EDUCATION DIFFERENCES IN ELEVATED BLOOD GLUCOSE: DO THEY VARY BY RACE, ETHNICITY AND SEX?

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

UNIVERSITY OF FLORIDA

2009

To my parents

ACKNOWLEDGMENTS

I must thank my committee, and especially Dr. Henretta, for the inordinate amount of time given to me and to this thesis. Dr. Henretta's help extends beyond careful attention to detail in the titles of tables, formatting, and logic of argument and reaches all the way to handwritten Statistical Analysis Software syntax to introduce me to the program. The process of writing this thesis, in preparation for future work, has been the best and most useful part of my education thus far. I can only hope that a little bit of Dr. Henretta's approach to problem solving has rubbed off and ill improve my answers to future questions.

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Abstract Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Master of Arts

EDUCATION DIFFERENCES IN ELEVATED BLOOD GLUCOSE: DO THEY VARY BY RACE, ETHNICITY AND SEX

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AUGUST 2009

Chair: John Henretta
Major: Sociology

The relationship between education and health has been well documented--increasing levels of education are associated with better health using various definitions of both education and health. This relationship has also been found to vary across demographic profiles. This study examines the relationship between education and blood glucose levels, whether the association varies across race and ethnicity and sex, and whether the association varies by level of blood glucose. Elevated levels of blood glucose can been classified into two stages: impaired fasting glucose (fasting glucose levels 100 to 125 mg/dL (5.6 to 6.9 mmol/L)) and diabetes (fasting glucose levels over 125 mg/dL(greater than or equal to 7.0 mmol/L)), with each stage associated with an array of health risks. This research is important because individuals with impaired fasting glucose are at increased risk for developing diabetes, and diabetics have an increased risk for developing cardiovascular disease--the leading cause of death in the United States.

Data from the combined 1999-2006 National Health and Nutrition Examination Survey are analyzed. Logistic regression is used to test the relationship between level of blood glucose and whether the association varies across sex and race and ethnicity. A continuation ratio model is used to test for difference in effects of covariates between the two stages of blood glucose.

Results indicate that education has a significant association with blood glucose levels, that this association is significantly different for males and females, that the association varies by race and ethnicity for females, and that the association with race and ethnicity varies by level of blood sugar for both males and females.

For males, education has no effect on blood sugar levels after adjusting for age, body mass index, and marital status. Having more than a high school degree is significantly associated with reduced levels of blood sugar for females. This effect is significantly different for men and women. Allowing for interactions between education and race and ethnicity suggest that blacks with less than a 9th grade education have a significantly reduced probability of developing elevated levels of blood glucose relative to other blacks, and being black has the effect of reducing the probability of having elevated blood sugar overall. Hispanics with a BA or more have a significantly increased probability of developing elevated blood glucose relative to other Hispanics, but being Hispanic has no significant association with elevated blood sugar levels.

The association between race and blood glucose varies across levels of blood glucose for both men and women. For males, given that one has EBS, being either black or Hispanic significantly increases the risk of developing diabetes. For females, given that an individual has EBS, being black significantly increases the risk of developing diabetes. The race and ethnicity and blood glucose association is significantly different across stages of blood glucose for both males and females, changing from having either no effect or a weak protective effect on development of elevated blood glucose to having a significant effect on increasing the risk of developing diabetes, given EBS.

CHAPTER 1
HEALTH DISPARITIES

Introduction

Differences in health outcomes by sex, race and socioeconomic status persist in American society today. One important health outcome in which disparities exist is elevated blood sugar (EBS), defined in this paper as having either impaired fasting glucose or diabetes (Borrell et. al. 2006). The significance of diabetes as a health outcome stems from its increasing incidence within the total U.S. population, and its strong association with cardiovascular disease. According to the Centers for Disease Control., the *incidence* of diabetes has increased 91% in the past decade. (CDC 2008). The *prevalence* of diabetes has also been increasing. The CDC.reports that from 1980 to 2006, the crude prevalence of diabetes has increased 132%, and this increase in diabetes is similar regardless of age standardization, indicating that the increasing prevalence of diabetes is not related to the changing age structure of the United States (CDC 2008). The increase in prevalence could also be related to better treatment and longer survival times; therefore incidence is a better measure to indicate that diabetes is of increasing concern.

While EBS is a health concern across the entire U.S. population, it affects different segments of the population in different ways. Two key axes of differentiation in the blood glucose disparity are race and ethnicity, and education. For example, Hispanics are twice as likely to die from diabetes as are whites and those with higher levels of education are less likely to have diabetes (Healthy People 2010, Borell 2006). Given the significance of studying diabetes due to the increasing incidence of diabetes in the U.S. population and its differential impact on key segments of the population, the objective of this research is to answer the following three questions: (1) What is the association between education and the development of EBS; (2) does this association vary by race and ethnicity and sex; and (3) does the association between race and ethnicity, sex, and elevated blood sugar vary depending on the level of blood sugar?

In order to answer these questions and develop initial hypotheses, relevant health disparities literature will first be reviewed. The definition of a health disparity and a framework for general health outcomes will be provided. A key axis of health disparities is education, which is a measure of socioeconomic status, thus socioeconomic disparities in health and EBS will be reviewed. Following the outline of socioeconomic status disparities in health, socioeconomic status will be integrated into the general framework of health outcomes (Figure 1-1) After the general review of socioeconomic status and health disparities, education will become the focus as a measure of socioeconomic status. The value of education as an socioeconomic status measure, its measurement, its effects on EBS, the difficulties associated with studying the effects of education on health, and theories of differential effects of education on health and EBS will complete Chapter 1.

After reviewing health disparities by race and ethnicity and educational attainment, and formulation of hypotheses in Chapter 1, a basic background to diabetes and impaired fasting glucose (IFG) will be provided in Chapter 2, including their definition, incidence and prevalence, and deleterious effects on the U.S. population. The empirical link between diabetes and IFG, as well as the biological difference between the two will be outlined, followed by a discussion and formulation of a model for the risk factors of EBS.

Once the critical covariates of EBS are reviewed in Chapter 2 , Chapter 3 lists the hypotheses formulated from the literature review of Chapters 1 and 2. Chapter 3 also discusses the data and methodology used to test the hypotheses, including background to the NHANES, sample analyzed, operationalizations of variables, and method of analysis are reviewed. Chapter 4 summarizes the results and Chapter 5 includes a discussion of the results and a conclusion.

Conceptualizing Health Disparities

A health disparity can be defined as "differences that occur by gender, race or ethnicity, education or income, disability, geographic location, or sexual orientation (Healthy People 2010). However, this definition is only one among many definitions of what constitutes a disparity (Smedley 2003, Whitehead 1991). Different definitions of what constitutes a health disparity often involve differing foci of who or what is experiencing a disparity, such as race and ethnicity or socioeconomic status. Most definitions of a disparity imply a reference group from which comparisons are to be made. These comparisons can be made to the majority group, the population mean, or to the healthiest group. (Adler 2008)

The difference between a *disparity* and a *difference* is not always clear, although a disparity usually implies either something amenable to change or a form of injustice (Adler 2008, Herbert et al. 2008.). In this thesis I explicitly conceptualize the experience of racial and ethnic minorities with impaired fasting glucose and diabetes as a disparity and not just a difference. It is difficult to differentiate between a disparity and a difference in the case of EBS. For example, genetic pre-dispositions towards development of diabetes in African-Americans may be rooted in historical events. Biological explanations, commonly known as the "slavery hypothesis", explain the higher incidence of hypertension in the African-American population than in the general population by mortality conditions aboard slave transportation ships which occasionally approached 20% (Curtin 1992, Klein 2001). Such high mortality rates make trans-Atlantic slave trading a plausible selective mechanism for individuals with certain metabolic characteristics that may predispose them to metabolic diseases under other conditions. If this explanation is valid, should the biological differences in diabetes be considered a genetic difference, or a disparity rooted in unjust historical circumstances?

The causes of health disparities are numerous and interwoven with each other. Because health itself is determined by numerous factors, including "physiological, psychological, cultural, and social factors" (Goldberg 2004), the causes of health disparities can be found in the interplay between these factors and the socio-historical context in which an individual or racial and ethnic group exists. The U.S. is composed of numerous racial and ethnic groups, thus it is vitally important to examine the extent and sources of racial and ethnic health disparities in the U.S. population, keeping in mind that the goal of addressing health disparities is to improve the overall health of society.

The complex factors to be taken into account when analyzing the sources of health disparities can be organized using a general framework developed from combining models from the Institute of Medicine and Office of Technology Assessment (Goldberg 2004). This framework has three primary dimensions: health before care, health care access, and health care delivery. Health before care refers to the variables that can influence health outside of the health care system. It encompasses important factors that can influence health including individual income, educational attainment, environment, personal characteristics, and overall social conditions such as employment opportunities. Health before care is the focus of the analysis in this thesis within the tri-partite framework for analyzing the origins of health disparities.

Health *access* refers to the ability of an individual to access and receive treatment for their health condition. Language barriers, lack of financial resources, and a mistrust of the health care system can all serve as barriers to affect health care access. Once one has gained access to the system, Health care *delivery* is the third dimension on which health disparities may emerge and includes variability of diagnosis, treatment, and communication.

Socioeconomic status is a key axis along which health behaviors, health care access and delivery can vary. The next section discusses the role of socioeconomic status in EBS health disparities.

Socioeconomic Status Health Disparities in Elevated Blood Sugar

Health disparities in diabetes by socioeconomic status have been well documented using multiple measures of socioeconomic status, and the effects of socioeconomic status seem to vary by sex (Smith 2007, Robbins et al. 2004. Stern et al. 1984). Those in the higher levels of socioeconomic status indicators, including income, occupation, and education, tend to have lower levels of diabetes. Along some socioeconomic status indicators, the gradient appears to be growing (Smith 2007). Smith finds evidence that between National Health and Nutrition Examination Survey II (NHANES) and NHANES IV, the gradient of diagnosed diabetes between those with less than a high school degree and those with more than a high school degree went from being insignificant to a gradient of diagnosed diabetes of about 4% (9.8% in the lowest category of education vs. 6.0% in the highest category). Sex differences in the association between socioeconomic status and diagnosed diabetes have been found for occupational status but not for education (Robbins 2004). Robbins finds that higher levels of income, greater occupational prestige, and higher levels of education were found to be associated with lower probability of having diagnosed diabetes among women, but among men only education and income were associated with lower probability of having diagnosed diabetes, not occupational status.

As the socioeconomic status gradient in health appears to be widening for diabetes, the proportion racial and ethnic groups with less than a high school degree is *increasing*. The increasing proportions of racial and ethnic groups at lower levels of socioeconomic status may undermine the success in equalizing the rates of undiagnosed diabetes between racial and ethnic groups since the socioeconomic status gradient in undiagnosed diabetes is relatively constant (Smith 2007). Table 1-1 reports undiagnosed diabetes rates in NHANES 1999-2006, as well as “reference numbers” from Cowie (2002). Cowie analyzed the same data set as this study, so Cowie’s estimates serve as a comparison for estimates in this study. While Cowie’s results differ slightly from the results of this analysis, so do Ioannou’s (2007) results without explanation.

Framework Linking Socioeconomic Status to Elevated Blood Sugar

A conceptual framework that links the socioeconomic status and diabetes should include both the "proximal" mechanisms such as health behaviors, access, and processes of care as previously discussed, as well "distal" measures such as cultural patterns that mediate the relationship between socioeconomic status and EBS and the proximal mechanisms that link them. Brown et al. (2004) develop such a model, however it is intended to model the relationship between socioeconomic status and health among persons with diabetes. This model, with some adjustment, can also be used to link socioeconomic status with the development of EBS. Figure 1-1 displays the modified conceptual framework.

In the model developed by Brown et al. (2004), socioeconomic status encompasses individual, household, and community characteristics that can shape the proximal mechanisms of health behaviors, access to health care, and the process of health care. At the individual level education, employment, and occupational prestige are likely to shape the proximal mediators between socioeconomic status and health outcomes. At the household level, income and wealth likely affect the proximal mediators for both adults and children. Finally, average community income, education, and crime rates are a part of socioeconomic status that shape proximal mediators.

Distal mediators and moderators are the effects of the characteristics of the individual, provider, community, and health care system on the primary, proximal mechanisms. Distal mediators may include level of acculturation and social-support at the individual level, language concordance in patient-doctor relations at the provider level, and environmental safety at the community level. Critical covariates to consider in any model with socioeconomic status are age, sex, and race and ethnicity. As Brown (2004) acknowledges, an underlying assumption of their model is a lack of endogeneity, or that socioeconomic status influences health, rather than health influencing socioeconomic status. As will be discussed in the section on measuring education, there are several issues to consider when modeling health outcomes. Early health events can influence socioeconomic status attainment (Palloni 2006). Issues of endogeneity may also effect health insurance, income, and occupational status. The model in this study does not consider the effect of early life events on socioeconomic status attainment. To reduce the risk of endogeneity, health insurance and income are excluded as possible explanatory variables between race and ethnicity and EBS, so that the model being estimated is a reduced-form model.

While there are many possible measures of socioeconomic status, this analysis will focus on education. The reasons for using education as a socioeconomic status proxy in health research are outlined in the next section.

Education as a Socioeconomic Status Measure and General Health Outcomes

Higher levels of education are associated with better health, across multiple indicators of health including including mortality, physical functioning, cardiovascular health, and cognitive functioning (Kitagawa and Hauser 1973; Zimmer et al. 2002; Winkelby et al. 1992).

An early study on the relationship using *mortality* as a measurement of health was done by Kitagawa and Hauser (Feinstein 1993). Using 1960 death certificates linked with census information with census information, Kitagawa and Hauser measured the association between levels of education and mortality. They found a strong inverse relationship up until the age of 65. Over 65, the association between education and health was smaller. Recent evidence suggests that the education gradient has been increasing in recent decades, with much of the gradient driven by gains in life expectancy by the more highly educated in older age groups (Meara and Cutler 2008). During the past two decades, the life expectancy of the highly educated increased by almost 3 years, compared to only half a year for the least educated. Increasing education gradients, with the important exception of a narrowing education gradient among young black men, occurred despite narrowing gradients across sex and ethnicity (Meara and Cutler 2008).

There is also evidence for sex differentials in the education gradient in mortality (Elo and Preston 1995). Elo and Preston (1995) confirm the finding that education differentials tend towards a maximum at older ages, but that these trends must be differentiated by sex. Females aged 25-64 have experienced a recent narrowing of the education gradient in mortality , and females age 65 and over have experienced a static gradient. Men, however, have experienced a broad pattern of widening education differentials in mortality since 1960 (Elo and Preston 1995).

Besides mortality, health can also be operationalized as *physical functioning*, and here too, research has shown a positive association with education. Zimmer et al. (2002) examined the relative predictive power of both the parent's and the child's education on the level of reported physical functioning of the parent, defined as reported difficulty in everyday tasks such as sitting, crouching, and reaching for objects. They found that older adults who had more than a primary level of education were "53% less likely to report a functional limitation in comparison to those with low-level education" (Zimmer 2002).

Higher levels of education are also associated with lower risk of cardiovascular diseases Using survey results from the Stanford Five-City project, Winkleby (1992) demonstrates that those with the lowest levels of education tend to have the highest levels of cardiovascular risk factors. For example, among men with less than a high school education, 47% reported being cigarette smokers. Among men who had completed a college education 18% reported being cigarette smokers. Females were found to have a similar gradient between education and cigarette smoking, 41% of dropouts reported smoking, while 14% of college graduates reported smoking. Across all levels of cardiovascular risk factors, men had higher levels of risk than women did.

Not every measure of health has as clear cut an association with education as mortality and physical functioning. Due to the nature of education itself, associations with cognitive functioning in late-life and level of education may be spurious but is also possible that associations between education and cognitive functioning could stem from lower “risk of chronic and infectious diseases throughout the life course, quality of health care, occupational or environmental exposures, or differences in health practices and lifestyle behaviors” (Cagney and Lauderdale 2002). While using education as a measure of socioeconomic status when modeling cognitive outcomes poses difficulties, using education as a measure of socioeconomic status to model blood glucose outcomes is more appropriate.

