metabolic conditions. While some years of data include questions concerning family history, it is not included in all survey sets. It is possible that a family history of diabetes is associated with a reduced capacity of the body to regulate glucose metabolism and therefore those with a family history who do meet physical activity recommendations are not receiving the same return on their investment as those without a family history (Ekman et al., 2015). Even if this did partially explain the findings of this dissertation, it would not eliminate the need to reevaluate current public health policy regarding health equity among social groups. The genetic factors associated with diabetes and physical activity would not fully explain the psychosocial dimensions that influence the environment in which individuals engage in activity.

Nevertheless, the findings here suggest that current understandings of the relationship between social factors and health behaviors requires a more critical approach. This extends to the literature concerning the social determinants of health. While a sociological approach to these topics has greatly influenced our knowledge of social factors in public health and aided in the construction of a social paradigm of health research that is critical of biological determinism, continued efforts toward uncovering the social bases for health require that, as researchers, we continually reevaluate the contexts in which our knowledge is being accumulated.

Notwithstanding the limitations noted above, this dissertation does extend our current knowledge related to the role social factors play in one of our most pressing contemporary health issues by critically examining the taken-for-granted relationship between health behaviors and health outcomes. It is a totality of research, from genetics and biomedicine to sociology that provides the scientific community with an understanding of how our health is related to the world in which we live. The role of sociology is to critically examine the social components related to the development, distribution, and experience of illness. This dissertation contributes to this role by integrating existing sociological theory concerning the relationship between social structure and human agency to explain why differences in the relationship between health behaviors and diabetes status may be attributed to educational attainment and race/ethnicity.

Moving forward, there is a need for further research that addresses the intersection of social life and physiological function. Studies addressing sources of stress and its relationship to glucose metabolism would extremely beneficial. Current studies in this field have examined the relationship between stressful situations (i.e. divorce, unemployment, bereavement) on diabetes onset and management (Björntorp, 1997; Lloyd, Smith, & Weinger, 2005), but few have addressed external stressors such as the experience of discrimination or internal stressors such as experiencing helplessness. Björntorp (1997) attempted to explain the physiological link between stressful experiences and the onset of diabetes. He argued that perceived stress and subsequent feelings of helplessness and defeatism, activates the hypolthalamo-pituritary-adrenal (HPA) axis that results in endocrine abnormalities of elevated cortisol and low secretion of gender-specific steroid and growth hormone. However no studies, to my knowledge, have addressed the roles social factors play in how chronic stress effects the biophysical responses of health behaviors that lead to disease. Even including measures of stress hormones such as cortisol and adrenaline in the NHANES would allow researchers to more fully understand this complex relationship.

Although the sociological perspective has not, at least historically, sought out factors associated with biology to explain observed disparities in disease, research in this area could bolster the arguments that sociologist have been making for years. Understanding what happens to individuals on a molecular basis as a result of their social environment only stands to reinforce the ideas for which sociologists so fervently argue – society matters. Our social arrangements impact health, this we know. However, we must continue to scrutinize the extent to which that is true by resisting complacency with our current understandings and critically examining existing paradigms, especially our own.

Bibliography

Adam, E. K., Heissel, J. A., Zeiders, K. H., Richeson, J. A., Ross, E. C., Ehrlich, K. B., . . . Eccles, J. S. (2015). Developmental histories of perceived racial discrimination and diurnal cortisol profiles in adulthood: A 20-year prospective study. *Psychoneuroendocrinology*, *62*, 279-291. doi:http://dx.doi.org/10.1016/j.psyneuen.2015.08.018

Adam, T. C., & Epel, E. S. (2007). Stress, eating and the reward system. *Physiology and Behavior*, *91*(4), 449-458. doi:10.1016/j.physbeh.2007.04.011

Agardh, E., Allebeck, P., Hallqvist, J., Moradi, T., & Sidorchuk, A. (2011). Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. *International Journal of Epidemiology*, *40*(3), 804-818. doi:10.1093/ije/dyr029

Alegría, M., Mulvaney-Day, N., Woo, M., Torres, M., Gao, S., & Oddo, V. (2007). Correlates of Past-Year Mental Health Service Use Among Latinos: Results From the National Latino and Asian American Study. *American Journal of Public Health, 97*(1), 76-83. doi:10.2105/ajph.2006.087197

American Diabetes Association. (2010). Standards of Medical Care in Diabetes—2010. *Diabetes Care, 33*(Supplement 1), S11-S61. doi:10.2337/dc10-S011

American Diabetes Association. (2015a). 2. Classification and Diagnosis of Diabetes. *Diabetes Care, 38*(Supplement 1), S8-S16. doi:10.2337/dc15-S005

American Diabetes Association. (2015b). Standards of Medical Care in Diabetes. *Diabetes Care, 38*(Supplement 1), S49-S90. doi:10.2337/dc15-S001

August, K. J., & Sorkin, D. H. (2010). Racial/Ethnic Disparities in Exercise and Dietary Behaviors of Middle-Aged and Older Adults. *Journal of General Internal Medicine, 26*(3), 245-250. doi:10.1007/s11606-010-1514-7

Bassuk, S. S., & Manson, J. E. (2005). Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *Journal of Applied Physiology*, *99*(3), 1193-1204. doi:10.1152/japplphysiol.00160.2005

Batty, G. D., Kivimaki, M., Smith, G. D., Marmot, M. G., & Shipley, M. J. (2007). Obesity and Overweight in Relation to Mortality in Men With and Without Type 2 Diabetes/Impaired Glucose Tolerance The original Whitehall Study. *Diabetes Care, 30*(9), 2388-2391. doi:10.2337/dc07-0294

Becker, G. S. (1964). Human Capital: a Theoretical and Empirical Analysis, With Special Reference to Education. Chicago: University of Chicago Press.

Beckles, G. L., & Chou, C.-F. (2013). Diabetes—United States, 2006 and 2010. *MMWR Surveillance Summarry, 62*(Suppl 3), 99-104.

Berg, J. D., Stehouwer, C. D. A., Bosma, H., Velde, J. H. P. M., Willems, P. J. B., Savelberg, H. H. C. M., . . . Koster, A. (2016). Associations of total amount and patterns of sedentary behaviour with type 2 diabetes and the metabolic syndrome: The Maastricht Study. *Diabetologia*, 1-10. doi:10.1007/s00125-015-3861-8

Bird, S. T., & Bogart, L. M. (2000). Perceived race-based and socioeconomic status (SES)-based discrimination in interactions with health care providers. *Ethnicity & Disease, 11*(3), 554-563.

