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## The Association Between Known Risk Factors for Type 2 Diabetes, and the Body Mass Index of Diabetic Adults

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The Association Between Known Risk Factors for Type 2 Diabetes, and the Body Mass Index of  
Diabetic Adults

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Science in Human Environmental Sciences

by

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King Faisal University  
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This thesis is approved for recommendation to the Graduate Council.

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## **Abstract**

Diabetes mellitus (DM) has been a major research topic in scientific health studies. Diabetes is a chronic condition in which blood glucose levels are chronically elevated to more than 7.0 mmol/l in fasting plasma glucose test. The most common form of diabetes is Type 2 (TD2M). The International Diabetes Federation (2015) estimated the number of DM cases worldwide to be 415 million people in 2015. This number is predicted to increase by the year 2040, to 642 million people. The purpose of this study was to use the National Health Interview Survey (NHIS) data to identify the risk factors for TD2M and their associations with the obesity as measured by the Body Mass Index (BMI) of diabetic and non-diabetic U.S. adults. The study findings for adults with diabetes included: (a) BMIs decreased as people aged, (b) females tended to have higher BMIs than males, (c) people who are Asian or Hispanic had lower BMIs, (e) smokers had lower BMIs than non-smokers, and (f) people who are more physically active had lower BMIs than less active people. For non-diabetic adults, relationships between BMI and age, gender, ethnicity, geographic region, education, physical activity, and smoking were significant. The relatively low  $R^2$ s, however, may indicate that salient variables were absent. Risk factors that might have been included in the IHIS are health history, genetics, diet, and social relationships.

*Keywords:* Diabetes Mellitus, Type 2 Diabetes Mellitus, risk factors, and body mass index (BMI)

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**Dedication**

This thesis is dedicated to the spirit of my deceased daughter, Fajjer, for all the lovely memories I have of her.

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## CHAPTER 1

### INTRODUCTION

Since 1916 when Elliott Joslin, MD published the first edition of *The Treatment of Diabetes Mellitus*, Diabetes mellitus (DM) has been one of the major subjects in scientific health studies (American Diabetes Association [ADA], 2014a). Diabetes is a chronic condition in which blood glucose levels are chronically elevated to more than 7.0 mmol/l in fasting plasma glucose test (Gupta, & Mukherjee, 2014). There are different forms of DM to include Type 1 (insulin-dependent), Type 2 (non-insulin-dependent), and gestational diabetes (GDM; ADA, 2015a; Craig et al., 2014). The most common form of diabetes is Type 2 (T2DM; Centers for Disease Control and Prevention [CDC], 2014). T2DM is responsible for 90% to 95% of all diagnosed incidence of diabetes in the United States (U.S.) adults (CDC, 2014). With T2DM, the body develops an insulin resistance (ADA, 2015b). The increase of the insulin will decrease over time because beta cells in the pancreas try to keep up with insulin demand (ADA, 2015b). However, the beta cells will fail and the pancreas will not be able to produce adequate insulin to maintain healthy blood glucose levels in the body (ADA, 2015b).

#### **Diabetes as a Global Phenomenon**

There are several reasons for the global prevalence of diabetes among adults including urbanization, age, and diet of the individual (Al-Rubeaan et al., 2014). Because diabetes is one of the widest spread diseases, researchers suggested worldwide effort to fight this public issue (Herman & Zimmet, 2012; Hu, 2011; Pearson, 2016). One of the main public health challenges in the world is Diabetes mellitus, especially in developing countries (Boutayeb, Lamlili & Boutayeb, 2016). These countries are not controlling this epidemic because of limited infrastructures (Boutayeb et al., 2016). In 2013, there were 382 million people suffering from

DM the world over (Guariguata et al., 2014). This number is projected to reach 592 million by 2035 (Guariguata et al., 2014). Islam et al. (2014) indicated that 70% of people with T2DM lived in developing countries worldwide. Some examples of these developing countries were India with 9.1% people with Type 2 diabetes, Mauritius with 14.8%, and Bangladesh with 6.3 % (Islam et al., 2014). In 2011, six of the Middle Eastern countries listed were in the top ten diabetes prevalent countries for people 20-79 years of age (Al-Rubeaan et al., 2014). Saudi Arabia ranked as number seven among the top ten countries with the highest risk population for diabetes (Al-Rubeaan et al., 2014).