Measuring Education

Aspects of a person’s education include the quantity of education, credentials, and selectivity of education received (Ross and Mirowsky 1999). The quantity of education is the number of years of education achieved, implying that each year has equal importance. In contrast, a focus on credentials argues that the value of an education comes from holding certain degrees. Selectivity of education refers to the prestige of the institution attended. The selectivity model could include aspects of both quantity and credentials: the institution offers a higher quality education thus each year of education has a greater value, and the institute’s degree is more highly valued by society, granting greater access to resources such as occupations and income. The selectivity model is more easily applied to college degrees. Measurement of “prestige” below the college level is more difficult. Some private schools are certainly recognized as prestigious, but there is no national ranking of the secondary schools attended by the vast majority of the population.

Increasing the quantity of education should increase the stock of "human capital" one has, according to human capital theory. School is seen as a place where students learn both specific skills such as mathematics, but also general problem solving skills and the ability to negotiate with others in the pursuit of a goal. Personality traits such as "self-directedness" are also encouraged. Specific knowledge, general skills, and personal growth are thus substantive parts of one's education that have a real impact on an individual, and the more exposure to that kind of environment, the greater "human capital" one has. In turn, human capital "ultimately shapes health and well-being" especially through the development of an internal locus of control (Ross and Mirowsky 1999). Healthy behaviors are more likely to be practiced by somebody if they believe a good part of their fate rests in their own hands.

The credential view of education argues that the substance of an education is minimal and that the true value comes from possessing a degree. This approach does not predict a linear association between years of schooling and various health outcomes. Rather, the possession of a degree is the best indicator for good health. Furthermore, the effects of the degree would be mediated by occupational status, assuming the positive association between good quality of jobs and higher levels of health (Ross and Mirowsky 1999).

The final model of education’s value is the selectivity model, which combines aspects of both quantity and credential views of education. This model predicts that the quality of an educational institution has health effects beyond the predicted effects of either quantity of education or credentials. These increasing health returns could be due to either self-selecting processes (the best students go to the best schools), or that the higher quality of the institution (either substantively or credentially) leads to better job placement, resulting in higher levels of health.

Research suggests that quantity of education has the largest impact on physical functioning and perceptions of health (Ross and Mirowsky 1999). Ross and Mirowsky also find that the credential model has no significant effect. Controlling for a healthy life-style, the selectivity of college attended becomes insignificant, suggesting that the beneficial economic pathways theorized for going to a high quality school are not the actual pathways through which education operates. Instead, selective schools somehow promote more healthful lifestyles or select for healthier individuals than less selective schools, although this intra-school difference is relatively unimportant compared to the effects of continued education at any institution of higher education.

Pathways Between Education and Health

Several pathways have been offered to explain the positive association between education and health (Ross and Wu 1995, Adams 2002). These pathways include work and economic conditions, social and psychological resources, a healthy lifestyle, and health care utilization skills ("productive efficiency") (Ross and Wu 1995, Adams 2002).

Work and economic effects assume those who have a higher education are more likely to have a job, with higher income, and greater opportunities for self-fulfillment. In 1991, 87% of college graduate students were employed compared to 77% of those who had a high school degree only, and 56% of people with eight years of education or less. Furthermore, those with greater educational attainment stay unemployed for lesser periods of time (Ross and Wu 1995, Moen 1999). Those who do not have the skills to enter the workforce face economic hardship from lack of income, which in turn might affect health through the daily stresses of living life on the edge and limited access to health care. Daily stresses may play a role in the in the health advantage more highly educated individuals enjoy, including lower levels of blood sugar (Surwit 1992, Goetsch 1990). Goetsch (1990) found stress to have a hyperglycemic effect in both laboratory and natural settings, with the greatest level of blood glucose range occurring on high stress days.

Social and psychological resources are a second way in which education might improve health. Education develops both a sense of personal control and social support network. The common sense argument says that education's emphasis on problem solving and interpretation increases one's perception of personal control. Thus when confronted with health problems, the highly educated will confront them with both increased knowledge and increased attention to changing unhealthy behaviors. Ironically, those who most need the tools of knowledge and the sense of efficacy to confront health issues are those least likely to have them. Social support systems are stronger for the college educated (Ross and Mirowsky 1999), and those with better social support systems have better health outcomes, such as lower rates of mortality. Men with few social connections experience a morality rate 2.3 times higher than those with better social support (House, Landis, and Umberson 1988).

A third link between education and health is the tendency for the more highly educated to practice healthier behaviors: they practice greater allocative efficiency. The greater one's education, the less likely one is to smoke and the greater one's likelihood to drink *moderately* (Ross and Wu 1995, Grossman 1997). Higher educational attainment is also associated with regular exercise, lower body weight, and knowledge about blood pressure. Blacks and Hispanics had different risk profiles than whites even after adjusting for educational attainment (Shea et al. 1991).

Those with greater levels of education may also have greater levels of productive efficiency. Productive efficiency occurs when a more highly educated patient is better able to recognize and express their symptoms to the doctor. In this way, the more highly educated are able to "get more" out of their inputs into health care processes (Grossman 1997). Support has been found for many of the theorized mechanisms (Ross and Wu 1995, Adams 2002). However, endogenous processes may select healthier individuals for higher levels of educational attainment.

Education and Endogeneity

Ross and Wu (1995), while developing excellent models of *possible* pathways through which education can affect health outcomes, do little to address issues of reverse causation. Both higher levels of education and better health may result from pre-existing factors. Issues of endogeneity also arise for allocative and productive efficient explanations for education’s association with health. Individuals who are already more efficient accumulators of human capital may already be healthier, or may have personality characteristic that predispose them to defer gratification (Grossman 1997, Palloni 2006). It could also be the case that parental background affects both health and educational attainment (Elo and Preston 1996). Despite these difficulties in measuring education's effect on health, evidence of a causal relationship between education and health has been found, with especially pronounced effects among women (Adams 2002).

A similar problem occurs when studying the effects of health insurance on health. Those with health insurance may have been able to acquire health insurance because of better levels of health, making health endogenous to the acquisition of health insurance. Acquisition of health insurance may also indicate individuals who place a higher initial value on health than those who don't acquire insurance. Thus good health and health insurance may both be a result of a higher valuation of health. One possible method of dealing with endogeneity in health insurance when examining its effect on health is to examine the effect of the acquisition of Medicare on health. (McWilliams et al. 2007).

Income is another measure of socioeconomic status that is susceptible to issues of endogeneity. Those with lower incomes may have worse health, but those with worse health likely have lower incomes. Sudden health transitions have a significant effect on reducing income levels, an important causal pathway through which health is endogenous to income (Smith 2005). In contrast to income, education is a fairly consistent status within the usual life-course ordering of events. Educational attainment is generally static after an individual has left school, making it better than other indicators such as income and occupation in efforts to avoid endogeneity (McWilliams 2002, Smith 2005).

Framework Linking Education to EBS

Many of the pathways through which education affects general health outcomes are likely to affect blood sugar levels. Those with a higher level of education experience lower rates of obesity, higher incomes, and greater levels of healthy behavior (Monteiro et al. 2001, Ross and Wu 1995, Shea 1991). Given obesity's status as a risk factor for diabetes, it is expected that increased education will reduce the probability of diabetes, with BMI as an important mediator. Higher levels of education are also associated with higher incomes, which in turn are associated with lower rates of diabetes (Rabi et al. 2006). Healthy behaviors, including exercise are also associated with lower rates of diabetes, thus as educational attainment increases, it would be expected that rates of diabetes might decrease, with healthy behaviors as moderators (Burns 2007). Given these clear associations between higher education and factors that reduce the risk for diabetes, it is expected that higher levels of education will be negatively associated with risk of EBS. However, this association may vary across different groups of the population for reasons outlined below.

Non-linear Effects of Education

The effect of education may vary by level of education itself-- i.e. its effects are non-linear (Cutler and Lleras-Muney 2007). That is, there may be a "heterogeneous effect for each year of education" (Cutler and Lleras-Muney 2007:6) A linear association between education and health has been found for some measures of health, including mortality, colorectal screenings, and use of smoke detectors, while for other measures there is a non-linear association (Cutler and Llerras-Muney 2007).

Smoking and obesity both tend to have non-linear associations with education. An increased effect per each year of additional schooling is only seen in those who are more highly educated. After 10 years of schooling however, health levels become linearly associated with education levels (Cutler and Lleras-Muney 2007

Theories of Differential Effects

The association between education and is stronger among whites and Hispanics than for blacks. This finding can be interpreted as evidence that education has a different “translation” for health across different groups of people (Borrel 2006). There are several reasons why the association between education and EBS might vary.

Genetic and Early Life Effects

Genetic pre-dispositions may account for race differences in prevalence of diabetes. If one group is genetically “destined” to develop diabetes, environmental interventions would have a lesser effect. For example, a population selected for a thrifty gene, once no longer needing the thrifty gene for survival, may be at increased risk of developing risk factors for diabetes, such as higher BMI. The thrifty gene hypothesis for Type 2 Diabetes states that certain populations developed especially efficient metabolic mechanisms that are overwhelmed by modern progress in food supplies and are therefore predisposed to obesity and Type 2 Diabetes (Neele 1968, Joffe and Zimmet 1998). The concept has found support in the animal world as well as in human populations particularly susceptible to diabetes.

More recent evidence also supports a “thrifty gene” hypothesis for perinatal malnutrition leading to cell dysfunction, also known as the Barker hypothesis (Joffe and Zimmet 1998).The Barker hypothesis conceptualizes poor fetal and early post-natal nutrition as "imposing mechanisms of nutritional thrift upon the growing individual"(Hales and Barker 1992). In a fetal environment with constrained growth, the fetus adopts survival mechanisms which elevate the risk of diabetes in later life. Possible evidence of the Barker hypothesis includes the example of the Naruruan islanders, who experienced increased rates of diabetes when malnutrition was followed by affluence with the introduction of phosphate mining (Hales and Barker 1992). If the Barker hypothesis is true, those populations which tend to experience less healthy fetal environments may develop this syndrome in larger number, which could moderate the relationship between diabetes and protective factors, such as education.

Other early life events may also play a large role in shaping both future socioeconomic status attainment and health outcomes. While some researchers argue that education structures the pathways that influence health, it is also likely that early health events help to structure socioeconomic status attainment (Ross and Wu 1995, Palloni 2006).

Selection and Personality Differences

Personality differences might also account for a proportion of health disparities. Personality, defined as the “distinctive and characteristic patterns of thought, emotion and behavior that define an individual's personal style and influence his or her interaction with the environment," was found to attenuate the relationship between education and all-cause mortality in men by 34% in a study of 1989 French cohort (Navi, Kimiaki, Marmot et al. 2008) Not surprisingly, those possessing the battery of personal characteristics deemed "anti-social" personalities were more likely to die than those with "rational" and "healthy" personalities. The same personality differences that account for a significant amount of health disparities might also explain why education might have differing value for people. Those personal traits that have been found to promote good health, such as placing high value on self-regulation of behavior and autonomy may help those who possess them also "get more" out of their education by studying harder, or staying calm under pressure-filled situations such as test-taking.

If personality traits tend to cluster around racial-ethnic groups it is possible that they might account for some of the variation in the strengths of association between education and health. Research on personality trait clustering, done in response to the use of personality tests in hiring to determine if certain demographic groups were more likely to be denied employment based on test results, indicates small but significant differences of mean scores on personality scales (Ones and Anderson 2002). if certain demographic groups were more likely to be denied employment based on test results Evidence has been found of small, but significant differences of mean scores on personality scales. Differences in scores on "decisiveness," "emotional control," "stamina," and "warmth" have been found for blacks and whites in data from the UK (Ones and Anderson 2002)

Cultural Capital Differences

Those who favor the cultural capital explanation for race and ethnic differences point to the different treatment of students and parents that may lead to these differences (Lareau and Horvat 1999, Morries 2005, 2007). If the value of education stems from the accumulation of skills taught in the educational setting, different treatment may imply differing accumulation of skills, altering the value of education. Evidence that the quantity of education is what matters, as opposed to selectivity of education or credentials bestowed by education, support the idea that education is a process of skill accumulation

Cultural capital explanations for varying effects of education argue that actors occupying the multitude of social locations have, and are perceived to have, certain kinds of cultural capital, and are treated accordingly. Those who are perceived to have the right cultural background will be treated more favorably, and will be more likely to accumulate skills taught in school. Advocates of the cultural capital framework point out that one measure of success in higher education is grades, and grade distributions fall along patterns of social location, with Blacks often underperforming compared to their Hispanic, Asian, and White peers (Massey 2003).

The currency of cultural capital that may vary from student to student includes a "wide variety of resources including such things as verbal facility, general cultural awareness, aesthetic preferences, information about the school system, and educational credentials" (Swartz 1997). Other scholars have found evidence for different educational experiences based on race and ethnicity. Black girls are treated differently than their peers based on perceptions of black femininity within the context of hegemonic white femininity (Morries 2007).

Stress

Others argue that stressors within the social environment are an important source of health disparities between classes of people (Surwit 1992, Williams 1997). Stress in the social environment can occur when the psychological demands of the environment are perceived to be greater than the perception of control over the environment. If certain groups of people experience differing levels of stress in the educational environment or in their current lives, the health value of education might be lessened.

Table 1-1. Undiagnosed Diabetes By Educational Attainment and Race, NHANES 1999-2006 Weighted Data

	Percentage
Overall:	2.6%
Reference**	2.8%
Education	
Less Than HS	4.6%
HS Degree	3.0%
More Than HS	1.8%
Race	
Black	2.6%
White	2.6%
Hispanic	2.2%

* Undiagnosed diabetes defined as individuals who reported having not been told by a doctor they have diabetes but who had blood glucose levels >= 7.0 mmol/L

** Cowie et al. 2006. "Prevalence of Diabetes and Impaired Fasting Glucose in Adults in the U.S. Population" *Diabetes Care*. Vol. 29:1263-1268.