Björntorp, P. (1997). Body fat distribution, insulin resistance, and metabolic diseases. *Nutrition, 13*(9), 795-803. doi:http://dx.doi.org/10.1016/S0899-9007(97)00191-3

Blaxter, M. (1990). *Health and Lifestyles*. New York: Routledge.
Borrell, L. N., Dallo, F. J., & White, K. (2006). Education and Diabetes in a Racially and Ethnically Diverse Population. *American Journal of Public Health, 96*(9), 1637-1642. doi:10.2105/AJPH.2005.072884
Bourdieu, P. (1984). *Distinction: A social critique of the judgment of taste*: Harvard University Press.
Boyle, J., Thompson, T., Gregg, E., Barker, L., & Williamson, D. (2010). Projection of the year 2050 burden of diabetes in the US adult population: dynamic modeling of incidence, mortality, and prediabetes prevalence. *Population Health Metrics, 8*(1), 29. Retrieved from http://www.pophealthmetrics.com/content/8/1/29
Brown, A. F., Ettner, S. L., Piette, J., Weinberger, M., Gregg, E., Shapiro, M. F., . . . Beckles, G. L. (2004). Socioeconomic Position and Health among Persons with Diabetes Mellitus: A Conceptual Framework and Review of the Literature. *Epidemiologic Reviews, 26*(1), 63-77. doi:10.1093/epirev/mxh002
Brown, W., Miller, Y., & Miller, R. (2003). Sitting time and work patterns as indicators of overweight and obesity in Australian adults. *International Journal of Obesity 27*, 1340 - 1346. doi:10.1038/sj.ijo.0802426
Brownson, R. C., Boehmer, T. K., & Luke, D. A. (2005). Declining Rates of Physical Activity in the United States: What Are the Contributers? *Annual Review of Public Health, 26*(1), 421-443. doi:10.1146/annurev.publhealth.26.021304.144437
Bullard, K. M., Saydah, S. H., Imperatore, G., Cowie, C. C., Gregg, E. W., Geiss, L. S., . . . Caspersen, C. J. (2013). Secular Changes in U.S. Prediabetes Prevalence Defined by Hemoglobin A1c and Fasting Plasma Glucose: National Health and Nutrition Examination Surveys, 1999–2010. *Diabetes Care, 36*(8), 2286-2293. doi:10.2337/dc12-2563
Camacho-Rivera, M., Kawachi, I., Bennett, G. G., & Subramanian, S. (2015). Revisiting the Hispanic health paradox: the relative contributions of nativity, country of origin, and race/ethnicity to childhood asthma. *Journal of Immigrant and Minority Health, 17*(3), 826-833. doi: 10.1007/s10903-013-9974-
Campos, C. (2012). Chronic hyperglycemia and glucose toxicity: pathology and clinical sequelae. *Postgraduate Medicine, 124*(6), 90-97. doi:10.3810/pgm.2012.11.2615
Caplan, L. J., & Schooler, C. (2003). The roles of fatalism, self-confidence, and intellectual resources in the disablement process in older adults. *Psychology and Aging, 18*(3), 551-561. doi:10.1037/0882-7974.18.3.551
Carnevale, A. P., Rose, S. J., & Cheah, B. (2011). *The college payoff: Education, occupations, lifetime earnings*. Retrieved from https://www2.ed.gov/policy/highered/reg/hearulemaking/2011/collegepayoff.pdf
Caspersen, C. J., Pereira, M. A., & Curran, K. M. (2000). Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Medicine and Science in Sports and Exercise, 32*(9), 1601-1609. doi:0195-9131/00/3209-1601/0
CDC. (2011a). Increasing Prevalence of Diagnosed Diabetes—United States and Puerto Rico, 1995–2010.
CDC. (2011b). National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States, 2011. *US Department of Health and Human Services*.

CDC. (2013). Specifying Weight Parameters. *Continous NHANES Web Tutorial.* Retrieved from http://www.cdc.gov/nchs/tutorials/nhanes/SurveyDesign/Weighting/intro.htm

CDC. (2014). *National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, 2014.* . Retrieved from Atlanta, GA:

CDC. (2015). *Health, United States, 2014: With Special Feature on Adults Aged 55-64.* Retrieved from Hyattsville, MD:

Chen, L., Magliano, D. J., & Zimmet, P. Z. (2012). The worldwide epidemiology of type 2 diabetes mellitus—present and future perspectives. *Nature Reviews Endocrinology, 8*(4), 228-236. doi:10.1038/nrendo.2011.183

Chung, C., & Myers, S. L. (1999). Do the poor pay more for food? An analysis of grocery store availability and food price disparities. *Journal of Consumer Affairs, 33*(2), 276-296. doi:10.1111/j.1745-6606.1999.tb00071.x

Cockerham, W. C. (2005). Health Lifestyle Theory and the Convergence of Agency and Structure. *Journal of Health and Social Behavior, 46*(1), 51-67. doi:10.1177/002214650504600105

Cockerham, W. C., Rütten, A., & Abel, T. (1997). Conceptualizing Contemporary Health Lifestyle *Sociological Quarterly, 38*(2), 321-342. doi:10.1111/j.1533-8525.1997.tb00480.x

Collins Jr, J. W., David, R. J., Handler, A., Wall, S., & Andes, S. (2004). Very low birthweight in African American infants: the role of maternal exposure to interpersonal racial discrimination. *American Journal of Public Health, 94*(12), 2132-2138. doi:10.2105/AJPH.94.12.2132

Cooper, A. R., Sebire, S., Montgomery, A. A., Peters, T. J., Sharp, D. J., Jackson, N., . . . Andrews, R. C. (2012). Sedentary time, breaks in sedentary time and metabolic variables in people with newly diagnosed type 2 diabetes. *Diabetologia, 55*(3), 589-599. doi:10.1007/s00125-011-2408-x

Cossrow, N., & Falkner, B. (2004). Race/Ethnic Issues in Obesity and Obesity-Related Comorbidities. *The Journal of Clinical Endocrinology & Metabolism, 89*(6), 2590-2594. doi:10.1210/jc.2004-0339

Cutler, D. M., & Lleras-Muney, A. (2006). *Education and health: evaluating theories and evidence*. Retrieved from http://www.nber.org/papers/w12352

Cutler, D. M., Lleras-Muney, A., & Vogl, T. (2008). *Socioeconomic status and health: dimensions and mechanisms*. Retrieved from http://www.nber.org/papers/w14333

de Koning, L., Chiuve, S. E., Fung, T. T., Willett, W. C., Rimm, E. B., & Hu, F. B. (2011). Diet-Quality Scores and the Risk of Type 2 Diabetes in Men. *Diabetes Care, 34*(5), 1150-1156. doi:10.2337/dc10-2352

Dunn, R. A., Sharkey, J. R., & Horel, S. (2012). The effect of fast-food availability on fast-food consumption and obesity among rural residents: An analysis by race/ethnicity. *Economics & Human Biology, 10*(1), 1-13. doi:http://dx.doi.org/10.1016/j.ehb.2011.09.005

Dutton, G. R., Johnson, J., Whitehead, D., Bodenlos, J. S., & Brantley, P. J. (2005). Barriers to physical activity among predominantly low-income African-American patients with type 2 diabetes. *Diabetes Care, 28*(5), 1209-1210. doi:10.2337/diacare.28.5.1209

Edson, E. J., Sierra-Johnson, J., & Curtis, B. (2009). Diabetes and obesity in older adults: a call to action. *Reviews in Clinical Gerontology, 19*(2), 135. doi:10.1017/S0959259809990128

Ekman, C., Elgzyri, T., Ström, K., Almgren, P., Parikh, H., Dekker Nitert, M., . . . Hansson, O. (2015). Less pronounced response to exercise in healthy relatives to type 2 diabetics compared to controls. *Journal of Applied Physiology*. doi:10.1152/japplphysiol.01067.2014

Evert, A. B., Boucher, J. L., Cypress, M., Dunbar, S. A., Franz, M. J., Mayer-Davis, E. J., . . . Yancy, W. S. (2014). Nutrition Therapy Recommendations for the Management of Adults With Diabetes. *Diabetes Care, 37*(Supplement 1), S120-S143. doi:10.2337/dc14-S120

Folkman, S. (1984). Personal control and stress and coping processes: a theoretical analysis. *Journal of Personality and Social Psychology, 46*(4), 839-852. doi:10.1037/0022-3514.46.4.839

Franzini, L., Ribble, J. C., & Keddie, A. M. (2001). Understanding the Hispanic paradox. *Ethnicity & Disease, 11*, 496-518.