The International Diabetes Federation (2015) estimated the number of DM cases worldwide to be 415 million people in 2015. This number was predicted to increase by the year 2040 to reach 642 million people. Furthermore, 80% of people diagnosed with diabetes are living in developing countries (Nanditha et al., 2016). Developing countries will face the highest increase in the number of people with diabetes because people in these countries do not have good access to healthcare and are not well educated about diabetes (Al-Yaarubi, Al-Shidani, & Habib, 2015; Guariguata et al., 2014; Li et al., 2015). The number of people with diabetes will increase worldwide because of population growth, aging population, and urbanization with associated lifestyle change (Chen, Magliano & Zimmet, 2012; Li et al., 2015).

Evaluations of the U.S. populace aged 20 years or older showed that 29.1 million of U.S., or 9.3 %, had diabetes while 86 million were pre-diabetic (ADA, 2016a; CDC & National Center for Chronic Disease Prevention and Health Promotion [NCCDPHP], 2014). Bhargava, Wartak, Friderici, and Rothberg (2014), purport there were 25.8 million U.S. citizens with diabetes, while 79 million were diagnosed with pre-diabetes. In 2012, 11% of the adult population in the U.S. had diabetes or pre-diabetes (Casagrande, 2012).

People who are aware they are at high risk for diabetes may be more likely to seek out regular medical care (ADA, 2014b). Researchers suggest ways to reduce the blood sugar level in T2DM patients, such as using insulin dosage and changing the patient's lifestyle (ADA, 2014b). However, prevention is the most effective method to protect people from different illnesses (Dunkley et al., 2016). One way to minimize the diabetic complications is to be aware that people have this disease (ADA, 2016b; CDC & NCCDPHP, 2012). Therefore, an early treatment established to stop any further future complications is recommended (ADA, 2016b). The earlier T2DM is detected, the easier it is to stop the disease from progressing and damaging the pancreas (Juvenile Diabetes Research Foundation [JDRF], 2015). About 37% of the U.S. population or 86 million adults were diagnosed with pre-diabetes (CDC & NCCDPHP, 2014). Of these 86 million adults, 11% will develop T2DM (CDC & NCCDPHP, 2014). Several studies indicated that lifestyle changes, moderate weight loss for overweight individuals, and improved physical activity levels will reduce the prevalence of diabetes (Murano et al., 2014;). Pre-diabetes has no clear signs; therefore, people may have it and not know it (Franz, Boucher, Rutten-Ramos & VanWormer, 2015; Gopalan, Lorincz, Wirtalla, Marcus, & Long, 2015; Van Gaal & Scheen, 2015). Moreover, not all people with pre-diabetes will suffer the symptoms of diabetes (Gopalan et al., 2015). To find out if they are susceptible to pre-diabetes, people should be checked for T2DM every one to two years (Gopalan et al., 2015).

## **Background**

The primary source of data on the health of the U.S. population is the National Health Interview Survey (NHIS; CDC, 2016a). The information from these data are used to keep a continuous record of the health of the U.S. citizens. Another goal of the NHIS is to address Healthy People 2020 objectives, a strategy to improve the health of all people in the U.S. by promoting individual health goals and emphasizing preventative care (CDC, 2013). The NHIS covers general health status, the distribution of acute and chronic illness, functional limitations, access to and use of medical services, insurance coverage, and health behaviors such as exercise, diet, and tobacco and alcohol use. Researchers have used the NHIS data to inform population health initiatives (Alwhaibi, & Sambamoorthi, 2016; Campo et al., 2016; Davern, Blewett, Lee, Boudreaux, & King, 2012). These data can be used to examine and prevent some conditions and provide credible knowledge of health behaviors in the U.S. population. For example, the Department of Health and Human Services (DHHS) used the NHIS data to monitor preventable diseases such as diabetes and heart disease, as well as plan programs designed to educate people who are at high risk (Minnesota Population Center, 2016a). Moreover, the NHIS provides researchers access to care, morbidity, and mortality data. Additionally, sociodemographic information is available, which allows for examination of social disparities. These data can be used for studying the changes in health over time because of the wide chronological coverage.