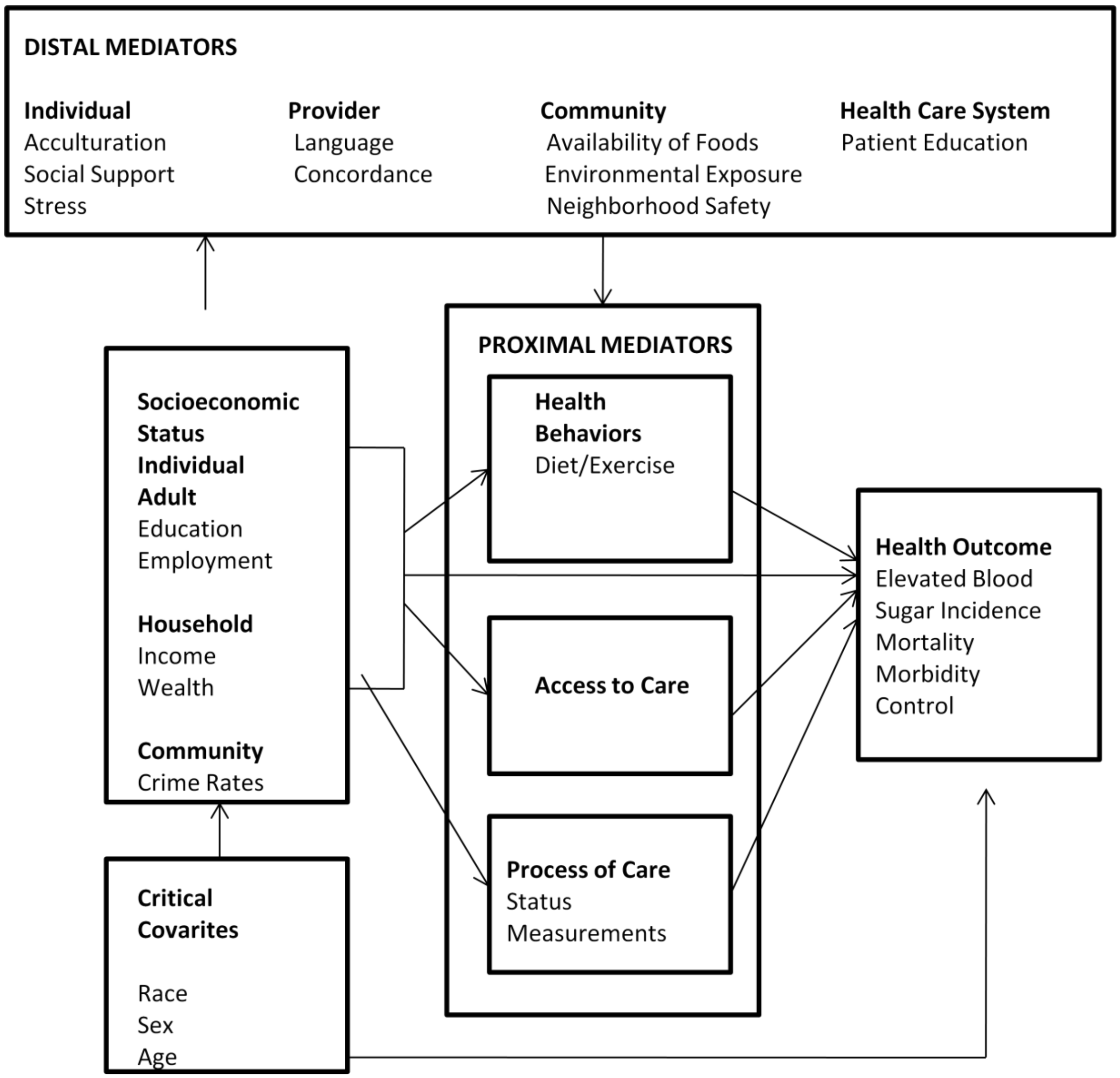


Figure 1-1. Conceptual Framework for the Association between Socioeconomic Status and Elevated Blood Sugar, Adapted from Brown (2004)

CHAPTER 2

BACKGROUND TO DIABETES AND IMPAIRED FASTING GLUCOSE

Diabetes

Type 2 diabetes (‘diabetes’ hereafter), defined as fasting plasma glucose level >126 mg/dl (7.0 mmol/l), is associated with numerous health problems, including significantly increased risk of mortality, often due to the cardiovascular complications that can result from having the disease. Those with diabetes have higher rates of mortality across all age, racial-ethnic, and gender groups (Bertoni et al. 2002). Using ICD-9 Medicare records, Bertoni et. al.(2002) found that elders with diabetes suffer higher mortality rates, with a standardized mortality ratio of 1.41 compared to that of non-diabetic elders. Furthermore, national declines in the death rate due to coronary heart disease have not been seen to the same extent in diabetic population (Gu, Cowei, Harris 1998).

Diabetes is also associated with significantly increased functional and work disability, as well as poor mental health. National Health and Nutrition Examination Survey data indicate that diabetes is associated with increased probability of disability in functional activities, including slower walking speed, decreased balance, and falling, and that the increased probability of disability is likely to reduce the quality of life (Gregg et al. 2000). Those with diabetes report more days of poor physical health (such as physical illness or injury) than matched respondents (8.3 days compared to 3.0 days), and report more days of poor mental health (such as stress or depression) than matched respondents (2.8 days compared to 1.8 days) (Valdmanis et al. 2001).

The prevalence of diabetes is increasing. From 1990 to 2000, the prevalence of self-reported diagnosed diabetes in the U.S. increased 49%, from a 4.9 percent to 7.3 percent of the U.S. population (Mokdad et al. 2001). Expanding the time frame to 1980-2000, the number of people with physician-diagnosed diabetes in the United States increased more than two-fold, from 5.8 million to 13.3 million (Kouznetsova 2007). Accompanying this increasing prevalence is a dramatically increased incidence rate. In 33 U.S. states that had data for both periods, the incidence rate increased 90% --from 4.8 per thousand in 1995--1997 to 9.1 in 2005--2007.

Increasing prevalence of a disease associated with increased mortality, increased functional disability, and many other detrimental health effects has significant policy implications because of its human and financial costs. Cost of illness estimates typically report either total cost to society or excess cost of illness (Ettaro et al. 2004). Cost of illness estimates for diabetes of both types are substantial, and total cost to society is growing , with an estimated total cost to society of diabetes of 100 billion dollars in 1995 (Ettaro 2004). The excess medical cost for an individual with diabetes is estimated to be 2-5 times greater than for the non-diabetic. The differential varies across groups, with those in the younger age groups typically experiencing the largest differential in excess cost. Contributing to the excess cost are the higher hospitalization rates for diabetics, which are approximately 2.5 times higher than for non-diabetics (Brown et. al. 1999). The higher rate contributes to the estimated $3.8 billion in costs for in-patient diabetic care from complications in 2001. Diabetes-related hospital visits cost the Medicare program $1.3 billion, with estimated preventable costs of $366 million if proper primary care had been provided prior to complications, such as diabetes, arising from diabetes (Economic and Health Costs of Diabetes: HCUP Highlight 1 2005).

To compound the difficulties of higher health care costs, diabetics are more likely to experience unemployment and are more likely to have incomes less than $20,000 than non-diabetics. 71% of diabetics have annual incomes less than $20,000, compared to 59% of non-diabetics. Minority status individuals are more likely have multiple hospitalizations than diabetic non-minority individuals (Valdmanis 2001).

Impaired Fasting Glucose (Pre-Diabetes)

Pre-diabetes, also known as impaired fasting glucose, is a pre-diabetic state recently defined in 2004 by the American Diabetes Association as individuals with impaired fasting glucose levels between 100 mg per dl and 125mg per dl. The previous definition had included only those individuals with IFG levels greater than 110 mg per dl. It is estimated that in 2002, about 26% of the adult population has impaired fasting glucose, one of the leading risk factors for developing diabetes mellitus (Cowie 2002).

Unlike diabetes, the prevalence of impaired fasting glucose has not dramatically increased. A study comparing prevalence of IFG between 1988 to 1994 and 1999-2002 using data from NHANES, the same data source used in this thesis, found a small increase in the prevalence of IFG, from 26.3% to 26.9% (Ioannou et al. 2007). Results from a second study, also using NHANES from the same year, found a slightly larger increase from 24.7% to 26.0% (Cowie 2002). While the results of these two studies are similar, they diverge more than would be expected given the same data. It is not known why the estimates vary by 1-2%. Recall that rates of diagnosed diabetes have risen significantly, from 5.1% to 6.5% during the same time frame as has been reported for IFG, even as undiagnosed diabetes remained stable.

Impaired fasting glucose itself is also associated with increased risk of cardiovascular disease, and those with pre-diabetes may also be at increased risk of mortality (Califf et al. 2008, Peterson and McQuire 2005, Snehalatha et al. 2003). Therefore efforts to reduce the incidence of CVD can target both diabetes and pre-diabetes.

Link Between Impaired Fasting Glucose and Diabetes

A major reason to set reduction of IFG prevalence as an important goal is impaired fasting glucose's strong association with development of diabetes. Reported rates of progression from IFG to diabetes have varied in the literature, with some research suggesting the percent of individuals progressing from IFG to diabetes to be as high as 33% over a 6 year period, to as low as 9.1% over a 12 year period, with non-white study populations generally reported to have higher percentages of progression from IFG to diabetes. (Nichols et al. 2007) The recent reduction in the IFG threshold, from 110 mg/dl to 100 mg/dl, also has an effect on the expected rate of change. One U.S. based study reported that, over a 9 year period, 24.3% of individuals who satisfied the old definition of IFG progressed to diabetes, whereas under the new definition of impaired fasting glucose only 8.1% of individuals progressed from IFG to diabetes (Nichols et al. 2007). Thus progression from IFG to diabetes is expected to occur at a slower rate under the new definition. Other determinants of progression from IFG to diabetes include higher levels of blood glucose, known hypertension, and high levels of triglycerides (Rasmussen et al. 2008).

The empirical link between IFG and diabetes, and the measurement of blood glucose along a continuous scale for both states of glycemia is the major reason for analyzing the data using a continuation ratio logistic regression model (CRM). This model, as explained in greater detail in Chapter 4, allows the researcher to test for significant differences in effects of covariates between stages of models. Some covariates may be more important for increasing risk of IFG than diabetes, or some covariates may not be significant until one already has IFG.

While fasting plasma glucose levels follow a continuous spectrum that allow for analysis via the CRM, it is important to recognize that the two conditions are separate. Diabetes is characterized by the failure of beta cells to produce the required amount of insulin in the context of insulin resistance, whereas IFG is characterized by the ability of the beta cells to accommodate the required increase in insulin production in the context of insulin resistance (Shabha 2004).

A Model and Critical Covariates for Risk of Diabetes

This study focuses on both IFG and diabetes and examines whether some of the primary risk factors associated with IFG and diabetes are different. The CRM model, for accurate comparisons, requires the inclusion of all covariates at each stage of the outcome level. The risk factors for diabetes will determine what covariates to include in the final CRM model, acknowledging that the risk factors for IFG may be different. Figure 2-1 outlines a model of risk factors for the development of diabetes. Primary risk factors for the development of diabetes include a family history of the disease and demographics, behavioral psychological, and clinical factors (Brown 2002).

Age and Sex

Figure 2-2, constructed using data from the National Health Interview Survey and provided by the Centers for Disease Control, illustrates the variation in diabetes prevalence between age-groups. Diabetes prevalence increases with age for all races and sexes up until 75+ years, at which point prevalence declines. Variation between age-groups is much greater than it is for sex groups, across all racial categories, and is thus important to control for it. To help adjust for age's possible non-linear association with risk of EBS, age is coded into 3 dummy variables: 24-35 years, 36-45 years, and 46+ years. Controlling for age also helps to account for the race and education differences that may occur between age groups. Overall prevalence of diabetes in most populations is equivalent across the sexes.

Race and Ethnicity

Blacks and Hispanics are both more likely to have diabetes than whites (Brancati et. al. 1996). The increasing proportion of the Hispanic population in the U.S. population and their elevated risk of mortality compared to whites makes it is especially important to address these health disparities in national efforts at reducing incidence and prevalence of diabetes. There are significant differences in prevalence of both pre-diabetes and diabetes between racial-ethnic groups over the age of 20, the ages analyzed here. Data from the National Institute of Health demonstrate the disparity of diabetes between racial-ethnic groups: Among non-Hispanic whites, 8.7% aged 20 and over have diabetes. Among Non-Hispanic blacks however, 13.3% aged 20 and over have diabetes. Among the Hispanic population, 9.5% aged 20 and over have diabetes. While Asian Americans aren't included in the final analysis of this thesis due to limited sample size, they are 1.5 times as likely to have diagnosed diabetes as non-Hispanic whites (National Institute of Diabetes and Digestive and Kidney Diseases 2008).

Obesity

Obesity is a primary risk factor in the development of diabetes (Shai, Im and Jiang, R. et al. 2006) Using data from the 2000 Behavioral Risk Factor Surveillance System, Mokdad et al. derived estimates of diabetes prevalence between the obese and non-obese across numerous characteristics. In each case, the obese group had a higher prevalence of diabetes than did the non-obese group. Prevalence of obesity has been increasing, and some have called both obesity and diabetes an “epidemic” among the U.S. population. (Mokdad et al. 2001). Table 2-1 reports the percentage of obese persons by sex and by age groups.

Obesity is also strongly related to educational attainment, with the least educated having the greatest likelihood of being obese (Borrell 2006). Since obesity is related to both education and diabetes, it may operate as a mediating variable in the relationship between them. Despite obesity’s strong association with diabetes, controlling for obesity has been found to explain some, but not all of the racial and ethnic differences in diabetes (Brancati 1996).

With regard to impaired fasting glucose, B.M.I. has been found to predictive for both blacks and whites. (Klein et. al. 2004) Using data from the National Heart, Lung, and Blood Institute, Klein (2004). found that *baseline* B.M.I was predictive of impaired fasting glucose for black girls and *rate* of B.M.I. increase was predictive of impaired fasting glucose for white girls. Whether the effect of B.M.I. remain constant through the progression of EBS remains unknown, and therefore will be examined in this analysis.

Marital Status

Marital status is also associated with diabetes. Choi and Shi (2001) found that "[w]omen who were single and 35 to 64 years old had a higher prevalence of diabetes than women of the same age who were married". Marital status is also associated with better health outcomes across other indicators of health (Shoenborn 2004). Using NHIS data pooled from the years 1999-2002, Shoenborn finds that “[r]egardless of population subgroup (age, sex, race, Hispanic origin, education, income, or nativity) or health indicator (fair or poor health, limitations in activities, low back pain, headaches, serious psychological distress, smoking, or leisure-time physical inactivity), married adults were generally found to be healthier than adults in other marital status categories”. A notable exception in their study was obesity-- married men were *more* likely to be obese than those in other martial groups. One possible explanation for all of these findings is that marriage selects for better health, i.e. healthier individuals are more likely to get married.

The relationship between education and marital status differs between men and women. For men, each increasing year of education is associated with an increasing likelihood of marriage, and this association has grown stronger from 1980-2000 (Rose 2003). For women, there exists a "marriage penalty" after 12-16 years of education. Initially, women and men can expect a positive association between education and likelihood of marriage. However, for women, after 12-16 years of education the association becomes *negative*. This "marriage penalty" for increasing levels of education lessened from 1980-2000. Thus the strength of education's effect on likelihood of marriage seems to be growing for men and women alike.

Since the more highly educated (up to 12-16 years for women) are more likely to be married, and marital status is associated with diabetes, it is important to control as another possible mediating variable in the association between education and diabetes.