Freedman, D. S., Ogden, C. L., Flegal, K. M., Khan, L. K., Serdula, M. K., & Dietz, W. H. (2007). Childhood overweight and family income. *MedGenMed : Medscape general medicine, 9*(2), 26. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17955082

Frohlich, K. L., Corin, E., & Potvin, L. (2001). A theoretical proposal for the relationship between context and disease. *Sociology of Health & Illness, 23*(6), 776-797. doi:10.1111/1467-9566.00275

Fuentes-Afflick, E., & Lurie, P. (1997). Low birth weight and Latino ethnicity. Examining the epidemiologic paradox. *Archives of Pediatric and Adolescent Medicine, 151*(7), 665-674. doi:10.1001/archpedi.1997.02170440027005

Fung, T. T., McCullough, M., van Dam, R. M., & Hu, F. B. (2007). A Prospective Study of Overall Diet Quality and Risk of Type 2 Diabetes in Women. *Diabetes Care, 30*(7), 1753-1757. doi:10.2337/dc06-2581

Gabir, M. M., Hanson, R. L., Dabelea, D., Imperatore, G., Roumain, J., Bennett, P. H., & Knowler, W. C. (2000). Plasma glucose and prediction of microvascular disease and mortality: evaluation of 1997 American Diabetes Association and 1999 World Health Organization criteria for diagnosis of diabetes. *Diabetes Care, 23*(8), 1113-1118. doi:10.2337/diacare.23.8.1113

Geiss, L. S., Wang, J., Cheng, Y. J., Thompson, T. J., Barker, L., Li, Y., . . . Gregg, E. W. (2014). Prevalence and incidence trends for diagnosed diabetes among adults aged 20 to 79 years, United States, 1980-2012. *JAMA, 312*(12), 1218-1226. doi:10.1001/jama.2014.11494

Geronimus, A. T., Hicken, M., Keene, D., & Bound, J. (2006). “Weathering” and age patterns of allostatic load scores among blacks and whites in the United States. *American Journal of Public Health, 96*(5), 826-833. doi: 10.2105/AJPH.2004.060749

Gerstle, J. F., Varenne, H., & Contento, I. (2001). Post-Diagnosis Family Adaptation Influences Glycemic Control in Women with Type 2 Diabetes Mellitus. *Journal of the American Dietetic Association, 101*(8), 918-922. doi:10.1016/S0002-8223(01)00227-9

Gillett, M. J., Royle, P., Snaith, A., & al., E. (Eds.). (2012). *Modifiable Risk Factors for Type 2 Diabetes Mellitus* (Vol. 2 (16.33)). Southampton (UK): NIHR Journals Library.

Graudal, N. A., Hubeck-Graudal, T., & Jürgens, G. (2012). Effects of low-sodium diet vs. high-sodium diet on blood pressure, renin, aldosterone, catecholamines, cholesterol, and triglyceride (Cochrane Review). *American Journal of Hypertension, 25*(1), 1-15. doi:10.1002/14651858.CD004022.pub3

Grier, S. A., & Kumanyika, S. K. (2008). The context for choice: health implications of targeted food and beverage marketing to African Americans. *American Journal of Public Health, 98*(9), 1616-1629. doi:10.2105/AJPH.2007.115626

Guenther, P. M., Casavale, K. O., Kirkpatrick, S. I., Reedy, J., Hiza, H. A. B., Kuczynski, K. J., . . . Krebs-Smith, S. M. (2013). Diet Quality of Americans in 2001-02 and 2007-08 as Measured by the Healthy Eating Index-2010.

Guinote, A., Brown, M., & Fiske, S. T. (2006). Minority Status Decreases Sense of Control and Increases Interpretive Processing. *Social Cognition, 24*(2), 169-186. doi:10.1521/soco.2006.24.2.169

Harris, M. I., Klein, R., Cowie, C. C., Rowland, M., & Byrd-Holt, D. D. (1998). Is the risk of diabetic retinopathy greater in non-Hispanic blacks and Mexican Americans than in non-Hispanic whites with type 2 diabetes?: A US population study. *Diabetes Care, 21*(8), 1230-1235. doi:10.2337/diacare.21.8.1230

Hatzenbuehler, M. L., Phelan, J. C., & Link, B. G. (2013). Stigma as a fundamental cause of population health inequalities. *American journal of public health, 103*(5), 813-821. doi:10.2105/AJPH.2012.301069

Heise, D. A. (2002). Hispanic American Influence on the U.S. Food Industry. Retrieved from www.nal.usda.gov/outreach/HFood.html

Heisler, M., Vijan, S., Anderson, R. M., Ubel, P. A., Bernstein, S. J., & Hofer, T. P. (2003). When do patients and their physicians agree on diabetes treatment goals and strategies, and what difference does it make? *Journal of General Internal Medicine, 18*(11), 893-902. doi:10.1046/j.1525-1497.2003.21132.x

Hiroto, D. S. (1974). Locus of control and learned helplessness. *Journal of Experimental Psychology, 102*(2), 187. doi:10.1037/h0035910

Hiza, H. A. B., Casavale, K. O., Guenther, P. M., & Davis, C. A. (2013). Diet Quality of Americans Differs by Age, Sex, Race/Ethnicity, Income, and Education Level. *Journal of the Academy of Nutrition and Dietetics, 113*(2), 297-306. doi:10.1016/j.jand.2012.08.011

Hoerger, T. J., Segel, J. E., Gregg, E. W., & Saaddine, J. B. (2008). Is glycemic control improving in US adults? *Diabetes Care, 31*(1), 81-86. doi:10.2337/dc07-1572

Hootman, J. M., Macera, C. A., Ham, S. A., Helmick, C. G., & Sniezek, J. E. (2003). Physical activity levels among the general US adult population and in adults with and without arthritis. *Arthritis Care & Research, 49*(1), 129-135. doi:10.1002/art.10911

Horowitz, C. R., Colson, K. A., Hebert, P. L., & Lancaster, K. (2004). Barriers to buying healthy foods for people with diabetes: evidence of environmental disparities. *American Journal of Public Health, 94*(9), 1549-1554.