The Integrated Health Interview Series (IHIS) is a project based on the NHIS and is a well-documented cross-sectional time series study (Minnesota Population Center, 2016a). The information is available free; researchers can use the web-based data dissemination system (available at <http://www.ihis.us>) to find and analyze information about U.S. health (Minnesota Population Center, 2016a).

Researchers have used the NHIS data in related articles about diabetes and its risk factors (Alang, McAlpine, & Henning-Smith, 2014; Bernstein, Meurer, Plumb, & Jackson, 2015; Whitaker et al., 2014). One study found that overweight is linked to lower rate of mortality (Wang, Liu, Pan, & Tong, 2016). Moreover, another study provided evidence that obesity is not responsible for the negative health outcomes, such as morbidity and mortality. More T2DM risk factors should be included when investigating the causes of T2DM, however (Panapasa, McNally, Heeringa, & Williams, 2015).

The purpose of this study was to use the NHIS data to identify the risk factors for TD2M and their associations with the obesity of diabetic and non-diabetic U.S. adults. More specifically, to study the relationships between age, gender, race and ethnicity, educational attainment, poverty, geographical region, smoking, depression, and physical activity and body mass index (BMI). Previous research has been conducted concerning one or two of the risk factors of diabetes and its relationship with BMI (Alang et al., 2014; Bernstein et al., 2015; Whitaker et al., 2014). However, little research has been done using the 2015 data or using four or more diabetic risk factors (Minnesota Population Center, 2016a).

## CHAPTER 2

### LITERATURE REVIEW

#### Risk Factors for Diabetes

Several risk factors have the potential to increase an individual's likelihood of developing T2DM (Zaccardi et al, 2015). T2DM risk factors are divided into modifiable risk factors such as overweight and obesity, physical inactivity, high blood pressure (hypertension), and abnormal cholesterol (lipid) levels (American Heart Association [AHA], 2015). Non-modifiable risk factors include socioeconomic demographic characters as well as genetics, age, mental health, and history of gestational diabetes (AHA, 2015). There are several risk factors of T2DM, such as obesity, physical inactivity, and low cardiorespiratory fitness (CRF; Zaccardi et al, 2015). As a risk factor of T2DM, ethnicity plays a large role in determining the risk of developing T2DM than other ethnic groups (Bhargava et al., 2014). The Hispanic population in the U.S. has a higher risk of developing T2DM (Bhargava et al., 2014) than other ethnic groups. Gender, disease duration, educational level, obesity, retinopathy, history of hypoglycemia, and insulin use are possible factors associated with glucose tolerance in T2DM patients (Yin et al., 2016). Smoking is highly linked to the development of T2DM (Spijkerman et al., 2014). Smoking cessation is encouraged to prevent diabetes (Spijkerman et al., 2014). Another risk factor, depression, is recognized as an affective illness that can cause the increase of mortality rates in people with diabetes (Park, Katon & Wolf, 2013). Risk factors, such as less education and lower income, are both strong predictors for the mortality rate between individuals with T2DM (Saydah, Imperatore & Beckles, 2013).

## **Demographic Characteristics**

**Genetics.** Although some risk factors, such as smoking and physical activity, are behavioral in nature, other risk factors are not lifestyle choices. There is strong evidence that genetics play a significant role in developing T2DM (Lyssenko, & Laakso, 2013). Some examples of genetic factors influencing the likelihood of developing T2DM include family history, history of pre-diabetes, and history of gestational diabetes mellitus (Lyssenko, & Laakso, 2013). Several studies show that if one of the person's family members has T2DM, that individual's chances of developing this condition will increase (Chernausek et al., 2016; Raghavan et al, 2016; Vornanen et al., 2016). Katulanda, Ranasinghe, Jayawardena, Sheriff and Matthews (2015) noted the prevalence of diabetes was 23% higher in patients with a family history of diabetes. Other researchers noted that high birth weight is linked to an increased risk of developing T2DM in young males (Johnsson, Haglund, Ahlsson, & Gustafsson, 2015).