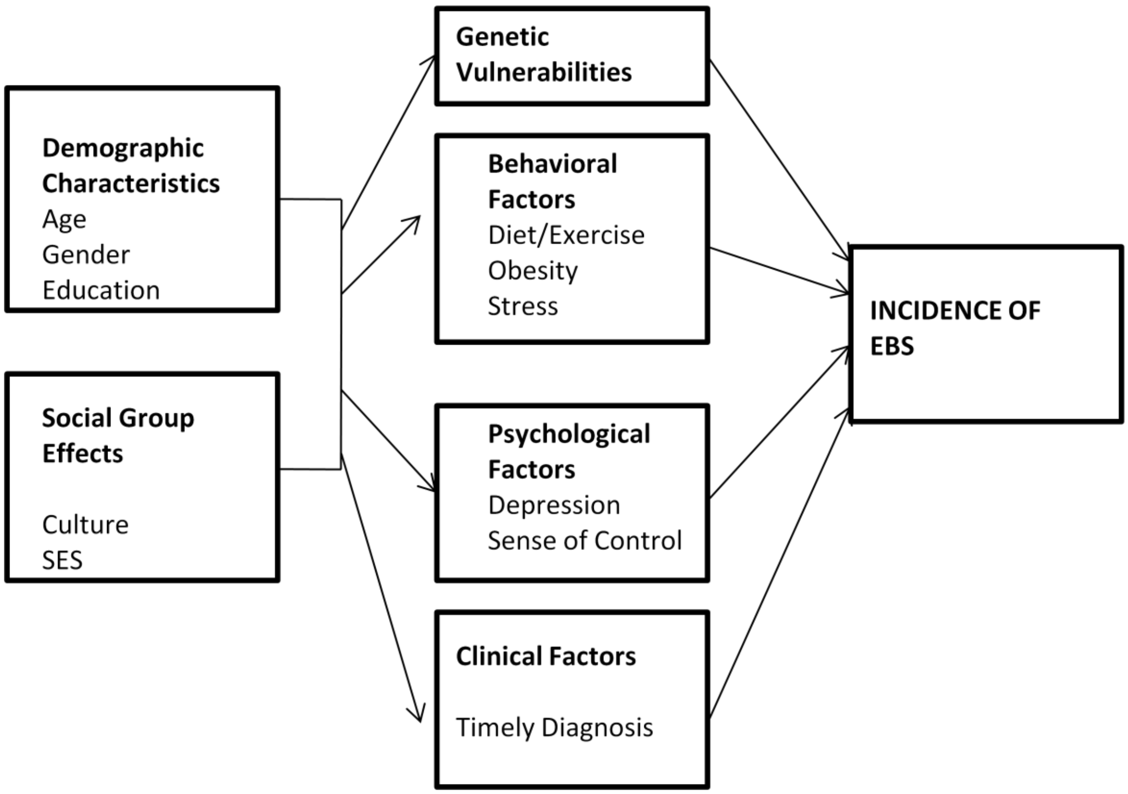
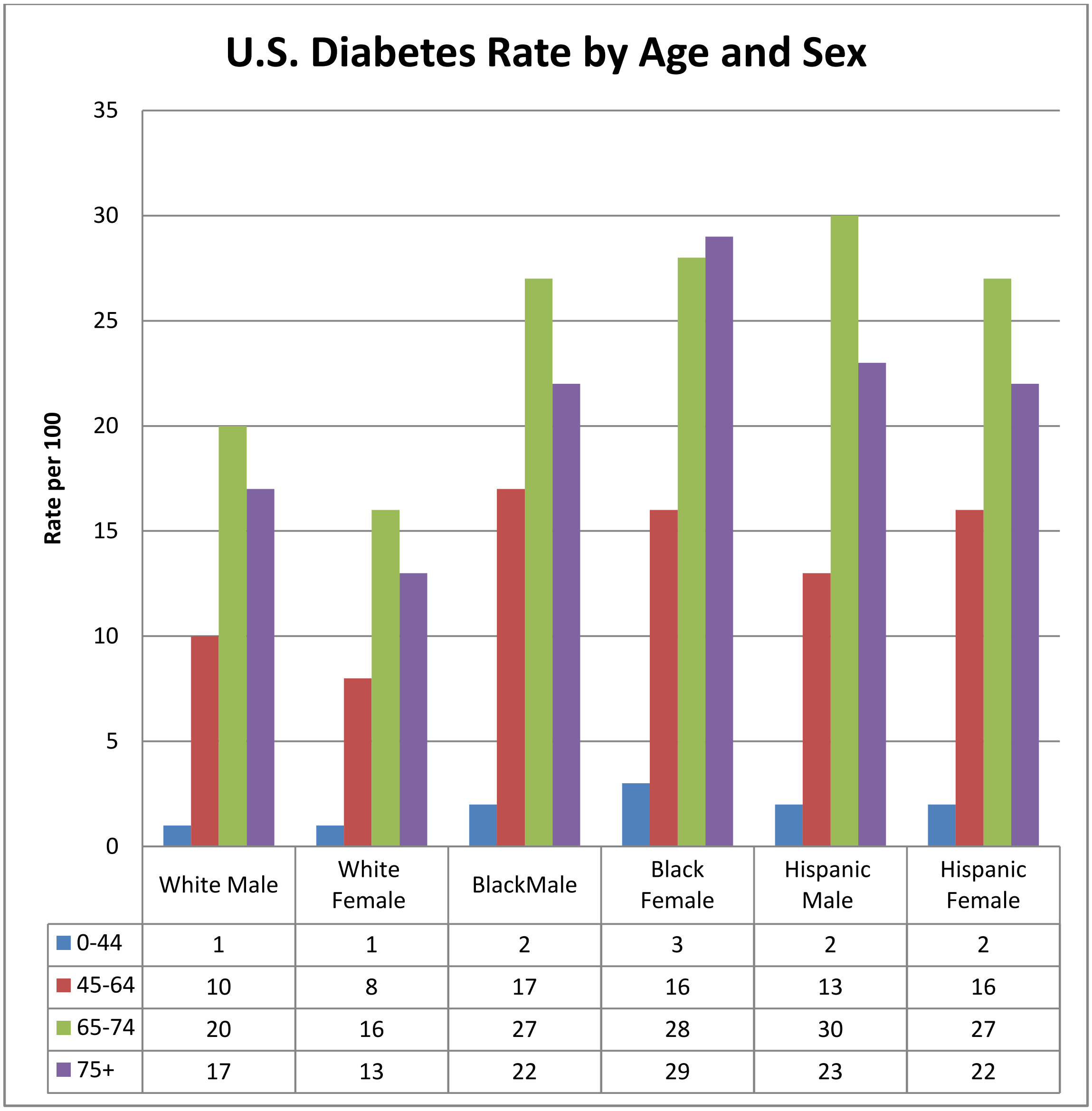


Figure 2-1. Conceptual Framework for Risk Factors for Diabetes, Adapted from Brown (2002).



	White Male	White Female	BlackMale	Black Female	Hispanic Male	Hispanic Female
0-44	1	1	2	3	2	2
45-64	10	8	17	16	13	16
65-74	20	16	27	28	30	27
75+	17	13	22	29	23	22

Figure 2-2. U.S. Diabetes Percentage by Age and Sex. Adapted from Centers for Disease Control 2006

Table 2-1. Obesity and Diabetes Prevalence Among U.S. Adults, by Sex and Age BRFFSS, 2000*

	Obesity %(SE)	Diabetes %(SE)
Total	19.8(.17)	7.3(.12)
Sex		
Male	20.2(.26)	6.5(.18)
Female	19.4(.21)	8.2(.15)
Age		
18-29	13.5(.33)	1.9(.13)
30-39	20.2(.36)	3.8(.18)
40-49	22.9(.41)	5.8(.27)
50-59	25.6(.47)	10.9(.37)
60-69	22.9(.50)	14.5(.44)
>=70	15.5(.41)	14.9(.42)

*Adapted from Mokdad 2008.

CHAPTER 3
DATA AND METHODOLOGY

Objectives and Research Questions

The objective of this thesis is to answer the following three questions: (1) What is the association between education and the development of EBS; (2) does this association vary by race and ethnicity and sex; and (3) does the association between race and ethnicity and elevated blood sugar vary depending on the level of blood glucose?

Hypotheses

Seven hypotheses follow from the research questions and past research. First, it is hypothesized that there is a negative correlation between level of education and probability of having EBS: as level of education increases, the probability of having EBS decreases (H1). This hypothesis is based on the research that has consistently found an association between higher levels of education and better health. Second, it is hypothesized that the association between education and EBS varies by race and ethnicity. The effect of education on probability of having EBS will be weaker among Blacks (H2). This hypothesis is based on the research that suggests there may be a “thrifty gene” that predisposes blacks to EBS and that blacks may not possess the same cultural capital as whites, limiting the effect of education. It is hypothesized that education has similar effects between Hispanics and whites (H3). This hypothesis is based on the previous research that found similar effects of education for whites and Hispanics but not for blacks. It is hypothesized that the effect of education will not differ by sex (H4). This hypothesis is based on research that suggests the effect of socioeconomic status varies by sex for occupational status, but not for level of education. Finally, it is hypothesized that the effect of race and ethnicity and education varies by level of blood glucose. This hypothesis is based on the fact that diabetes and IFG are two different, although closely linked, disease states. Past research and descriptive statistics of the sample analyzed suggest that being black will be associated with lower rates of IFG but higher rates of diabetes (H5). It is expected that being Hispanic will not have a different association with either IFG or diabetes (H6). It is expected that education will have a stronger association with EBS than with diabetes (H7).

Data

Background

The NHANES (National Health and Nutrition Examination Survey has been the primary tool of the National Center for Health Statistics of collecting information on the health of the U.S. population since 1960. NHANES data have been released in two year cycles since 1999 to allow the survey to adjust more quickly to the needs of researchers studying a diversity of health issues within the US population. The NHANES is especially useful to researchers because the survey collects laboratory measures as well as self-reported information on health statuses and other relevant dimensions. Pooled data from the 1999-2006 NHANES are analyzed in this study.

Sample and Selection Procedures

The target population of the survey is the civilian, non-institutionalized US population, with low-income and minority oversamples The survey population is selected through a stratified multistage probability sample. There are four primary stages of sample selection: “1) selection of Primary Sampling Units (PSUs), which are counties or small groups of contiguous counties; 2) segments within PSUs (a block or group of blocks containing a cluster of households); 3) households within segments; and 4) one or more participants within each household. A total of 15 PSU’s are visited during a 12-month time period” (National Center for Health Statistics 2009). Once a household has been selected, it is notified via mail and a NHANES representative makes direct contact with the household to determine if it contains eligible participants. All eligible interviewees are also asked to participate in the medical examination component of

NHANES. Each respondent is randomly assigned to either a morning or afternoon examination session. The morning participants were tested for their fasting levels of various blood chemicals such as glucose. Because the survey sample population varied at each level of the NHANES (questionnaire, medical examination component, and fasting subsample), it is important to use the proper weighting variables when doing analyses. NHANES is based on a clustered sampling design and respondents have different probabilities of selection. Failing to adjust for the sampling design through the use of weights may bias estimates and overstate significance levels (National Center for Health Statistics 2009).

Blood sugar levels in the NHANES were assessed using fasting plasma glucose, two hour glucose tolerance test, and serum insulin in participants aged 12 years and older. The present analysis uses the fasting plasma glucose measure. This measurement comes from the smallest sub-sample group in the NHANES, and following NHANES documentation, the weighting for the smallest subsample is used. Thus the fasting subsample weight variable is appropriate for the analysis. Since data were pooled across four survey cycles, the weight variable had to be adjusted to account for the differing survey years. The NHANES provides a 4 year sample weight to be used with analysis for both 1999-2000 and 2001-2002, and provides a 2 year weight specific to either 2003-2004 or 2005-2006. Combined survey cycles should be representative of the population at the midpoint of the combined survey period and the sum of rescaled weights should match the survey population at the midpoint of each period. The 4 and 2 year weights used in this analysis were made directly comparable by assigning half the 4 year sample weight for respondents in 1999-2002, and ¼ of the sample weight for respondents 2004-2006 (National Center for Health Statistics 2009).

The target sample for analysis consists of US born persons aged 24 and over, although descriptive tables 4-1 through 4-5 report the prevalence of IFG and diabetes in the U.S. population over the age of 20 in order to make a more precise comparison with previously published statistics. Limiting the sample to those born in the US in the regression analysis helps to prevent measuring education received outside the US, and controls for the better health of the immigrant population, also known as the "healthy immigrant" effect (Kennedy et al. 2006).

Variables

Elevated Blood Glucose Level

For the regression analysis, the dependent variable elevated blood sugar is defined as having fasting blood glucose levels greater than or equal to 100 mg/DL, reporting by the respondent that he or she has been told by a doctor the individual has diabetes, or currently taking medication to reduce blood sugar levels. This cut-off point was chosen because it is the new standard definition of having impaired fasting glucose. Elevated blood glucose is coded dichotomously, with 1= having EBS and 0 as not having EBS.

Diagnosed Diabetes

While the regression analysis uses the broadest definition of diabetes, several tables report descriptive statistics using more narrow definitions, such as diagnosed only or undiagnosed diabetes. Tables that report diagnosed diabetes define diabetes as a self-report of a doctor's diagnosis of diabetes, without making use of the blood glucose analysis. Tables that report undiagnosed diabetes report individuals as undiagnosed if they report blood sugar levels greater than 125 mg/dL but do not report having been told by a doctor they have diabetes.

Independent Variables

Education

The education variable used in this analysis was measured as an ordinal variable by handing a respondent a card, reading the categories to them as necessary, and recording the respondent's choice. The respondent could choose from first through 12^{th} grade, high school graduate, GED or equivalent, some college, AA degree, technical degree, BA, MA, or PhD. Codes were also used for Refusal or Don't Know. For analysis, education will be recoded into five categories: less than 9th grade, less than high school, high school degree, some college, and BA or greater. Although data for blood glucose and education is available for all respondents aged 12 and over, analysis is limited to those age 24 and over because this is the standard minimum age at which someone is likely to earn a degree beyond that of the BA.

Race

The race variable used in this analysis was constructed from two variables that are respondent self-reports on questions of race and ethnicity. From these questions, the main race variable was constructed containing the following racial-ethnic categories: Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, and Other. These categories are collapsed for the final analysis into Hispanic, Non-Hispanic White, and Non-Hispanic Blacks.

Age

Age was ascertained by asking the respondent "How old are you", with a resulting response range (for the final sample used in the analysis) between 24 and 85 years of age. Anything greater than 85 was put into the 85+ category. (N=599). Age is coded into three categories: age 24-35, age 36-45, and age 46 or older.

Marital Status

Marital status was computed from both the question asking the respondent their marital status, and imputing data from responses that made reference to marital status. Marital status is coded as a dummy variable in the analysis, with 1 being married, 0 if not married.

BMI

BMI was calculated using measurements from the medical examination portion of the NHANES survey. This variable was coded as overweight for any individual over 24.9 kg divided by meters of height squared and normal for any individual less than 25 kg divided by meters of height squared.

Methods: Continuation Ratio Model

The continuation ratio model is an appropriate model when the ordered categories follow a progression of stages. Stages of elevated blood glucose are an appropriate outcome to model using a continuation ratio as it is possible to rank the stages from “low” to “high”, and generally one must proceed through one stage of blood glucose before entering into another. This study uses the continuation ratio model because the objectives require an analysis of the effects of selected covariates across the different stages of blood glucose.

Pooled data from the 1999-2006 NHANES are analyzed using binomial logistic regression to determine racial and ethnic differences in the magnitude of education’s effect on blood sugar levels. For this analysis, there exist three different stages of blood sugar to be compared: normal, elevated, and diabetic stages of blood sugar. The first comparison, or “stage” will be made between those with normal blood sugar and those at the first "cut-off" point of blood glucose levels of 100 mg/dL or more. The second comparison, or “stage” will be between those who have diabetes versus those who do not, among the population of individuals with EBS. Finally, interaction terms of the form stage*'x', where x is an independent variable, can be used to test for differences of effects of the variables included in the model across the different stages of the outcome variable. A significant interaction term indicates that the effect of the particular variable differs depending on the stage of the outcome variable.

Models for males and females are estimated separately because an overall Wald Test indicated that at least one coefficient was significantly different for males and females ($F=2.62$, $p<.05$). Thus our fourth hypothesis, that of no interaction between sex and education in the association with EBS is not supported. Significant sex differences will be reported in Tables 4-7 and 4-8. The first model will use EBS (having either impaired fasting glucose or diabetes) as its outcome measure. The second regression model will compare those with diabetes, defined as having a blood glucose level greater than or equal to 126 mg/dL, taking medication to control blood sugar, or having been told by a doctor the individual has diabetes, with those who have EBS but do not have diabetes.

CHAPTER 4
RESULTS AND ANALYSIS

Data Description

Table 4-1 summarizes weighted and un-weighted estimates of impaired fasting glucose percentages for the U.S. population over the age of 20 across sex and race and ethnicity. While later analyses use National Health and Nutrition Examination data for ages 24 and older, this table uses data for ages 20 and over to facilitate comparison with previous studies. This table includes a column for a "reference" parameter, derived from another article that used data from the 1999-2002 NHANES for estimates of impaired fasting glucose and diabetes in the U.S. population (Cowie 2002). Cowie’s estimates generally differ from the present analysis by about 1%. These differences likely are the result of different weighting procedures used by Cowie (2002) to derive estimates from a combined sample.

Data for each two year release cycle of the NHANES is presented, as well as a weighted average constructed using all eight years of data. The weighted population average of IFG across all eight years of data is 26.6%. Results from this thesis’ analysis replicate the finding that rates of impaired fasting glucose have not risen dramatically, changing from 25.3% for 1999-2002 to 27.9% in 2003-2006, although a 2.5% increase in the U.S population suggests that well over half-a million people more in 2006 have impaired fasting glucose than in 2002. Overall, men are consistently found to have higher percentages of IFG than women. The eight year average of percentage of men with IFG is 34.5%, versus 21.8% for women. Men across all three race/ethnicities also have a higher percentage of IFG than women. The eight year average percentages of white, black, and Mexican-American men are 34.0%, 22.0%, and 35.3%, respectively. The eight year average percentages of women with IFG are 21.2%, 18.9%, and 19.0%, respectively. With respect to race, whites and Hispanics consistently have a higher percentage of their populations with IFG than blacks. Whites have an eight year average of 27.3% and Hispanics have a similar 27.7% average. The eight year average for blacks is 20.3%.