Hunt, K. J., Williams, K., Resendez, R. G., Hazuda, H. P., Haffner, S. M., & Stern, M. P. (2002). All-Cause and Cardiovascular Mortality Among Diabetic Participants in the San Antonio Heart Study: Evidence against the “Hispanic Paradox”. *Diabetes Care, 25*(9), 1557-1563. doi:10.2337/diacare.25.9.1557

Infurna, F. J., & Gerstorf, D. (2013). Linking perceived control, physical activity, and biological health to memory change. *Psychology and Aging, 28*(4), 1147-1163. doi:10.1037/a0033327

Infurna, F. J., Gerstorf, D., & Zarit, S. H. (2011). Examining dynamic links between perceived control and health: longitudinal evidence for differential effects in midlife and old age. *Developmental Psychology, 47*(1), 9-18. doi:10.1037/a0021022

Infurna, F. J., Ram, N., & Gerstorf, D. (2013). Level and change in perceived control predict 19-year mortality: findings from the Americans' changing lives study. *Developmental Psychology, 49*(10), 1833-1847. doi:10.1037/a0031041

Inzucchi, S. E., Bergenstal, R. M., Buse, J. B., Diamant, M., Ferrannini, E., Nauck, M., . . . Matthews, D. R. (2012). Management of hyperglycaemia in type 2 diabetes: a patient-centered approach. Position statement of the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetologia, 55*(6), 1577-1596. doi:10.1007/s00125-012-2534-0

Jackson, A. S., Ellis, K. J., McFarlin, B. K., Sailors, M. H., & Bray, M. S. (2009). Body mass index bias in defining obesity of diverse young adults: the Training Intervention and Genetics of Exercise Response (TIGER) Study. *British Journal of Nutrition, 102*(07), 1084-1090. doi:10.1017/S0007114509325738

Jackson, C. L., Hu, F. B., Kawachi, I., Williams, D. R., Mukamal, K. J., & Rimm, E. B. (2015). Black-White differences in the relationship between alcohol drinking patterns and mortality among US men and women. *American Journal of Public Health, 105*(3), 23. doi:10.2105/AJPH.2015.302615

Jerant, A. F., von Friederichs-Fitzwater, M. M., & Moore, M. (2005). Patients' perceived barriers to active self-management of chronic conditions. *Patient Education and Counseling, 57*(3), 300-307. doi:10.1016/j.pec.2004.08.004

Johnson, W., Kyvik, K. O., Mortensen, E. L., Skytthe, A., Batty, G. D., & Deary, I. J. (2010). Education reduces the effects of genetic susceptibilities to poor physical health. *International Journal of Epidemiology, 39*(2), 406-414. doi:10.1093/ije/dyp314

Kanjilal, S., Gregg, E. W., Cheng, Y. J., & et al. (2006). SOcioeconomic status and trends in disparities in 4 major risk factors for cardiovascular disease among us adults, 1971-2002. *Archives of Internal Medicine, 166*(21), 2348-2355. doi:10.1001/archinte.166.21.2348

Karter, A. J., Ferrara, A., Darbinian, J. A., Ackerson, L. M., & Selby, J. V. (2000). Self-monitoring of blood glucose: language and financial barriers in a managed care population with diabetes. *Diabetes care, 23*(4), 477-483. doi:10.2337/diacare.23.4.477

Katz, S. (2013). Active and Successful Aging: Lifestyle as a Gerontological Idea. *Recherches sociologiques et anthropologiques, 44*(1).

Kirkpatrick, S. I., Dodd, K. W., Reedy, J., & Krebs-Smith, S. M. (2012). Income and Race/Ethnicity Are Associated with Adherence to Food-Based Dietary Guidance among US Adults and Children. *Journal of the Academy of Nutrition and Dietetics, 112*(5), 624-635.e626. doi:10.1016/j.jand.2011.11.012

Kohn, M. L., & Schooler, C. (1982). Job conditions and personality: A longitudinal assessment of their reciprocal effects. *American Journal of Sociology*, 1257-1286.

Krein, S. L., Heisler, M., Piette, J. D., Makki, F., & Kerr, E. A. (2005). The effect of chronic pain on diabetes patients' self-management. *Diabetes Care, 28*(1), 65-70. doi:10.2337/diacare.28.1.65

Krueger, P. M., & Chang, V. W. (2008). Being Poor and Coping With Stress: Health Behaviors and the Risk of Death. *American Journal of Public Health, 98*(5), 889-896. doi:10.2105/ajph.2007.114454

Krueger, P. M., Saint Onge, J. M., & Chang, V. W. (2011). Race/ethnic differences in adult mortality: The role of perceived stress and health behaviors. *Social Science & Medicine, 73*(9), 1312-1322. doi:10.1016/j.socscimed.2011.08.007

Lachman, M. E., & Agrigoroaei, S. (2010). Promoting functional health in midlife and old age: long-term protective effects of control beliefs, social support, and physical exercise. *PLoS One, 5*(10), e13297. doi:10.1371/journal.pone.0013297

Lachman, M. E., & Firth, K. (2004). The adaptive value of feeling in control during midlife. In O. Brim, C. Ryff, & R. Kessler (Eds.), *How healthy are we* (pp. 320-349). Chicago: University of Chicago Press.

Lachman, M. E., & Weaver, S. L. (1998). The sense of control as a moderator of social class differences in health and well-being. *Journal of Personality and Social Psychology, 74*(3), 763-773. doi:10.1037/0022-3514.74.3.763

Lantz, P. M., House, J. S., Lepkowski, J. M., Williams, D. R., Mero, R. P., & Chen, J. (1998). Socioeconomic factors, health behaviors, and mortality: results from a nationally representative prospective study of US adults. *JAMA, 279*(21), 1703-1708. doi:10.1001/jama.279.21.1703

Leong, K. S., & Wilding, J. P. (1999). Obesity and diabetes. *Best Practice & Research Clinical Endocrinology & Metabolism, 13*(2), 221-237.

Ley, S. H., Hamdy, O., Mohan, V., & Hu, F. B. (2014). Prevention and management of type 2 diabetes: dietary components and nutritional strategies. *The Lancet, 383*(9933), 1999-2007. doi:10.1016/S0140-6736(14)60613-9

Liese, A. D., Nichols, M., Sun, X., D'Agostino, R. B., & Haffner, S. M. (2009). Adherence to the DASH Diet Is Inversely Associated With Incidence of Type 2 Diabetes: The Insulin Resistance Atherosclerosis Study. *Diabetes Care, 32*(8), 1434-1436. doi:10.2337/dc09-0228

Lin, B.-H., Guthrie, J., & Frazao, E. (1999). Nutrient contribution of food away from home. *America's eating habits: Changes and consequences, 750*.

Lin, Y., & Vogt, W. P. (1996). Occupational Outcomes for Students Earning Two-Year College Degrees: Income, Status, and Equity. *The Journal of Higher Education, 67*(4), 446-475. doi:10.2307/2943807

Link, B. G., & Phelan, J. (1995a). Social conditions as fundamental causes of disease. *Journal of health and social behavior*, 80-94.

Link, B. G., & Phelan, J. (1995b). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior, Spec No*, 80-94.

Liu, S. Y., Walter, S., Marden, J., Rehkopf, D. H., Kubzansky, L. D., Nguyen, T., & Glymour, M. M. (2015). Genetic vulnerability to diabetes and obesity: Does education offset the risk? *Social Science & Medicine, 127*, 150-158. doi:10.1016/j.socscimed.2014.09.009

Lloyd, C., Smith, J., & Weinger, K. (2005). Stress and Diabetes: A Review of the Links. *Diabetes Spectrum*, *18*(2), 121-127. doi:10.2337/diaspect.18.2.121

Long, J. S. (1997). *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks, CA: Sage Publications.

Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using Stata*: Stata press.