**Age.** Elderly individuals are at a higher risk of developing metabolic abnormalities, such as T2DM, than other younger adults (Kirkman et al., 2012). The number of people with T2DM is increasing gradually each year along with life expectancy and average weight (Dragsbæk et al., 2016). Elderly people with T2DM are at a higher risk for morbidity and mortality than other older individuals without diabetes (ADA, 2015b). People aged 45 to 64 were the group most frequently diagnosed with T2DM (CDC & NCCDPHP, 2014).

**Gender.** Being female is related to poorer glycemic control in people with T2DM (Stadlmayr et al., 2015). Females who have had children tend to have higher adiposity and prevalence of T2DM than males as a result of the increased weight during pregnancy and the subsequent inability to shed that weight (Ekpenyong, Akpan, Ibu, & Nyebuk, 2012). The risk of developing T2DM and the prevalence of this condition are associated with gender-related

differences in lifestyle (Kautzky-Willer, Harreiter, & Pacini, 2016). Females with higher BMIs tend to be at greater risk for T2DM than males with higher BMIs (Peters, Huxley & Woodward, 2016). Mothers have a higher chance of transmitting T2DM to their children than fathers (Collier, Ghosh, Hair & Waugh, 2015). Gender and socioeconomic status are two risk factors that are highly correlated with the development of T2DM (Collier et al., 2015).

**Race and ethnicity.** The risk of developing T2DM is higher in some ethnic groups in the U.S. For example, African Americans, Mexican Americans, Native Americans, native Hawaiians and some Asian Americans are at higher risk of developing T2DM than other populations (Chow, Foster, Gonzalez, & McIver, 2012). Mexican Americans are at higher risk of developing diabetes than any other group in the U.S. (Sorkin et al., 2014). Some elderly Americans from Latinos, African Americans, Native Americans, and some Asian American groups are at higher risk of developing T2DM than others (Mayeda, et al., 2014).

**Educational attainment.** Diabetes were predicted by educational level such as high school verses some college. Sacerdote et al. (2012) demonstrated there is a relationship between lower education level and T2DM incidence primarily in females. According to Walker et al. (2011), males and females with T2DM and a low education level have a higher prevalence of mortality. Diabetic patients with a high educational level tend to have better awareness of the diabetes' complications and have a higher rate of adherence to the diet restrictions (Al-Rasheedi, 2014).

**Poverty.** People with low income have a higher prevalence of diabetes (Kim et al., 2015; Sims et al., 2011). Food insecurity is often linked to a low income and therefore poverty (Levine, 2011; Saydah et al., 2013). For example, Levine (2011) found that almost half of the low-income households were food insecure. Adults with a low-income level and who are food



insecure are considered to have poor blood sugar control (Seligman, Jacobs, Lopez, Tschann, & Fernandez, 2012). The term “food insecurity” refers to people who cannot afford to purchase food, therefore, they are going hungry or are at risk for going hungry (Weiser et al., 2013; Seligman et al., 2012). Food insecurity can be an independent predictor of glycemic control in people with T2DM (Seligman et al., 2012). It is more difficult for adults with low income or food insecurity to have control over their diet due to the high cost of diabetic friendly food (Seligman et al., 2012). Moreover, diabetic patients without health insurance will pay for many diabetic supplies out of pocket, which can create a financial burden (Seligman et al., 2012).