This table suggests that there are racial and ethnic differences as well as sex differences in the U.S. population in prevalence of impaired fasting glucose. IFG puts the individual at greater risk for developing diabetes. Do these apparent differences between sex and racial and ethnic groups persist into the next stage of elevated blood sugar, diabetes? Table 4-2 presents weighted and unweighted estimates of percentages of individuals with diagnosed diabetes. Data for each two year release cycle of the NHANES is presented, as well as a weighted average constructed using all eight years of data. The weighted population average of diagnosed diabetes is 7.1%. Overall, men and women have similar levels of diagnosed diabetes. The eight year average of percentage of men with diagnosed diabetes is 7.1%, versus 7.2% for women. Blacks and Hispanics consistently have a higher percentage of diagnosed diabetes than Whites. Whites have an eight year average of 6.3%, whereas blacks have the highest eight year average, 10.9%, and Hispanics have an eight year average of 7.3%. Within racial and ethnic categories, only white men have a higher percentage of diagnosed diabetes than woman, 6.5% vs. 6.1%. For blacks and Hispanics, women appear to have a higher percentage of diagnosed diabetes than their male counterparts: 9.9% vs. 11.7% among blacks and 6.2% vs. 8.4% among Hispanics.

The apparent difference in diagnosed diabetes by race and ethnicity reverses the trend seen in Table 4-1, where whites consistently had a higher percentage of individuals with IFG. However as previously discussed, racial and ethnic differences of undiagnosed diabetes appear minimal. (Please see Table 1-1) Thus it is not surprising that in Table 4-3, which presents the percentage of persons with diabetes, including diagnosed, undiagnosed, and those taking medication, the patterns seen in Table 4-2 persist.

Data for each two year release cycle of the NHANES are presented in Table 4-3, as well as a weighted average constructed using all eight years of data. The weighted population average of diabetes is 9.9%. (versus 7.1% with diagnosed diabetes). Overall, men and women have similar levels of diabetes, although men have a slightly higher percentage of individuals with diabetes than women with the expanded definition of diabetes. Blacks and Hispanics consistently have a higher percentage of diagnosed diabetes than Whites. Whites have an eight year average of 6.3%, whereas blacks have the highest eight year average, 10.9%, and Hispanics have an eight year average of 7.3%. Within racial and ethnic categories, only white men have a higher percentage of diagnosed diabetes than woman, 10.3% vs. 7.7%. For blacks and Hispanics, women appear to have a higher percentage of diabetes than their male counterparts: 9.9% vs. 11.7% among blacks and 6.2% vs. 8.4% among Hispanics. Thus there seem to be two differences between levels of elevated blood sugar (IFG and diabetes): both Table 4-2 and Table 4-3 reverse the trend seen in Table 1, where whites consistently had a higher percentage of individuals with IFG.; and there are only small sex differences for diabetes, unlike the sex differences found at the IFG level of blood sugar.

Tables 4-1 through 4-3 show some evidence for different effects of race and ethnicity and sex across different levels of blood sugar. Males, especially white males, seem to have a higher percentage of individuals with IFG, however this sex effect is not as pronounced at the diabetic stage. Race effects also appear to differ: blacks have the lowest 8 year average percentage of individuals with IFG (20.3%) but the highest 8 year average percentage of individuals with diabetes (13.2%).

Tables 4-4 and 4-5 present descriptive statistics for another independent variable of interest, education, and the weighted percentages of individuals with both IFG and diabetes within 3 categories of educational attainment: less than high school, high school degree, and college or more. Estimated percentages of both IFG and diabetes tend to decrease as level of education increases. Overall, among those in the lowest level of education, 31% and 15.2% are estimated to have IFG and diabetes, respectively. These estimates decrease to 24.3% and 7.7%, respectively, for those individuals in the highest category.

At the level of IFG, there are some apparent race differences: the estimated percentage of whites decreases with each increasing category of education; moving from 34.8% among those with less than a high school education to 29.8% among those with a high school degree, to 24.6% among those with some college education or more. Among Blacks, for both men and women, there appears to be little effect of increasing education on the estimated percentages of individuals with IFG. For Hispanics, the highest estimated percentage of individuals with IFG is in the lowest category (30.6%), and the lowest estimated percentage is for individuals with a high school degree (19.5%).

At the level of diabetes, there are again some apparent race differences: the estimated percentage of whites decreases with each increasing category of education; moving from 14.6% among those with less than a high school education, 9.9% among those with a high school degree, and 7.3% among those with some college education or more. Among blacks there also appears to be a trend of decreasing percentages of individuals with diabetes, moving from 17.5%, to 14.2%, to 9.9%. For Hispanics, the highest estimated percentage of individuals with diabetes is in the lowest category of education (14.1%), and the lowest estimated percentage is for individuals with a high school degree (8.2%). For Hispanic women, the downward trend continues on into the highest category of education, with 6.7% of Hispanic women estimated to have diabetes. However for Hispanic men, having some college education or more seems to have little effect on percentage of individuals with diabetes compared to Hispanic men with a high school degree.

Tables 4-1 through 4-5 tables have provided evidence for differing effects of sex, race and ethnicity, and education in their respective associations with levels of blood sugar. The next section presents formal tests to see if these apparent trends have statistical significance

Table 4-6 is the final descriptive statistics table, and includes the means and proportions of variables used in the continuation ratio model analysis. For percentages of educational attainment across five levels of education for the entire NHANES sample, rather than just the US born segment, see Table 1, Appendix A.

Results for Men

Table 4-7 displays the logistic regression results for males. These regression results represent the effects of the covariates across two different stages of blood sugar. The regression coefficients of the covariates reported in Stage 1 describe the effects of their respective variables on the log odds of having either impaired fasting glucose or diabetes compared to normal levels. The regression coefficients of the covariates reported in Stage 2 describe the effects of their respective variables on the log odds of having diabetes, given that the individual has elevated blood sugar. Coefficients with a significance level of less than .05 are considered significant. Four different models were tested: (1) a model with just race and age, (2) a model that additionally adjusts for educational attainment, (3) a model which additionally adjusts for marital status and BMI, and finally (4) a model which allows interaction between race and ethnicity and education. The column labeled as "Stage Diff" reports the results of significant stage interactions for the covariates. This interaction signals that the effect of the covariate is significantly different from one level of blood sugar to the next. For males, stage differences were tested using equation three because of the lack of significant education and race and ethnicity interactions in equation four. For females, stage differences were tested using equation four, which included the interaction between education and race and ethnicity.

Although the education and race and ethnicity interaction effects are insignificant for males they are included for the sake of model comparisons with females. The same four models were estimated for males and females at the two stages of elevated blood sugar: impaired fasting glucose and diabetes. The column labeled as "Sex Diff" report the results of significant sex interactions for each of the two stages of blood sugar. Significant sex differences correspond to equation four, which allowed for education and race and ethnicity interactions.

Males, Stage 1: Impaired Fasting Glucose

Model 1 examines the main effects of race controlling for age. Being black has a significant effect on reducing the log odds of developing EBS relative to whites (b=-0.28, p<.05). Being in either of the two youngest age categories is also significantly associated with reduced probability of developing EBS.

Model 2 additionally adjusts for level of education. Having a BA or more is the only level of education found to be statistically different in its effect on the log odds relative to having a high school education. Having a BA or more reduces the log odds of having either IFG or diabetes by 0.33. Being black continues to have a significant association with reduced log odds of developing EBS.

Model 3 additionally adjusts for marital status and BMI. Being married has no significant association with EBS relative to non-married individuals, however having a BMI of 26 or over is associated with a significant increase in the log odds of developing EBS (b=0.94, p<.01). Being in either of the younger age groups significantly reduces the probability of having EBS (b=-1.53, p<.01 for ages 24-35 and b=-0.86, p<.01 for ages 36-45). There are no significant effects of race, education, or marital status in the full main effects model for males. Thus for males, our first hypothesis of a direct association between education and probability of having EBS is not supported.

Model 4, the last model, allows for an interaction effect between race and ethnicity and education. These interaction terms are insignificant, indicating that our second hypothesis of an interaction between being black and educational attainment that reduces the effect of education on probability of having EBS is not supported. Our third hypothesis that education's association with EBS is similar for Hispanics and whites *is* supported by the lack of interaction. The interaction terms, although insignificant, are included in the final model for proper comparisons of males with the final model for females.

Males, Stage 2: Diabetes

Four models were again tested for stage 2. The regression coefficients of the covariates reported in stage 2 describe the effects of their respective variables on the log odds of having diabetes, given that the individual already has EBS.

Model 1 tests just the effects of race and age. Being black is found to have a significant association with increased log odds of having diabetes ($b=.56$, $p<.01$). This is a reversal blacks association with reduced probability of having elevated blood sugar. However statistical tests of stage differences are not conducted until equation 3, the full model. Being Hispanic is also found to have a significant association with an increased probability of developing diabetes, given EBS ($b=.70$, $p<.01$) Being in the youngest age category has a significant association with reduced probability of developing diabetes given one has EBS ($b=-1.13$, $p<.01$).

Model 2 additionally adjusts for level of education. Unlike in Stage 1, no level of education is found to be statistically different in its association with the log odds of developing diabetes relative to having a high school education, nor are any of the effects of education found to be significantly different depending on stage of blood sugar or race and ethnicity. After adjusting for education, being in the youngest category relative to the oldest category continues to be associated with reduced probability of having diabetes given one has EBS (b=-1.2-, p<.01).

Model 3, the full main effects model for males, additionally adjusts for marital status and B.M.I. Being married has no significant association with probability of having diabetes, given IFG. Having a BMI in the "overweight" or "obese" categories has a significant association with increased log odds of developing diabetes relative to those with a "normal" B.M.I. (b=0.52, p<.05). Being black or Hispanic continues to have a significant association with increased probability of developing diabetes given EBS.

As in stage 1, model 4, the final model, allows for an interaction between race and ethnicity and education. These interaction terms continue to be insignificant but are included in the final model for proper comparisons of males with the final model for females.

Stage Differences for Males

Statistical tests for difference of effect of covariates within the statistical model for males were conducted using equation 3, the full main effects model. Three variables were found to vary significantly by stage for males: being black, being Hispanic, and BMI. The lack of an interaction between education and stage of blood glucose does not support our seventh hypothesis that education's association with EBS would be stronger than with diabetes, given IFG.

In stage 1, model 3, being black had a significant association with reduced probability of developing EBS. In stage 2, model 3, being black is found to have a significant association with increased probability of developing diabetes, given EBS. This finding supports the fifth hypothesis that the effect of being black will vary by level of blood glucose. The proportional odds model is limited in that it forces the effect of the independent variable to have the same effect for every level of the outcome variable. The ability of the continuation ratio model to both estimate and test differences across stages indicates its superiority to the proportional odds model in this particular analysis. The continuation ratio model provides more flexibility in the effect of the independent variable and allows a *third* statistical inference about the effect of being black: that these two coefficients are significantly different from each other across the stages of blood glucose. The results of the stage interaction tests are evidence that the effect of being black has a significantly different effect depending on the level of blood glucose. Being black reduces the probability of developing EBS. However, being black has a significantly different effect given EBS on increasing the probability of diabetes.

A second variable found to have significantly different effects across stages of blood glucose is being Hispanic. In stage 1, equation 3, being Hispanic has no significant effect on estimated probability of EBS. In stage 2, equation 3, being Hispanic has a significant effect on increasing the probability of developing diabetes. Thus our sixth hypothesis of no interaction between being Hispanic and level of blood glucose is rejected. The lack of statistical difference in stage 1 highlights the difference between a CRM stage test of difference and a standard inference about regression coefficients: CRM tests for difference of effect by level of the dependent variable whereas standard inference tests difference from zero. Thus even though both coefficients may be insignificantly different from zero, the two coefficients may be different from each other.

The third variable found to have a significantly different effect by level of blood glucose is BMI. In stage 1, model 3, being overweight has a significant effect on increasing the probability of developing EBS ($b=0.94$, $p<.01$) In stage 2, model 3, being overweight has a significant effect on increasing the probability of diabetes, given EBS. BMI thus appears to have a significantly smaller effect on developing diabetes given EBS then on developing EBS for males.

Results for Females

Table 8 presents the regression results for females across the two different stages of blood sugar. The regression coefficients of the covariates reported in Stage 1 describe the effects of their respective variables on the log odds of having *either* impaired fasting glucose *or* diabetes relative to the population that does not have impaired fasting glucose or diabetes. The regression coefficients of the covariates reported in Stage 2 describe their effects on the log odds of having diabetes, given that the individual has impaired fasting glucose. Four models were tested: (1) a model with just race and age, (2) a model that additionally adjusts for educational attainment (3) a model which additionally adjusts for marital status and B.M.I. and finally (4) a model which allows for an interaction between race and ethnicity and education.

Females, Stage 1: Impaired Fasting Glucose

In model 1 with just race and age, being either black or Hispanic has a significant association with reduced log odds of having either IFG or diabetes relative to whites. Like males, being in either non-referent age group, Age 20-35 and Age 35-45, is found to have a significant association with reduced log odds of having either IFG or diabetes relative to being over the age of 45.

Model 2 additionally adjusts for level of education. Each level of education for females in stage 1 was found to have a significantly different effect on log odds of developing EBS relative to having a high school degree. Having less than a high school degree has a significant association with increased log odds, while having more than a high school degree had a significant effect on decreased log odds.

Model 3 additionally adjusts for marital status and B.M.I. Being married has no significant association with EBS probability, however being overweight or obese has a significant association with increased log odds of developing EBS relative to those with a overweight

B.M.I. (b= 1.33, p<.01). All levels of education continue to be associated with probability of developing diabetes.

Model 4 allows for an interaction between race and ethnicity and education. The two younger categories continue to have a significant association with reduced log odds of having elevated blood sugar. Having less than a high school education is associated with a higher probability of having EBS and having more than a high school education is associated with a lower probability of having EBS, supporting the first hypothesis. An adjusted Wald test was performed to see if the slopes for educational attainment vary by race and ethnicity. The omnibus test provides strong evidence that there is an interaction effect (F=3.14, p<.01). The interaction between being black and having less than a 9th grade education lends support to the second hypothesis that being black lessens the association between education and probability of having EBS. An interaction for Hispanics having a BA or more is significant (b=1.6, p<.01). Thus there is evidence that being Hispanic is associated with a reduced assoication of having a BA or more on the log odds of having EBS. This does not support the third hypothesis of no interaction between education and Hispanics.

Females, Stage 2: Diabetes

The same four models were tested for stage 2. Again, the regression coefficients of the covariates reported in stage 2 describe the statistical effects of their respective variables on the log odds of having diabetes, given that the individual already has EBS.

Model 1 tests just the effects of race and age. Unlike in stage 1, being black is found to have a significant association with increased log odds of having diabetes relative to whites, given one has EBS (b=.80, p<.01).. Being Hispanic does not have a significantly different effect on the progression from IFG to diabetes. Unlike that of having either IFG or diabetes, age is not associated with progression from IFG to diabetes.

Model 2 additionally adjusts for level of education. No level of education is found to be statistically different in its effect on the log odds relative to having a high school, nor are any of the effects of education found to be significantly different depending on stage of blood sugar or race and ethnicity.

Model 3 additionally adjusts for marital status and B.M.I. For females, being married is associated with a decreased probability of developing diabetes given EBS ($b=-0.52$, $p<.01$).. Being overweight or obese is again associated with increased log odds of developing diabetes relative to those with a "normal" B.M.I. ($b=0.74$, $p<.01$). Being in the youngest categories continues to be associated with reduced log odds of having elevated blood sugar relative to those in the oldest age category, given one has EBS

Model 4 allows for an interaction effect between race and ethnicity and education however no interactions are found to be significant.

Stage Differences for Females

Four covariates were found to have statistical effects that differed by level of blood glucose: being black, being in the youngest age category, being married, and BMI. The seventh hypothesis of a stronger association between education and lower levels of blood glucose is not supported by the lack of an interaction between education and level of blood glucose.

In stage 1, model 4, the effect of being black on probability of EBS was insignificant. In stage 2, model 4, being black was still insignificant in its effect on diabetes. However, the two estimates are significantly different from each-other, supporting the fifth hypothesis of an interaction between being black and stage of blood glucose. Being black has no statistically significant effect on probability of either EBS or diabetes, but the effect in stage 2 is significantly greater than in stage 1. The lack of an interaction between being Hispanic and level of blood glucose in the association with probability of EBS supports the sixth hypothesis that the association between EBS probability and being Hispanic does not vary with level of blood glucose

In stage 1, model 4, being married has no association with EBS. In stage 2, model 4, being married has a significant association with a reduced the probability of developing diabetes (b= -0.77, p<.05). In stage 1, model 4, being overweight has a significant association with an increased probability of EBS (b=1.32, p<.01). Like males, the direction of association of BMI with EBS remains constant into stage two, increasing the probability of diabetes given EBS (b=0-.77, p<.05). Again, the effect of BMI is significantly different and weaker for females in stage 2 than in stage 1.