Lopez, R. P., & Hynes, H. P. (2006). Obesity, physical activity, and the urban environment: public health research needs. *Environmental Health: A Global Access Science Source, 5*(1), 1-10. doi:10.1186/1476-069x-5-25

Loria, C. M., Bush, T. L., Carroll, M. D., Looker, A. C., McDowell, M. A., Johnson, C. L., & Sempos, C. T. (1995). Macronutrient intakes among adult Hispanics: a comparison of Mexican Americans, Cuban Americans, and mainland Puerto Ricans. *American Journal of Public Health*, *85*(5), 684-689. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1615437/

Lovallo, W. R. (2015). *Stress and health: Biological and psychological interactions*: Sage publications.

Lutfey, K., & Freese, J. (2005). Toward some fundamentals of fundamental causality: socioeconomic status and health in the routine clinic visit for diabetes. *American Journal of Sociology, 110*(5), 1326-1372. doi:10.1086/428914

Maier, S. F., & Seligman, M. E. (1976). Learned helplessness: Theory and evidence. *Journal of Experimental Psychology: General, 105*(1), 3. doi:10.1037/0096-3445.105.1.3

Marmot, M., & Brunner, E. (2005). Cohort Profile: The Whitehall II Study. *International Journal of Epidemiology 34*(2), 251-256. doi:10.1093/ije/dyh372

Marmot, M. G. (1994). Social differentials in health within and between populations. *Daedalus*, 197-216.

Menke, A., Casagrande, S., Geiss, L., & Cowie, C. C. (2015). Prevalence of and trends in diabetes among adults in the United States, 1988-2012. *JAMA*, *314*(10), 1021-1029. doi:10.1001/jama.2015.10029

Merikangas, K. R., He, J.-P., Brody, D., Fisher, P. W., Bourdon, K., & Koretz, D. S. (2010). Prevalence and Treatment of Mental Disorders Among US Children in the 2001–2004 NHANES. *Pediatrics, 125*(1), 75-81. doi:10.1542/peds.2008-2598

Mirowsky, J., & Ross, C. E. (1983). Paranoia and the structure of powerlessness. *American Sociological Review*, 228-239.

Mirowsky, J., & Ross, C. E. (1984). Mexican culture and its emotional contradictions. *Journal of Health and Social Behavior*, 2-13. doi:10.2307/2136700

Mirowsky, J., & Ross, C. E. (1986). Social pattern of distress. *Annual Review of Sociology*, 23-45. doi:10.1146/annurev.so.12.080186.000323

Mirowsky, J., & Ross, C. E. (2003a). *Education, social status, and health*: Transaction Publishers.

Mirowsky, J., & Ross, C. E. (2003b). *Social causes of psychological distress*: Transaction Publishers.

Mirowsky, J., & Ross, C. E. (2015). Education, Health, and the Default American Lifestyle. *Journal of health and social behavior, 56*(3), 297-306. doi:10.1177/0022146515594814

Mokdad, A. H., Ford, E. S., Bowman, B. A., & et al. (2003). Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA*, *289*(1), 76-79. doi:10.1001/jama.289.1.76

Morland, K., Wing, S., Diez Roux, A., & Poole, C. (2002). Neighborhood characteristics associated with the location of food stores and food service places. *American Journal of Preventive Medicine, 22*(1), 23-29. doi:10.1016/S0749-3797(01)00403-2

Morley, J. E. (2008). Diabetes and aging: epidemiologic overview. *Clinics in geriatric medicine, 24*(3), 395-405. doi:10.1016/j.cger.2008.03.005

Morrato, E. H., Hill, J. O., Wyatt, H. R., Ghushchyan, V., & Sullivan, P. W. (2007). Physical Activity in U.S. Adults With Diabetes and At Risk for Developing Diabetes, 2003. *Diabetes Care*, *30*(2), 203-209. doi:10.2337/dc06-1128

Narayan, K. M. V., Boyle, J. P., Thompson, T. J., Gregg, E. W., & Williamson, D. F. (2007). Effect of BMI on Lifetime Risk for Diabetes in the U.S. *Diabetes Care, 30*(6), 1562-1566. doi:10.2337/dc06-2544

Nathan, D. M., Davidson, M. B., DeFronzo, R. A., Heine, R. J., Henry, R. R., Pratley, R., & Zinman, B. (2007). Impaired Fasting Glucose and Impaired Glucose Tolerance. *Implications for care, 30*(3), 753-759. doi:10.2337/dc07-9920

Nguyen, N. T., Nguyen, X.-M. T., Lane, J., & Wang, P. (2010). Relationship Between Obesity and Diabetes in a US Adult Population: Findings from the National Health and Nutrition Examination Survey, 1999–2006. *Obesity Surgery, 21*(3), 351-355. doi:10.1007/s11695-010-0335-4

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014). PRevalence of childhood and adult obesity in the united states, 2011-2012. *JAMA, 311*(8), 806-814. doi:10.1001/jama.2014.732

Ogden, C. L., Lamb, M. M., Carroll, M. D., & Flegal, K. M. (2010). *Obesity and socioeconomic status in adults: United States 1988-1994 and 2005-2008* (Vol. NCHS data brief no. 50). Hyattsville, MD: National Center for Health Statistics.

Pampel, F. C., & Rogers, R. G. (2004). Socioeconomic status, smoking, and health: a test of competing theories of cumulative advantage. *Journal of Health and Social Behavior, 45*(3), 306-321. doi:10.1177/002214650404500305

Pascoe, E. A., & Richman, L. S. (2009). Perceived Discrimination and Health: A Meta-Analytic Review. *Psychological Bulletin*, *135*(4), 531-554. doi:10.1037/a0016059

Paulin, G. D. (1998). A growing market: Expenditures by Hispanic Consumers. *Monthly Labor Review, 121*(3), 3-19.

Pearlin, L. I. (1980). Life strains and psychological distress among adults. In N. S. a. E. H. Erikson (Ed.), *Themes of work and love in adulthood* (pp. 174-192): Harvard University Press.

Pearlin, L. I., Menaghan, E. G., Lieberman, M. A., & Mullan, J. T. (1981). The stress process. *Journal of Health and Social behavior*, 337-356. doi:10.2307/2136676

Penninx, B. W., van Tilburg, T., Kriegsman, D. M., Deeg, D. J., Boeke, A. J., & van Eijk, J. T. (1997). Effects of social support and personal coping resources on mortality in older age: the Longitudinal Aging Study Amsterdam. *American Journal of Epidemiology, 146*(6), 510-519.