Sex Differences

Stage One

All tests of sex interaction were done using equation four. Three covariates were found to have significantly different effects by sex for stage 1: having more than a high school education, having a BA or more, and BMI. Having more than a high school degree was not significantly associated with EBS for males, however it significantly reduced the probability of EBS for females. The same pattern was found for having a BA or more. These findings suggest that educational attainment has a stronger association for females than for males in reduced probability of EBS for whites.

The third covariate found to differ by sex in stage 1 was BMI. For females, the effect of being overweight was stronger than for males (beta(males)=0.94, beta(females)=1.32). This suggests that, like high educational attainment, higher BMI has a stronger association with an increased probability of EBS for females than for males.

Stage Two

Two sex differences in the effects of covariates on the probability of diabetes given EBS were found in stage 2: the effect of marital status and an interaction term for Hispanics and having a BA or more.For males, being married does not have a significant effect on the probability of developing diabetes given IFG. For females however, being married has a significant effect on reducing the probability of diabetes ($b=-.54$, $p<.01$).

The interaction term is not significantly different from zero for either males of females, but appears to have a different direction of effect: having a BA or more for male Hispanics is associated with higher probability of diabetes but having a BA or more for female Hispanics is associated with a lower probability. While the term approaches significance for females, neither term is significantly different from zero.

Figures 4-1 through 4-4 present estimated risk of EBS and diabetes given IFG for individuals in the oldest age category, single, and overweight based on equation four in tables 4-7 and 4-8. In Figure 4-1, one of the clearest rends is that for Hispanic males—the estimated risk of EBS per 1,000 decreases with each increasing level of education, except for having more than a high school degree. In Figure 4-2, Hispanics do not show the same nearly stepwise benefit from increasing education. Whites however have a large difference in estimated relative risk of developing diabetes. Having less than a 9th grade education for white males is estimated to increase the probability of developing diabetes by 23% relative to a high school degree whereas having a BA or more reduces the probability by 14%.

Figure 4-3 describes the risk of having EBS for females who are overweight, single, and over age 45. Among Hispanics, there is a “U’ shaped trend in the estimated relative risk of developing EBS, with the lowest risk among Hispanics with a high school degree and the highest risk in the two lower categories of education and in the highest category of education. In Figure

4-4, this ‘U’-shaped trend disappears for relative risk of having diabetes for Hispanic females. Hispanics with a BA or more are estimated to have a 76% lower probability of having diabetes, given EBS, than Hispanics with a high school degree. Having a BA or more for blacks and whites is also estimated to reduce probabilities of developing diabetes relative to having a high school degree.

Table 4-1. Frequencies and Prevalence of IFG* for Individuals Aged 20 and Over Without Diagnosed Diabetes** in the U.S. Population, NHANES 1999-2006, Aged 20 and Over Without Diagnosed Diabetes in the U.S. Population NHANES 1999-2006,Weighted Data

	Frequencies 1999-2000	Frequencies 2001-2002	Frequencies 2003-2004	Frequencies 2005-2006	Combined Frequencies 1999-2002	Reference*** Prevalence 1999-2002	Weighted Prevalence 1999-2002	Weighted Prevalence 2003-2006	Weighted Prevalence 1999-2006
Total	479(25.9%)	617(28.0%)	523(26.6%)	605(30.5%)	1096(27.1%)	26.0%	25.3%	27.9%	26.6%
Men	282(32.6%)	380(36.1%)	290(30.7%)	365(37.9%)	662(34.5%)	33.0%	31.8%	34.2%	34.5%
Women	197(20.0%)	237(20.6%)	233(22.9%)	240(23.6%)	434(20.4%)	20.0%	19.4%	22.1%	21.8%
White	223(26.6%)	356(30.1%)	314(29.4%)	311(31.1%)	579(28.7%)	27.0%	26.2%	28.5%	27.3%
Men	140(34.5%)	215(38.0%)	181(35.2%)	203(40.0%)	355(36.6%)	34.0%	33.0%	35.0%	34.0%
Women	83(19.21%)	141(22.9%)	133(24.0%)	108(22.0%)	224(21.4%)	21.0%	20.0%	22.4%	21.2%
Black	64(19.9%)	71(18.9%)	82(22.5%)	120(27.3%)	135(19.4%)	17.0%	17.3%	23.0%	20.3%
Men	29(20.6%)	39(21.6)	36(21.0%)	62(30.1%)	68(21.1%)	19.2%	19.1%	24.7%	22.0%
Women	35(19.4)	32(16.5%)	46(23.8%)	58(24.7%)	67(17.9%)	15.0%	15.8%	21.7%	18.9%
Hisp.	148(28.6%)	154(31.4)	94(23.7%)	121(30.8%)	302(29.9%)	30.0%	29.2%	26.4%	27.7%
Men	88(36.8%)	106(45.5)	52(26.3%)	67(36.6%)	194(41.1%)	41.1%	41.2%	30.3%	35.3%
Women	60(21.6%)	48(18.7)	42(21.1%)	54(25.7%)	108(20.2%)	18.0%	15.6%	22.0%	19.0%

* Impaired Fasting Glucose defined as individuals with glucose levels 100-125 mg/dL(5.6 to 6.9 mmol/L)
**Individual who had been told by doctor they had diabetes were excluded from the sample
*** Cowie et al. 2006. "Prevalence of Diabetes and Impaired Fasting Glucose in Adults in the U.S. Population" *Diabetes Care*. Vol. 29:1263-1268.

Table 4-2. Frequencies and Prevalence (SE) of Diagnosed Diabetes * for Individuals Aged 20 and Over in the U.S. Population, NHANES 1999-2006. Weighted Data

	Frequencies 1999-2000	Frequencies 2001-2002	Frequencies 2003-2004	Frequencies 2005-2006	Combined Frequencies 1999-2002	Reference** Prevalence 1999-2002	Weighted Prevalence 1999-2002	Weighted Prevalence 2003-2006	Weighted Prevalence 1999-2006
Total	480(9.8%)	511(9.5%)	545(10.8%)	509(10.2%)	2045(10.1%)	6.5%	6.5%2	7.7%	7.1%
Men	233(10.3%)	248(9.8%)	269(11.1%)	247(104%)	997(10.4%)	6.7%	6.7%	7.4%	7.1%
Women	247(9.5%)	263(9.2%)	276(10.5%)	262(10.1%)	1048(9.8%)	6.3%	6.3%	8.1%	7.2%
White	146(6.6%)	220(7.7%)	243(9.0%)	192(7.7%)	801(7.8%)	5.6%	5.6%	6.9%	6.3%
Men	84(7.9%)	112(8.4%)	130(10.1%)	92(7.6%)	418(8.5%)	6.1%	6.2%	6.7%	6.5%
Women	62(5.4%)	108(7.1%)	113(8.0%)	100(7.8%)	383(7.1%)	5.0%	5.1%	7.1%	6.1%
Black	130(14.3%)	118(11.7%)	124(12.5%)	169(15.1%)	541(13.4%)	10.0%	10.0%	11.7%	10.9%
Men	55(13.4%)	53(11.1%)	53(11.1)%	89(16.4%)	250(13.1%)	8.2%	8.2%	11.4%	9.9%
Women	75(15.0%)	65(12.2%)	71(13.7%)	80(13.8%)	291(13.6%)	11.4%	11.4%	12.0%	11.7%
Hisp.	151(11.8%)	127(11.4%)	146(14.8%)	113(11.3%)	537(12.3%)	6.5%	6.5%	7.9%	7.3%
Men	71(12.0%)	59(11.0%)	73(15.2%)	51(10.7%)	254(12.2%)	5.4%	5.3%	7.0%	6.2%
Women	80(11.6%)	68(11.9%)	73(14.5%)	62(11.7%)	282(12.3%)	7.8%	7.7%	9.0%	8.4%

*Physician diagnosis *only* of diabetes

** Cowie et al. 2006. "Prevalence of Diabetes and Impaired Fasting Glucose in Adults in the U.S. Population" *Diabetes Care*. Vol. 29:1263-1268.

Table 4-3. Prevalence (SE) of Diabetes as Measured from Either Diagnosis Medication Usage or Blood Analysis for Individuals Aged 20 and Over in the U.S. population, NHANES 1999-2006 Weighted Data

	1999-2000	2001-2002	2003-2004	2005-2006	1999-2006
Total	8.5%(.01)	10.0%(.01)	10.3%(.01)	10.6%(.01)	9.9%(<.01)
Men	9.1%(.01)	11.9%(.01)	11.4%(.01)	9.6%(.01)	10.6%(.01)
Women	7.9%(.01)	8.3%(.01)	9.3%(.01)	11.5%(.01)	9.3%(.01)
White	7.7%(.02)	9.1%(.01)	9.2%(.01)	9.7%(.01)	9%(.01)
Men	9.6%(.02)	11.8%(.02)	11.3%(.01)	8.4%(.02)	10.3%(.01)
Women	5.9%(.01)	6.5%(.01)	7.3%(.01)	10.9%(.01)	7.7%(.01)
Black	9.6%(.01)	13.2%(.02)	14.2%(.02)	15%(.02)	13.2%(.01)
Men	5.1%(.01)	11.5%(.02)	12.9%(.03)	15.3%(.02)	11.6%(.01)
Women	12.8%(.02)	14.6%(.03)	15.2%(.03)	14.8%(.02)	14.4%(.01)
Hisp.	10.3(.01)	10%(.01)	11.6%(.03)	12.4%(.01)	11.3%(.01)
Men	8.8%(.03)	9.5%(.02)	11.4%(.03)	11.4%(.03)	10.2%(.01)
Women	11.6%(.05)	12.6%(.02)	11.8%(.04)	13.6%(.03)	12.4%(.02)
	N=1,854	N=2,205	N=1,977	N=1,982	N=8,018

*Diabetes includes individual self-reports of physician diagnosis, medication usage, and analysis of glucose levels from blood samples with diabetic levels >=7.0 mmol per L (>=126 mg per dL)

Table 4-4. Prevalence (SE) of U.S. Population Aged 20 Years and Older with IFG*
by Educational Attainment, NHANES 1999-2006: Weighted Data

	Impaired Fasting Glucose Less Than High School	High School Degree	College or More
Total	31%(.013)	27.8%(.015)	24.3%(.010)
Men	36%(.019)	31.8%(.020)	31.1%(.013)
Women	26.4%(.015)	24.1%(.015)	18.1%(.011)
White	34.8%(.013)	29.8%(.017)	24.6%(.013)
Men	39.6%(.030)	34.0%(.024)	31.7%(.015)
Women	30.5%(.028)	25.9%(.018)	18%(.014)
Black	21.8%(.021)	23.4%(.026)	19.1%(.015)
Men	22.4%(.028)	25.0%(.036)	20.2%(.027)
Women	21.2%(.212)	21.9%(.030)	18.3%(.019)
Hisp.	30.6%(.016)	19.5%(.031)	21.1%(.022)
Men	38.7%(.023)	23.9%(.039)	27.6%(.031)
Women	22.2(.021)%	14.6%(.037)	15.0%(.032)
	N=2,440	N=1,872	N=3,667

* Impaired Fasting Glucose defined as individuals
with glucose levels 5.6 to 6.9 mmol per L (100-125 mg per dL)

Table 4-5. Prevalence (SE) of Diabetes in U.S. Population by Educational Attainment

	Less Than High School	High School Degree	College or More
Total	15.2%(.01)	10.5(.01)	7.7%(.01)
Men	12.8%(.01)	9.9%(.01)	10.1%(.01)
Women	17.3%(.02)	11.1%(.01)	5.6%(.01)
White	14.6%(.02)	9.9%(.01)	7.3%(.01)
Men	14.3%(.02)	9.5%(.02)	9.9%(.01)
Women	15%(.02)	10.2%(.01)	4.9%(.01)
Black	17.5%(.02)	14.2%(.02)	9.9%(.01)
Men	14.1%(.02)	10.6%(.02)	10.0%(.02)
Women	20.8%(.03)	17.4%(.03)	9.8%(.02)
Hisp.	14.1%(.01)	8.4%(.02)	8.6%(.02)
Men	10.8%(.02)	8.5%(.03)	10.6%(.03)
Women	17.5%(.03)	8.2%(.03)	6.7%(.03)
	*N=2,450	N=1,880	N=3,673

*Diabetes includes individual self-reports of physician diagnosis, medication usage, and analysis of glucose levels from blood samples with diabetic levels >=7.0 mmol per L (>=126 mg per dL)

Table 4-6. Proportions and Means of U.S. Born Population(SE) Over the Age of 24. Weighted Data NHANES 1999-2006

		White	Black	Hispanic
Age(In Years)	48(.42)	43.3(.50)	40.7(1.6)	
Education				
Less Than 9th Grade	4%	5%	10%	
Less Than HS Degree	9%	24%	21%	
High School Degree	28%	24%	22%	
More Than High School	32%	33%	37%	
BA or More	27%	13%	10%	
Marital Status				
Married	62%	33%	57%	
BMI				
Over	64%	74%	74%	
Under	2%	2%	2%	
Normal	34%	24%	24%	

Table 4-7. Results From a Logistic Regression Continuation Ratio Model for Males Greater Than 24 Years Old for Having EBS Given Normal Blood Glucose (Stage 1):NHANES 1999-2006

	Model 1		Model 2		Model 3		Model 4		Sex diff.	Stage diff.
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE		
Constant	0.27	0.07**	0.33	0.09**	0.62	.15**	0.61	0.15**		
Race (White=Ref)										
Black	-0.28	0.12*	-0.36	0.12**	-0.38	.13**	-0.17	0.19		x
Hispanic	0.14	0.16	0.07	0.16	-0.05	0.19	-0.36	0.4		x
Age (>45=ref)										
Age24-35	-1.6	0.13**	-1.56	0.13**	-1.54	0.13**	-1.53	.14**		
Age 36-45	-0.84	0.12**	-0.84	0.13**	-0.86	.13**	-0.86	.13**		
Edu. (HSDG=Ref)										
< 9th Grade			0.04	0.19	0.14	0.19	0.02	0.21		
<HS Degree			0.13	0.16	0.22	0.14	0.19	0.18		
> High School			0.04	0.11	0.04	0.1	0.09	0.11	#	
BA or More			-0.33	.13*	-0.26	0.13	-0.25	0.13	#	
Married (1=Yes)					-0.12	0.11	-0.11	0.11		
BMI(Normal=ref)										
Over					0.94	.10**	0.94**	0.09	#	x
Educ*Race										
Black*LT9th							0.02	0.46		
Black*LTHS							-0.16	0.32		
Black*MTHS							-0.51	0.28		
Black* BAOM							-0.09	0.4		
Hisp.*LT9th							1.12	0.75		
Hisp.LTHS							0.7	0.63		
Hisp.*MTHS							0.14	0.22		
Hisp.*BAOM							0.22	0.71		

*=p<.05; **p<.01; x=sig. diff. by stage; #=sig diff. by sex

Table 4-8. Results from a Logistic Regression Continuation Ratio Model for Males Greater Than 24 Years Old for Having Diabetes Given EBS (Stage 2):NHANES 1999-2006

	Model 1		Model 2		Model 3		Model 4		Sex diff.	Stage diff.
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE		
Constant	-1	0.09	-1.1	0.17	-1.01	0.22	-1.01	0.23**		
Race (White=Ref)										
Black	0.56	.18**	0.52	.19*	0.54	.21*	0.56	0.40		x
Hispanic	0.7	0.33*	0.65	0.32*	0.62	.25*	0.25	0.57		x
Age (>45=ref)										
Age24-35	-1.13	.35**	-1.14	0.35**	-1.2	0.36**	-1.23	.37**		
Age 36-45	-0.42	0.25	-0.4	0.26	-0.48	0.26	-0.48	0.27		
Edu. (HSDG=Ref)										
< 9th Grade			0.14	0.27	0.19	0.29	0.3	0.34		
<HS Degree			0.12	0.25	0.09	0.25	-0.04	0.39		
> HS			0.27	0.22	0.23	0.22	0.23	0.25		
BA or More			-0.19	0.22	-0.18	0.23	-0.2	0.25		
Married (1=Yes)					0.05	0.17	0.05	0.17		
BMI(Normal=ref)										
Over					0.52	.22*	0.51	0.23*		x
Educ*Race										
Black*LT9th							-0.14	0.56		
Black*LTHS							0.32	0.45		
Black*MTHS							-0.35	0.53		
Black* BAOM							0.12	0.67		
Hisp.*LT9th							-0.41	0.88		
Hisp.LTHS							0.76	0.73		
Hisp.*MTHS							0.57	0.68		
Hisp.*BAOM							0.72	0.97	#	

*=p<.05; **p<.01; x=sig. diff. by stage; #=sig diff. by sex

Table 4-9. Results From a Logistic Regression Continuation Ratio Model for Females Greater Than 24 Years Old for Having EBS Given Normal Blood Glucose (Stage 1):NHANES 1999-2006

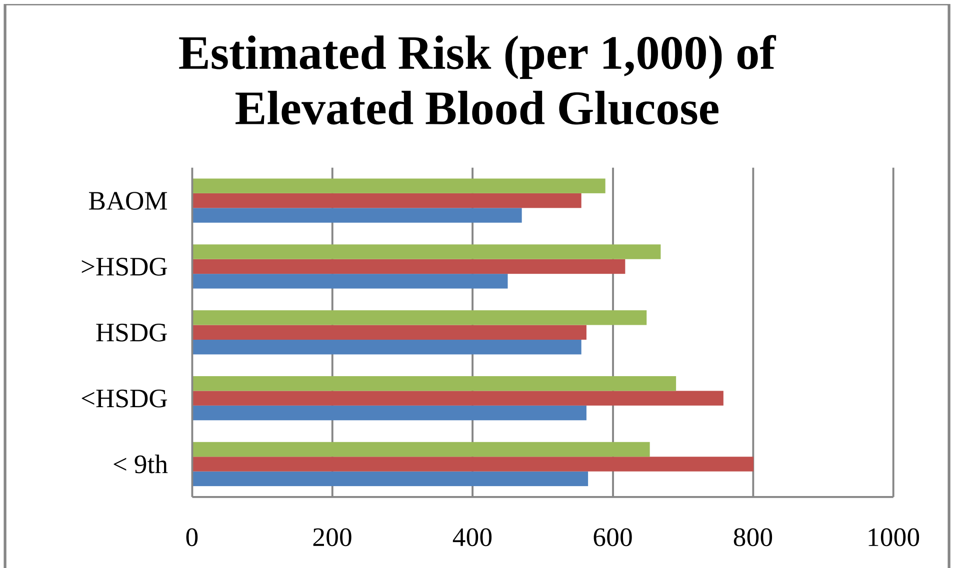
	Model 1		Model 2		Model 3		Model 4		Sex diff.	Stage diff.
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE		
Constant	-0.43	.08**	-0.28	0.09**	0.22	0.11*	0.23	0.12		
Race (White=Ref)										
Black	0.35	.12**	0.23	.12*	-0.03	0.12	0.05	0.23		x
Hispanic	0.43	.14**	0.21	0.15	0.14	0.17	-0.39	0.33		
Age (>45=ref)										
Age24-35	-1.95	.18**	-1.9	0.18**	-1.9	.18**	-1.9	.19**		x
Age 36-45	-0.42	.08**	-0.93	0.14**	0.88	.14**	-0.89	0.15		
Edu. (HSDG=Ref)										
< 9th Grade			0.41	.17*	0.47	.19*	0.7	.23**		
<HS Degree			0.39	.16*	0.36	.16*	0.39	0.21		
> HS			-0.27	.12*	-0.32	.13*	-0.35	0.15*	#	
BA or More			-0.56	.14**	-0.51	.14**	-0.57	.16**	#	
Married (1=Yes)					-0.15	0.09	-0.15	0.1		x
BMI(Normal=ref)										
Over					1.33	.13**	1.32	.13**	#	x
Educ*Race										
Black*LT9th							-0.94	0.47*		
Black*LTHS							-0.22	0.34		
Black*MTHS							0.01	0.31		
Black* BAOM							0.13	0.37		
Hisp.*LT9th							-0.27	0.46		
Hisp.LTHS							0.5	0.37		
Hisp.*MTHS							0.53	0.46		
Hisp.*BAOM							1.6	0.55**		

*=p<.05; **p<.01; x=sig. diff. by stage; #=sig diff. by sex

Table 4-10. Results from a Logistic Regression Continuation Ratio Model for Feales Greater Than 24 Years Old for Having Diabetes Given EBS (Stage 2):NHANES 1999-2006

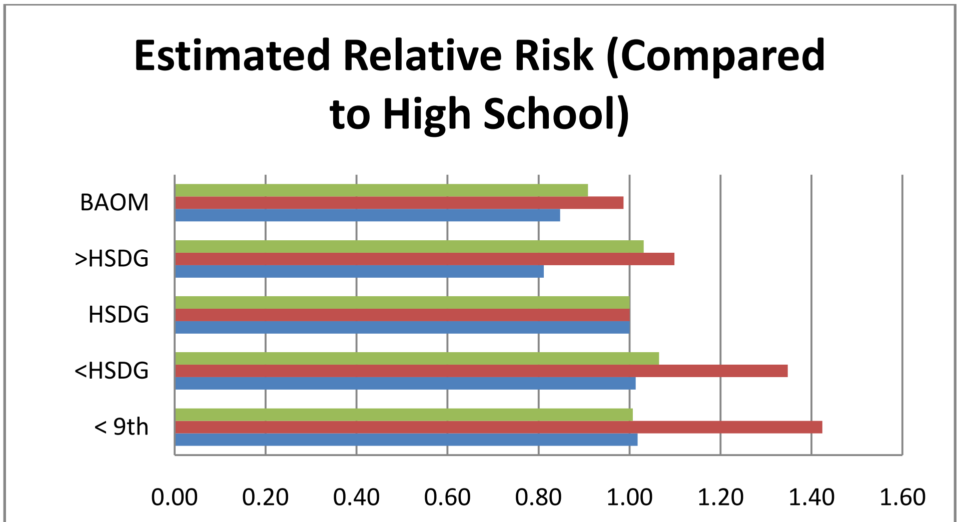
	Model 1		Model 2		Model 3		Model 4		Sex diff.	Stage diff.
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE		
Constant	-0.87	.10**	-0.78	0.15	-0.35	0.18	-0.36	0.19		
Race (White=Ref)										
Black	0.84	.15**	0.83	.15**	0.59	.15**	0.64	0.34		x
Hispanic	0.38	0.2	0.3	0.19	0.39	0.21	0.92	0.50		
Age (>45=ref)										
Age24-35	-0.36	0.4	-0.27	0.42	-0.33	0.39	-0.34	0.41		x
Age 36-45	0.58	0.3	-0.56	0.3	-0.49	0.32	-0.49	0.33		
Edu. (HSDG=Ref)										
< 9th Grade			0.16	0.34	0.16	0.35	0.29	0.40		
<HS			0.06	0.26	-0.07	0.27	-0.17	0.36		
> HS			-0.49	0.26	-0.5	.25*	-0.5	0.30		
BA or More			-0.59	0.34	-0.55	0.34	-0.36	0.37		
Married (1=Yes)					-0.52	0.18**	-0.54	0.18**		x
BMI(Normal=ref)										
Over					0.74	.29*	0.77	.30*		x
Educ*Race										
Black*LT9th							-0.18	0.77		
Black*LTHS							0.21	0.56		
Black*MTHS							0.08	0.54		
Black* BAOM							-0.84	0.69		
Hisp.*LT9th							-1.30	0.86		
Hisp.LTHS							-0.13	0.68		
Hisp.*MTHS							-0.44	0.67		
Hisp.*BAOM							-1.90	1.20	#	

*=p<.05; **p<.01; x=sig. diff. by stage; #=sig diff. by sex



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	652	690	648	668	589
HISPANIC	801	758	562	618	555
BLACK	565	562	555	450	470

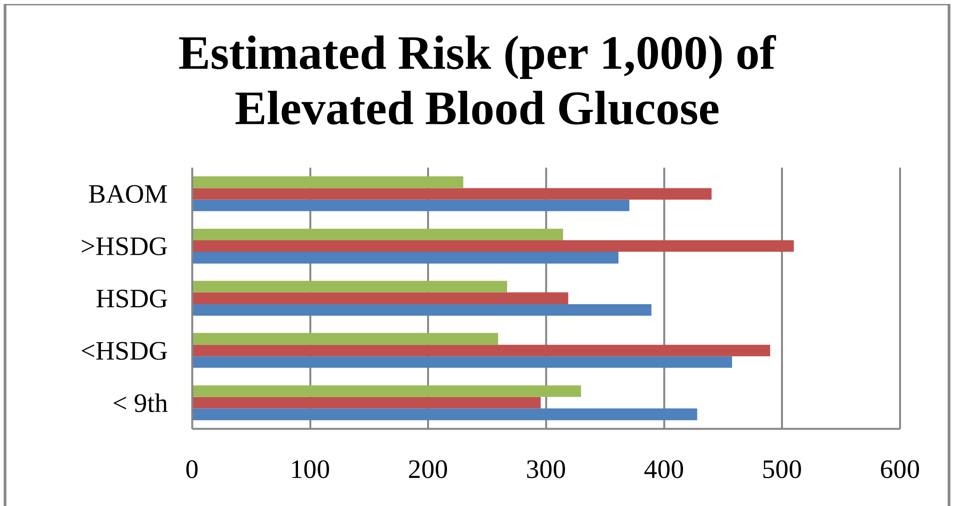
A



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	1.01	1.06	1.00	1.03	0.91
HISPANIC	1.42	1.35	1.00	1.10	0.99
BLACK	1.02	1.01	1.00	0.81	0.85

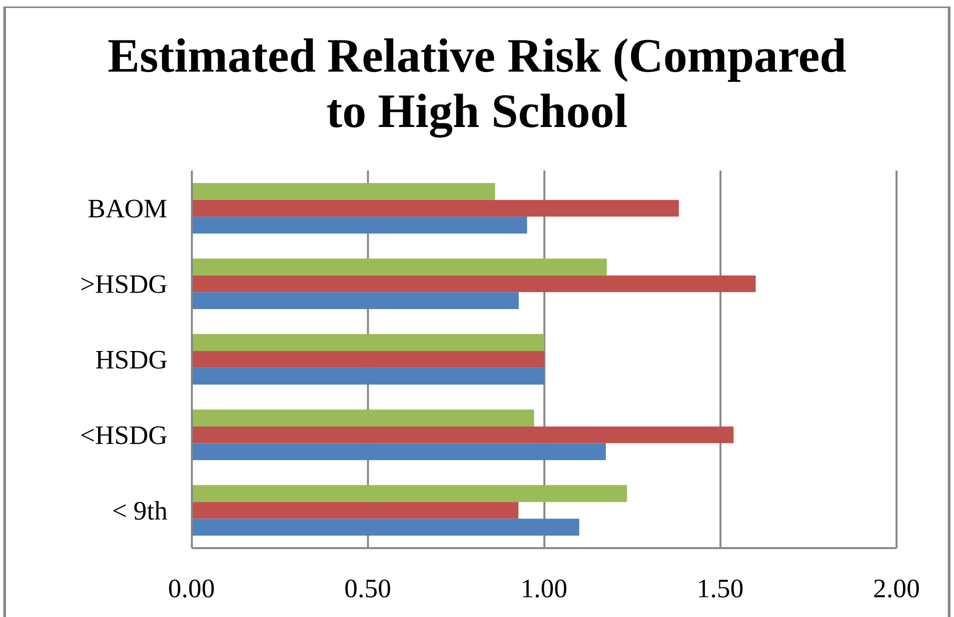
B

Figure 4-1. Estimated Risk of EBS by Educational Attainment and Race For Males Over Age 45: A) Estimated Risk and B) Estimated Relative Risk



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	330	259	267	314	230
HISPANIC	295	490	319	510	440
BLACK	428	458	389	361	371

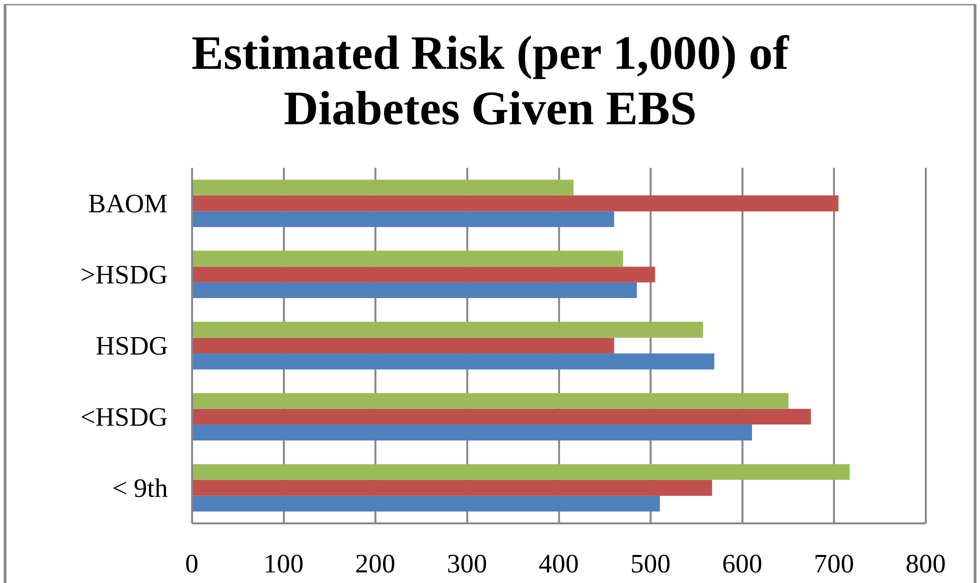
A



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	1.23	0.97	1.00	1.18	0.86
HISPANIC	0.93	1.54	1.00	1.60	1.38
BLACK	1.10	1.18	1.00	0.93	0.95

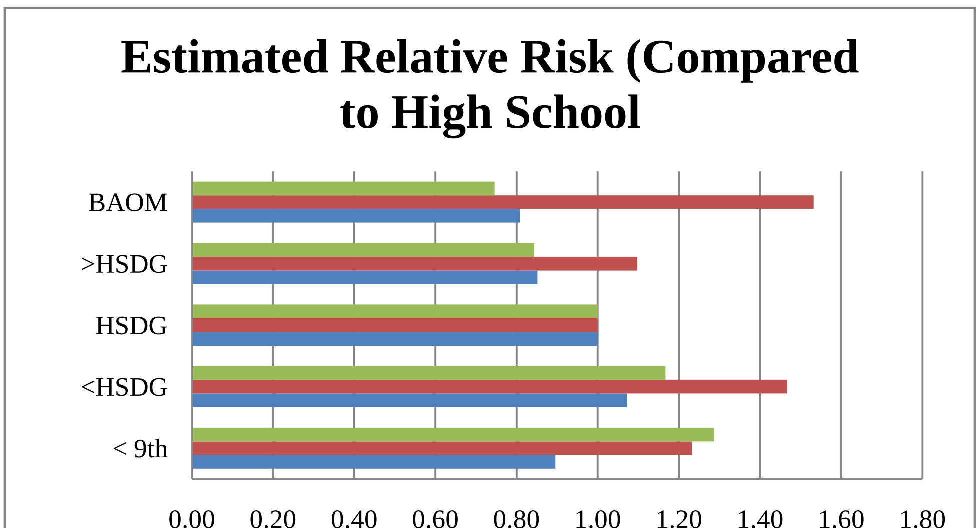
B

Figure 4-2. Estimated Risk of Diabetes Given EBS by Educational Attainment and Race: A) Estimated Risk and, B) Estimated Relative Risk



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	717	650	557	470	416
HISPANIC	567	675	460	505	705
BLACK	510	611	570	485	460