Phelan, J. C., Link, B. G., & Tehranifar, P. (2010). Social Conditions as Fundamental Causes of Health Inequalities: Theory, Evidence, and Policy Implications. *Journal of Health and Social Behavior, 51*(1 suppl), S28-S40. doi:10.1177/0022146510383498

Piette, J. D., Schillinger, D., Potter, M. B., & Heisler, M. (2003). Dimensions of Patient-provider Communication and Diabetes Self-care in an Ethnically Diverse Population. *Journal of General Internal Medicine, 18*(8), 624-633. doi:10.1046/j.1525-1497.2003.31968.x

Piette, J. D., Wagner, T. H., Potter, M. B., & Schillinger, D. (2004). Health insurance status, cost-related medication underuse, and outcomes among diabetes patients in three systems of care. *Medical Care, 42*(2), 102-109. doi:10.1097/01.mlr.0000108742.26446.17

Powell, L. M., Chaloupka, F. J., & Bao, Y. (2007). The Availability of Fast-Food and Full-Service Restaurants in the United States: Associations with Neighborhood Characteristics. *American Journal of Preventive Medicine, 33*(4, Supplement), S240-S245. doi:10.1016/j.amepre.2007.07.005

Powell, L. M., Szczypka, G., & Chaloupka, F. J. (2010). Trends in exposure to television food advertisements among children and adolescents in the United States. *Archives of Pediatrics and Adolescent Medicine, 164*(9), 794-802. doi:10.1001/archpediatrics.2010.139

Raja, S., Changxing Ma, & Yadav, P. (2008). Beyond Food Deserts: Measuring and Mapping Racial Disparities in Neighborhood Food Environments. *Journal of Planning Education and Research, 27*(4), 469-482. doi:10.1177/0739456x08317461

Robbins, J. M., Vaccarino, V., Zhang, H., & Kasl, S. V. (2005). Socioeconomic status and diagnosed diabetes incidence. *Diabetes Research and Clinical Practice, 68*(3), 230-236. doi:10.1016/j.diabres.2004.09.007

Rose, D., & Richards, R. (2004). Food store access and household fruit and vegetable use among participants in the US Food Stamp Program. *Public Health Nutrition, 7*(08), 1081-1088. doi:10.1079/PHN2004648

Ross, C. E., & Mirowsky, J. (1989). Explaining the social patterns of depression: control and problem solving--or support and talking? *Journal of health and social behavior*, 206-219. doi:10.2307/2137014

Sacerdote, C., Ricceri, F., Rolandsson, O., Baldi, I., Chirlaque, M.-D., Feskens, E., . . . Wareham, N. (2012). Lower educational level is a predictor of incident type 2 diabetes in European countries: The EPIC-InterAct study. *International journal of epidemiology, 41*(4), 1162-1173. doi:10.1093/ije/dys091

Sacks, F. M., Svetkey, L. P., Vollmer, W. M., Appel, L. J., Bray, G. A., Harsha, D., . . . Cutler, J. A. (2001). Effects on Blood Pressure of Reduced Dietary Sodium and the Dietary Approaches to Stop Hypertension (DASH) Diet. *New England Journal of Medicine, 344*(1), 3-10. doi:10.1056/NEJM200101043440101

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: status, limitations, and future directions. *Research Quarterly for Exercise and Sport, 71*(sup2), 1-14. doi:10.1080/02701367.2000.11082780

Sapolsky, R. M. (1982). The endocrine stress-response and social status in the wild baboon. *Hormones and Behavior, 16*(3), 279-292. doi:10.1016/0018-506X(82)90027-7

Sapolsky, R. M. (2005). The influence of social hierarchy on primate health. *Science, 308*(5722), 648-652. doi:10.1126/science.1106477

Sapolsky, R. M., Krey, L. C., & McEwen, B. S. (1986). The neuroendocrinology of stress and aging: the glucocorticoid cascade hypothesis*. *Endocrine Reviews, 7*(3), 284-301. doi:10.1210/edrv-7-3-284

Sarkar, U., Fisher, L., & Schillinger, D. (2006). Is Self-Efficacy Associated With Diabetes Self-Management Across Race/Ethnicity and Health Literacy? *Diabetes Care, 29*(4), 823-829. doi:10.2337/diacare.29.04.06.dc05-1615

Seeman, M., & Seeman, T. E. (1983). Health Behavior and Personal Autonomy: A Longitudinal Study of the Sense of Control in Illness. *Journal of Health and Social Behavior, 24*(2), 144-160. Retrieved from http://www.jstor.org/stable/2136641

Seligman, H. K., Laraia, B. A., & Kushel, M. B. (2010). Food Insecurity Is Associated with Chronic Disease among Low-Income NHANES Participants. *The Journal of Nutrition, 140*(2), 304-310. doi:10.3945/jn.109.112573

Selvin, E., Parrinello, C. M., Sacks, D. B., & Coresh, J. (2014). Trends in Prevalence and Control of Diabetes in the United States, 1988–1994 and 1999–2010Trends in Prevalence and Control of Diabetes in the United States. *Annals of Internal Medicine, 160*(8), 517-525. doi:10.7326/m13-2411

Shaw, R. J., & Pickett, K. E. (2013). The Health Benefits of Hispanic Communities for Non-Hispanic Mothers and Infants: Another Hispanic Paradox. *American Journal of Public Health, 103*(6), 1052-1057. doi:10.2105/AJPH.2012.300985

Sheard, N. F., Clark, N. G., Brand-Miller, J. C., Franz, M. J., Pi-Sunyer, F. X., Mayer-Davis, E., . . . Geil, P. (2004). Dietary Carbohydrate (Amount and Type) in the Prevention and Management of Diabetes: A statement by the American Diabetes Association. *Diabetes Care, 27*(9), 2266-2271. doi:10.2337/diacare.27.9.2266

Shuey, K. M., & Willson, A. E. (2008). Cumulative Disadvantage and Black-White Disparities in Life-Course Health Trajectories. *Research on Aging, 30*(2), 200-225. doi:10.1177/0164027507311151

Sterling, T., & Weinkam, J. (1990). The confounding of occupation and smoking and its consequences. *Social Science and Medicine, 30*(4), 457-467. doi:10.1016/0277-9536(90)90348-V

Stinson, F. S., Nephew, T. M., Dufour, M., & Grant, B. (1996). State trends in alcohol-related mortality, 1979-92. *US Alcohol Epidemiologic Data Reference Manual, 5*.

Stranges, S., Dorn, J. M., Muti, P., Freudenheim, J. L., Farinaro, E., Russell, M., . . . Trevisan, M. (2004). Body fat distribution, relative weight, and liver enzyme levels: A population-based study. *Hepatology, 39*(3), 754-763. doi:10.1002/hep.20149

Surtees, P. G., Wainwright, N. W., Luben, R., Wareham, N. J., Bingham, S. A., & Khaw, K. T. (2010). Mastery is associated with cardiovascular disease mortality in men and women at apparently low risk. *Health Psychology 29*(4), 412-420. doi:10.1037/a0019432

Surwit, R. S., van Tilburg, M. A. L., Zucker, N., McCaskill, C. C., Parekh, P., Feinglos, M. N., . . . Lane, J. D. (2002). Stress Management Improves Long-Term Glycemic Control in Type 2 Diabetes. *Diabetes Care, 25*(1), 30-34. doi:10.2337/diacare.25.1.30

The Diabetes Prevention Program Research Group. (2002). The Diabetes Prevention Program (DPP): Description of lifestyle intervention. *Diabetes Care, 25*(12), 2165-2171. doi:10.2337/diacare.25.12.2165

Troiano, R. P., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise, 40*(1), 181. doi:10.1249/mss.0b013e31815a51b3

Tuomilehto, J., Lindstrom, J., Eriksson, J. G., Valle, T. T., Hamalainen, H., Ilanne-Parikka, P., . . . Uusitupa, M. (2001). Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *New England Journal of Medicine, 344*(18), 1343-1350. doi:10.1056/nejm200105033441801

Turiano, N. A., Chapman, B. P., Agrigoroaei, S., Infurna, F. J., & Lachman, M. (2014). Perceived Control Reduces Mortality Risk at Low, Not High, Education Levels. *Health Psychology, 33*(8), 883-890. doi:10.1037/hea0000022