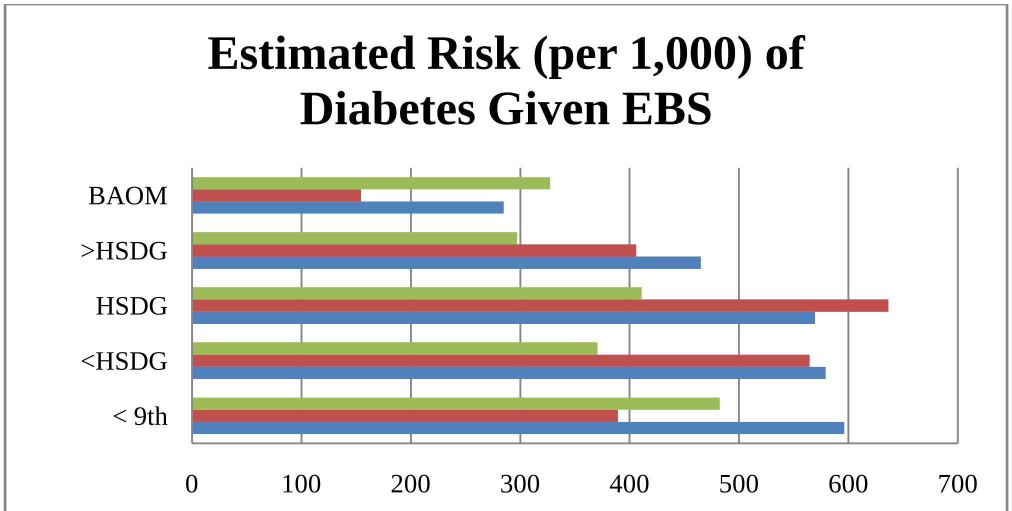
A



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	1.29	1.17	1.00	0.84	0.75
HISPANIC	1.23	1.47	1.00	1.10	1.53
BLACK	0.90	1.07	1.00	0.85	0.81

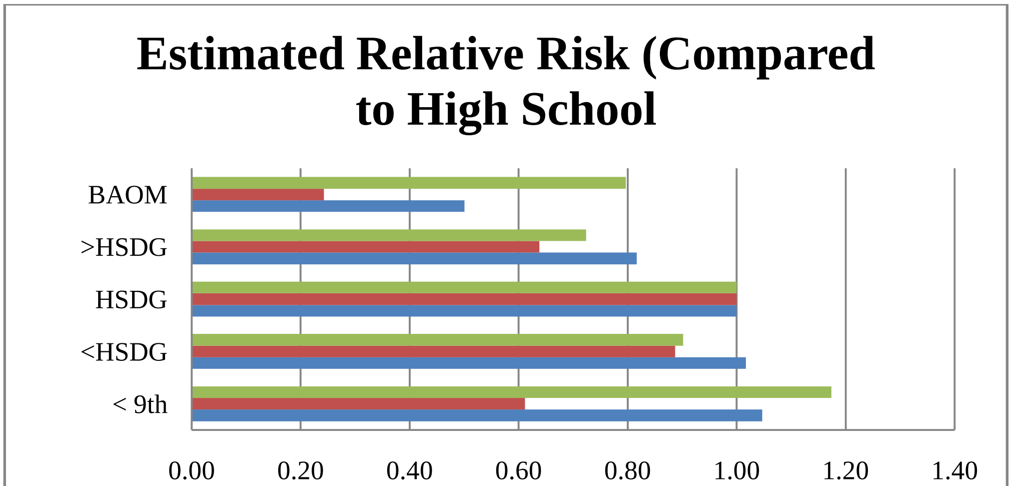
B

Figure 4-3. Estimated Risk of EBS by Educational Attainment and Race For Females Over Age 45, Single, and Overweight: A) Estimated Risk and B) Estimated Relative Risk



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	483	371	411	297	327
HISPANIC	389	565	636	406	154
BLACK	596	579	570	465	285

A



	< 9th	<HSDG	HSDG	>HSDG	BAOM
WHITE	1.17	0.90	1.00	0.72	0.80
HISPANIC	0.61	0.89	1.00	0.64	0.24
BLACK	1.05	1.02	1.00	0.82	0.50

B

Figure 4-4. Estimated Risk of Diabetes Given EBS by Educational Attainment and Race For Females Over Age 45, Single, and Overweight: A)Estimated Risk and B) Estimated Relative Risk

CHAPTER 5
DISCUSSION AND CONCLUSION

Discussion

The objective of this thesis was to answer the following three questions: (1) What is the association between education and the development of elevated blood sugar, (2) does this association vary by race and ethnicity and sex, and (3) does the association between race and ethnicity, sex, and elevated blood sugar vary depending on the level of blood sugar? Seven hypotheses emerged from these three research questions.

First, it was hypothesized that as the level of education increased, the probability of having EBS would decrease. The results of the analysis suggest that there is indeed a positive association between the development of EBS and educational attainment for *females* but not for males. Females with less than a high school degree have a significantly increased probability for developing EBS, and females with more than a high school education have a significantly decreased probability of developing EBS. Moreover, the effect of education is found to vary significantly by sex. The effect of having more than a high school education on probability of EBS is significantly greater for females than for males. This finding supports previous research that suggests increasing socioeconomic status attainment has a stronger effect for females than for males for blood glucose related outcomes (Stern et al. 1984).

Only limited little evidence is found in support of the second and third hypotheses of an interaction between race and educational attainment. Two interactions were found to be significant for females, however interpretation of these terms is difficult. In stage 1, being black significantly reduced the probability of diabetes given less than a 9th grade education. Figure 4-3 aids in the interpretation of this interaction term by estimating probabilities by level of education. A downward trend in the relative risk of developing diabetes as educational attainment increases can be observed for white females; however no such trend is observed for black females. Thus for females, there is some evidence in support of the third hypothesis. Past research has suggested that a downward trend of diabetes with increasing education for whites exists, but not for blacks (Borrell 2006). One possibility is that these associations happened by chance—i.e. noise in the data. Only 57 black females had less than a 9th grade education across all eight years, making a chance significant finding plausible. Another possibility is that one of the previous reasons given for expecting variation in the effect of education plays a role for blacks. It could be the effect of genes: black females may be predisposed to development of EBS due to a "thrifty gene", thereby reducing the protective effect of education. Pre-natal environments (Barker hypothesis) may be worse for females, and the mechanism their bodies adapt to scarcity may predispose them to risk if their post-natal environment overwhelms their metabolic mechanisms for dealing with glucose. Cultural capital explanations may also play the role: it could be that black females and the schools they attend are ill-equipped to aid in their accumulation of human capital that pays dividends in later health outcomes. Unfortunately, these data makes it impossible to disentangle the multitude of early-life and current life events, as well as direct measurement of concepts such as "capital", precluding a direct test of any of these hypotheses.

The second significant interaction was among Hispanic females with a BA or more. In this case, being Hispanic and having a BA or more had a significant effect on increasing the probability of EBS. This interaction does not support the third hypothesis that the statistical effect of education would be similar for whites and Hispanics. Again, there are several possible but un-testable explanations for this interaction term. It could be noise in the data: Only Hispanic 39 females had a BA or more across all eight years, and 47% of these highly educated Hispanics had EBS. Again, early life events could have an influence on this outcome: Hispanic females with a BA probably have greater access to food resources than lesser educated Hispanic females. If genetic predispositions or early-life events primed a “thrifty” gene, then greater access to food resources may not necessarily predict better health outcomes in terms of blood glucose and blood glucose-related health risks. Another explanation is that having a BA or more is a proxy for level of acculturation. Acculturation has been found to have varying effects on the probability of developing diabetes. Some studies suggest that among Mexican-Americans, greater acculturation is associated with lower risk of diabetes, whereas other studies suggest that higher levels of acculturation are associated with greater risk of diabetes for non-Mexican Hispanics (Hazuda 1988, Kandula 2008).

The association with acculturation may vary by ethnic origin and may also vary by time. As American society becomes increasingly overweight, acculturation to such a lifestyle may be increasingly associated with risk of diabetes. Evidence of the reduced effect of having a BA or more on lowering the probability of EBS for Hispanics lends support to the possibility that acculturation to a US lifestyle may play a role in increasing risk of EBS. The effect of the interaction between Hispanics and higher levels of education on increasing the probability of an adverse outcome runs counter to traditional ideas of a Hispanic paradox. Typically, Hispanics have been found to have lower mortality rates than would be expected given the socioeconomic status. This has often been attributed to “cultural” differences, although recent research indicates the effect is likely due to reverse migration (Palloni 2004). Since the health outcome of interest is EBS and not morality, then the findings aren’t a contradiction. Rather, it lends support to the reverse migration explanation insofar as the interaction term is valid. Future research should adjust for levels of acculturation to see if it accounts for some of the counter-intuitive effects of education on Hispanic females at the extreme end of educational attainment.

Racial/ethnic differences and sex differences in associations with EBS also exist. No evidence is found in support of the fourth hypothesis of no sex and education interactions. There is strong support for the fifth hypothesis however. Among males and females, blacks are at lower risk of developing impaired fasting glucose relative to whites, even after adjustments for age, education, marital status and body mass index. This seems counter-intuitive given the higher risk of diabetes for blacks, but is a finding borne out in other research (Cowie 2002).

With regards to the third objective, what makes the finding of the protective effect of being black on IFG especially interesting is the significant reversal of the effect of being black on developing diabetes, given one has EBS. Among blacks, this significant difference of effect is found for both males and females.

There is mixed evidence for the sixth hypothesis. Among males, being Hispanic has a significantly different effect depending on the level of blood glucose. No such interaction is found for females. Unlike blacks, being Hispanic is associated with an increased probability of EBS at both stages of blood glucose. Given EBS, the statistical effect of being Hispanic on the probability of having diabetes is significantly different, and stronger than association being Hispanic has when modeling EBS alone.

The seventh hypothesis stated that as the level of blood glucose increased from EBS to diabetes given IFG, the association of education with the probability of EBS would decrease. This hypothesis was not supported as education is found to have no statistical effect on increasing the probability of developing diabetes, given EBS. It is important to remember, however, that this doesn’t mean education has no association with the likelihood of developing diabetes, rather, only that it is not associated with increased probability of progression from EBS to diabetes.

For males, BMI is the only other variable with a different effect across stages of EBS. The difference of effect of BMI is also seen in females. The effect of BMI on increasing the probability of developing diabetes is significant for both males and females and for both stages of blood sugar. However, the effect of BMI on increasing risk of IFG is significantly greater than the effect of BMI on increasing risk of diabetes. These findings suggest that while BMI is an important risk factor for EBS, other factors help to "push" an individual across the edge into diabetes. One avenue of further research would be to differentiate between "overweight" and "obesity" in the CRM model to test if obesity retains an equally significant effect on risk of diabetes. Another possibility would be to examine race by BMI interactions to see if that extra something need for BMI to push people into being diabetic is being in a particular racial and ethnic group. These BMI findings also demonstrates one advantage of using BMI coded ordinally: it allows one to capture the varying effects of stages of BMI on risk of EBS.

For females, the effect of BMI is also found to be significantly different depending on level of blood glucose. Unique to females however, is the significant reversal of the effect of being married. Being married has no significant effect on probability of EBS but has a significant effect on reducing the probability of diabetes given EBS.

A potential limitation of this analysis is “over-controlling”—covariates such as low educational attainment are arguably a part of the “minority experience”. If one conceptualizes race as a marker for a wide range of social experiences that influence health outcomes, then even if every conceivable experience was controlled for and explained the relationship, a health disparity would remain so long as race and ethnicity exerted constraints upon an individual's life experience. This conceptualization views the health-related factors that contribute to the health disparity of elevated blood sugar to "lie along a causal pathway by which race and ethnicity affects health and … have their roots in an injustice."(Herbert 2008). By adjusting for BMI, age, and marital status, this paper can be criticized for "over-controlling" when looking for significant racial differences. However, one objective of the analysis is to test for different effects of the variables across different stages of elevated blood sugar, thus not including them in attempts to avoid "over-controlling" would preclude this objective.

Conclusion

This thesis began with the conceptualization of EBS as a racial and ethnic health disparity, implying that differences in health outcomes related to blood glucose can and should be addressed. EBS is an especially important health outcome to address in the U.S today: it is increasing in incidence and prevalence and is a risk factor for the leading cause of death in the U.S. today, cardiovascular disease.

Disparities such as that associated with EBS can occur as a result of health behaviors, health care access, and health care process. This paper has conceptualized education as one possible factor that might explain some of the racial disparity in EBS. Education certainly has an effect within all three origins of health disparities. Those who are educated practice healthier lifestyles, have better jobs, greater levels of health insurance, and can afford better quality health care. If the effect of education had been found to be significantly different by race and ethnicity, then further research into why the effect varied would be warranted in an attempt to maximize the beneficial effect of education for all. This research only found the effect of education to vary at 2 intersections of race and ethnicity and education: Hispanics with a BA or more are at an increased risk of EBS and blacks with less than a 9th grade education are at a decreased risk. Whether these variations are due to noise, early life differences, different experiences within the educational setting, or different abilities to translate educational resources into better health behaviors access and process requires further research.

A strength of this study is its conceptualization of elevated blood glucose as occurring along a spectrum, the categorization of the spectrum into separate stages, and the testing for differences of effect of the covariates across the stages of blood glucose. Using a CRM, the effect of race, education, BMI, and marital status were all found to have significantly different effects given the level of blood glucose. Of these, perhaps the finding that BMI has a significantly stronger association with the probability of EBS than on diabetes given EBS provides the most immediate recommendations for health interventions. While obesity has been recognized a primary factor in the increasing prevalence of diabetes, it plays an even more important role in the development of EBS as a whole. Continuing efforts at reducing the increasing rates of obesity should also include the reduction of elevated blood sugar as a central objective.

APPENDIX
ADDITIONAL EDUCATIONAL ATTAINMENT

Table A-1. Percentage of Educational Attainment Within Five Category. Educational Attainment and By Race/Ethncity in the U.S. Population. NHANES 1999-2006 Weighted Data

	Less Than 9th Grade	Less Than High School	High School Degree	Some College/ Training	BA+
Black	5.9%	26.2%	24.1%	31.0%	12.6%
Hispanic	8.4%	19.5%	25.7%	33.4%	12.6%
White	3.5%	9.9%	27.7%	31.0%	27.8%

Table A-2. Prevalence (SE) of U.S. Born Population Aged 20 years and Older With IFG* By Educational Attainment, NHANES 1999-2006, Weighted Data

	Less Than High School	High School Degree	College or More
Total	31.30%	29.10%	24.30%
Men	34.5%	33.6%	30.9%
Women	28.4%	24.8%	18.5%
White	34.5%	30.2%	24.8%
Men	38.4%	35.9%	31.7%
Women	30.8%	25.7%	18.3%
Black	22.5%	24.2%	19.2%
Men	23.0%	26.1%	21.0%
Women	22.0%	22.5%	18.1%
Hisp.	30.8%	21.6%	18.9%
Men	38.4%	25.4%	19.6%
Women	25.2%	17.6%	18.2%
	N=1,410	N=1,603	N=3,170

* Impaired Fasting Glucose defined as individuals with glucose levels 5.6 to 6.9 mmol per L (100-125 mg per dL)

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BIOGRAPHICAL SKETCH

Gregory Pavela earned his Bachelor of Arts from the University of Virginia with majors in sociology and history. He is currently enrolled as a graduate student at the University of Florida and received his Master of Arts in sociology from the University of Florida in 2009. He plans to continue his research on diabetes and health disparities.

EDUCATION DIFFERENCES IN ELEVATED BLOOD SUGAR: DO THEY VARY BY RACE, ETHNICITY AND SEX?

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This thesis develops our understanding of the risk factors associated with impaired fasting glucose (pre-diabetes) and diabetes. Diabetes is a risk factor for cardiovascular disease, the leading cause of death in the U.S., and as such it is important to understand how known risk factors such as race and ethnicity, obesity, and education interact with each other and with the level of disease to increase the risk of development of diabetes. The goal of such an understanding is to reduce the overall prevalence of the disease and to reduce racial and ethnic disparities in diabetes.