Turner, R. C., Cull, C. A., Frighi, V., & Holman, R. R. (1999). Glycemic control with diet, sulfonylurea, metformin, or insulin in patients with type 2 diabetes mellitus: Progressive requirement for multiple therapies (ukpds 49). *JAMA, 281*(21), 2005-2012. doi:10.1001/jama.281.21.2005

Turrell, G., Hewitt, B., Patterson, C., & Oldenburg, B. (2003). Measuring socio-economic position in dietary research: is choice of socio-economic indicator important? *Public Health Nutrition, 6*(02), 191-200. doi:10.1079/PHN2002416

Turrell, G., & Kavanagh, A. M. (2006). Socio-economic pathways to diet: modelling the association between socio-economic position and food purchasing behaviour. *Public Health Nutrition, 9*(3), 375-383. doi:10.1079/PHN2005850

Wang, Y., & Chen, X. (2011). How much of racial/ethnic disparities in dietary intakes, exercise, and weight status can be explained by nutrition-and health-related psychosocial factors and socioeconomic status among US adults? *Journal of the American Dietetic Association, 111*(12), 1904-1911. doi:10.1016/j.jada.2011.09.036

Warnecke, R. B., Johnson, T. P., Chávez, N., Sudman, S., O'Rourke, D. P., Lacey, L., & Horm, J. (1997). Special Issue: Interface Between Molecular and Behavioral EpidemiologyImproving question wording in surveys of culturally diverse populations. *Annals of Epidemiology, 7*(5), 334-342. doi:10.1016/S1047-2797(97)00030-6

Weber, M. ([1992] 1978). *Economy and Society: An Outline of Interpretative Sociology* (E. F. e. al., Trans.). Berkeley: University of California Press.

Wheaton, B. (1980). The sociogenesis of psychological disorder: An attributional theory. *Journal of Health and Social Behavior*, 100-124.

Wheaton, B. (1983). Stress, personal coping resources, and psychiatric symptoms: An investigation of interactive models. *Journal of Health and Social Behavior*, 208-229.

White, S. M., Wojcicki, T. R., & McAuley, E. (2012). Social cognitive influences on physical activity behavior in middle-aged and older adults. *The Journals of Gerontology, Series B: Psychological Sciences and Social Science, 67*(1), 18-26. doi:10.1093/geronb/gbr064

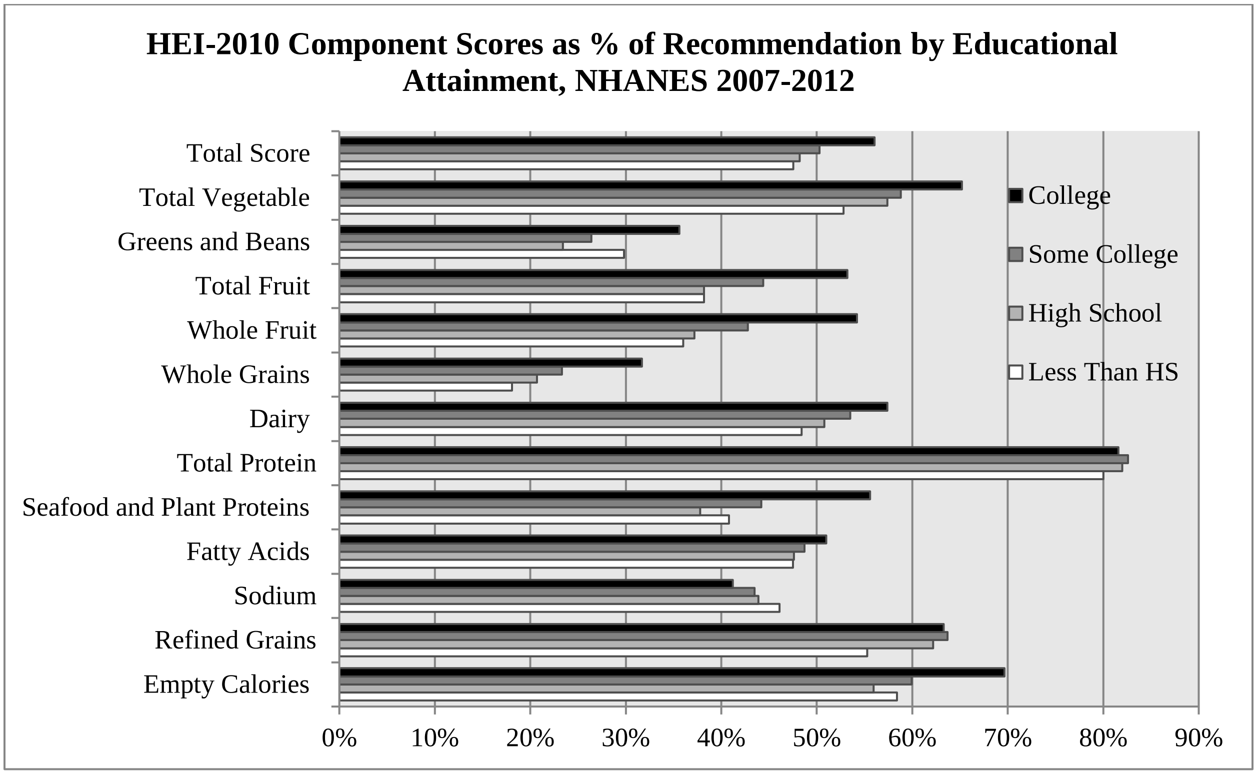
Whiting, D., Unwin, N., & Roglic, G. (2010). Diabetes: equity and social determinants. In E. Blaus & A. S. Kurup (Eds.), *Equity, social determinants and public health programmes*. Geneva: World Health Organization.

Williams, D. R. (1997). Race and health: Basic questions, emerging directions. *Annals of Epidemiology, 7*(5), 322-333. doi:10.1016/S1047-2797(97)00051-3

Williams, D. R., Mohammed, S. A., Leavell, J., & Collins, C. (2010). Race, socioeconomic status, and health: complexities, ongoing challenges, and research opportunities. *Annals of the New York Academy of Sciences, 1186*(1), 69-101. doi:10.1111/j.1749-6632.2009.05339.x

Zgibor, J. C., & Simmons, D. (2002). Barriers to blood glucose monitoring in a multiethnic community. *Diabetes Care, 25*(10), 1772-1777. doi:10.2337/diacare.25.10.1772

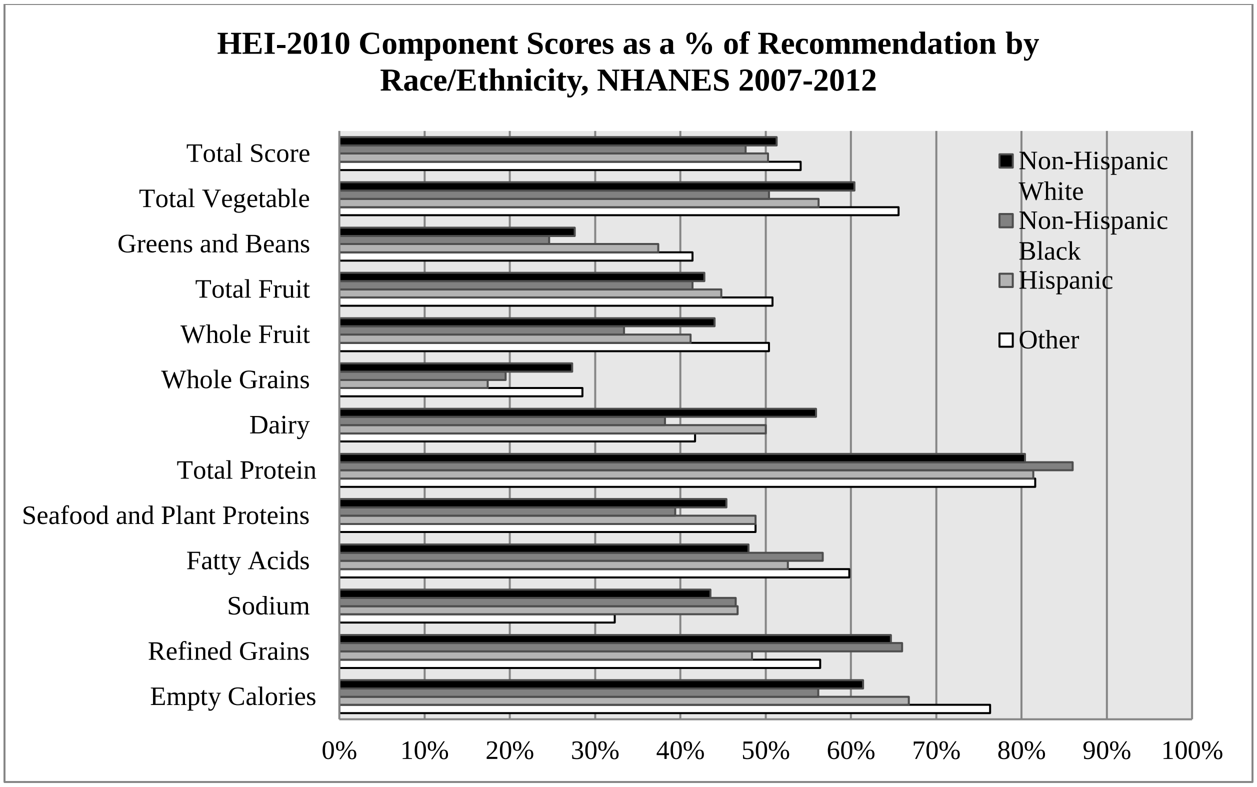
Appendix



HEI-2010 Components Scores According to Educational Attainment, NHANES 2007-2012

Component (max score)	**Less Than HS** (95% CI)		**High School** (95% CI)		**Some College** (95% CI)		**College** (95% CI)	
Adequacy								
Total Score (100)	47.1	(46.03-48.17)	47.51	(46.31-48.70)	50.23	(49.35-51.11)	55.64	(54.50-56.78)
Total Vegetable (5)	2.64	(2.54-2.73)	2.87	(2.76-2.97)	2.94	(2.84-3.04)	3.26	(3.19-3.33)
Greens and Beans (5)	1.49	(1.36-1.61)	1.17	(1.01-1.33)	1.32	(1.20-1.44)	1.78	(1.64-1.92)
Total Fruit (5)	1.91	(1.76-2.06)	1.91	(1.79-2.03)	2.22	(2.15-2.30)	2.66	(2.50-2.81)
Whole Fruit (5)	1.8	(1.63-1.98)	1.86	(1.75-1.97)	2.14	(2.03-2.25)	2.71	(2.54-2.88)
Whole Grains (10)	1.81	(1.67-1.96)	2.07	(1.83-2.31)	2.33	(2.17-2.49)	3.17	(2.91-3.42)
Dairy (10)	4.84	(4.60-5.04)	5.08	(4.88-5.28)	5.35	(5.11-5.60)	5.74	(5.53-5.94)
Total Protein (5)	4	(3.92-4.08)	4.1	(4.03-4.18)	4.13	(4.05-4.22)	4.08	(4.01-4.14)
Seafood and Plant Proteins (5)	2.04	(1.90-2.18)	1.89	(1.74-2.04)	2.21	(2.07-2.34)	2.78	(2.66-2.91)
Fatty Acids (5)	4.75	(4.51-5.00)	4.76	(4.61-4.91)	4.87	(4.68-5.07)	5.1	(4.88-5.31)
Moderation								
Sodium (10)	4.61	(4.44-4.79)	4.39	(4.15-4.63)	4.35	(4.20-4.51)	4.12	(3.91-4.33)
Refined Grains (10)	5.53	(5.21-5.85)	6.22	(6.02-6.42)	6.37	(6.15-6.59)	6.33	(6.15-6.50)
Empty Calories (20)	11.6	(11.07-12.29)	11.19	(10.81-11.57)	11.99	(11.68-12.31)	13.93	(13.48-14.38)

All data adjusted for complex sampling frame



HEI-2010 Components Scores According to Race/Ethnicity, NHANES 2007-2012

Component (max score)	**Non-Hispanic White** (95% CI)		**Non-Hispanic Black** (95% CI)		**Hispanic** (95% CI)		**Other** (95% CI)	
Adequacy								
Total Score (100)	51.3	(50.26-52.31)	47.7	(46.79-48.54)	50.3	49.59-51.00)	54.1	(52.94-55.
Total Vegetable (5)	3.0	(2.95-3.09)	2.5	(2.43-2.61)	2.8	(2.73-2.89)	3.3	(3.15-3.4
Greens and Beans (5)	1.4	(1.29-1.48)	1.2	(1.12-1.34)	1.9	(1.77-1.98)	2.1	(1.87-2.2
Total Fruit (5)	2.1	(2.05-2.24)	2.1	(1.97-2.17)	2.2	(2.14-2.34)	2.5	(2.35-2.7
Whole Fruit (5)	2.2	(2.09-2.31)	1.7	(1.56-1.79)	2.1	(1.95-2.18)	2.5	(2.31-2.7
Whole Grains (10)	2.7	(2.56-2.91)	2.0	(1.80-2.10)	1.7	(1.58-1.91)	2.9	(2.55-3.1
Dairy (10)	5.6	(5.47-5.72)	3.8	(3.63-4.00)	5.0	(4.83-5.16)	4.2	(3.90-4.4
Total Protein (5)	4.0	(3.97-4.05)	4.3	(4.24-4.36)	4.1	(4.01-4.14)	4.1	(3.94-4.2
Seafood and Plant Proteins (5)	2.3	(2.17-2.37)	2.0	(1.84-2.10)	2.4	(2.32-2.57)	2.4	(2.58-2.9
Fatty Acids (5)	4.8	(4.32-4.98)	5.7	(5.49-5.85)	5.3	(5.08-5.43)	6.0	(5.71-6.2
Moderation								
Sodium (10)	4.4	(4.25-4.46)	4.7	(4.48-4.81)	4.7	(4.53-4.81)	3.2	(2.90-3.5
Refined Grains (10)	6.5	(6.31-6.62)	6.6	(6.36-6.85)	4.8	(4.62-5.05)	5.6	(5.25-6.0
Empty Calories (20)	12.3	(11.92-12.64)	11.2	(10.86-11.60)	13.4	(13.06-13.66)	15.3	(14.71-15.

All data adjusted for complex sampling frame