**Geographical region.** States within the U. S. with the highest incidence T2DM are located in the South (Barker, Kirtland, Gregg, Geiss & Thompson, 2011). According to Gonzalez, Thorpe, and Wilson (2015), geographical region has a role in the incidence of diabetes. In the southern region of the U.S., the rate of developing T2DM is higher because poverty and obesity rates are also higher (Barker et al., 2011). In addition, individuals living in the Diabetes Belt, a geographic part of the U.S., largely in the South, where people have higher risk of developing T2DM than any other part of the U.S, have lower education levels (Barker et al., 2011). Furthermore, having lower education levels can lead to increased risk of T2DM (Barker et al., 2011). Obesity and physical inactivity incidents mostly occur in Diabetes Belt area (Barker et al., 2011).

## **Behaviors**

**Smoking.** Cigarette smoking increases the likelihood that a person will develop T2DM as well as to a number of other illnesses (Luo et al., 2015). There are two types of smoking behaviors, active and passive smoking (Luo et al., 2015; Zhu, Wu, Wang, Zheng, & Sun 2014). The active smoker is the person who actively uses the cigarette, while the passive smoker is the

person who is exposed to the tobacco smoke involuntarily (Pan, Wang, Talaei, Hu, and Wu, 2015). Passive and active smoke are strongly and independently linked to the risk of developing T2DM (Zhang et al., 2011). The possibility of a person developing T2DM has been shown to increase when exposed to passive smoking (Zhu et al., 2014). Active smokers are at double the risk of developing T2DM when compared to non-smokers (Luo et al., 2015). Researchers suggested smoking quitting to avoid diabetes complications (Clair, Meigs & Rigotti, 2013).

**Depression.** One out of every four participants in a recent study suffered from clinically significant depression (Semekovich, Brown, Svrakic & Lustman, 2015). Depressed people are more likely to develop T2DM, subsequent hyperglycemia, insulin resistance, and macrovascular complications (Semenkovich et al., 2015). Moreover, not only are people with T2DM are more likely to develop depression, but they are more likely to suffer a more severe course of depression (Semenkovich et al., 2015). There is a strong relationship between depression symptoms and the increased risk of diabetes (Rotella & Mannucci, 2013). Furthermore, the relationship between depression and diabetes cannot be explained solely through the use of antidepressant drugs or being overweight (Rotella & Mannucci, 2013). Intensified screening for diabetes should include depression as an additional risk factor (Rotella & Mannucci, 2013). Mortality rates are higher in people with T2DM that face significant depression (Park et al., 2013)

**Physical inactivity.** Being physically inactive contributes to a person's overall likelihood of developing T2DM (Liese, Ma, Maahs & Trilk, 2013). A number of studies have been conducted concerning the relationship between physical activity and the risk of developing T2DM (Aune, Norat, Leitzmann, Tonstad, & Vatten, 2015; Lavie et al., 2014; Liese et al., 2013). Most of these studies provide evidence of a strong relationship between the two variables

(Aune et al, 2015; Lavie et al., 2014; Liese et al., 2013). To prevent T2DM, people should increase their physical activity level. The U.S. government and the World Health Organization (WHO) highly recommended that individuals get at least 150 min per week of modest physical activity, 75 min per week of strong physical activity, or a comparable mixture of the two intensities (Honda et al., 2015). A patient's compliance to moderate physical activity recommendations such as brisk walking can significantly decrease the risk of developing T2DM (Kaminsky, 2014).

**Body mass index.** To indicate high body fitness people over 20 years of age, the CDC recommends using the BMI calculator. According to the CDC, "BMI is a person's weight in kilograms divided by the square of height in meters" (CDC, 2015, para. 1). Normal BMI is between 18.5 to 24.9 kg/m<sup>2</sup>, the overweight range is from 25-29.9 kg/m<sup>2</sup>, and obesity is above 30 kg/m<sup>2</sup> (CDC, 2015). There are several risk factors linked to T2DM, and having a high BMI is one of them (Zaccardi et al, 2015). Additionally, having an unhealthy diet, being physically inactive, and having a low socioeconomic status are factors that contribute to both obesity and T2DM (Hu, Bhupathiraju, de Koning, & Hu, 2014). According to Martin et al. (2016), the diagnosis of obesity is underestimated when using BMI measurements alone. Obese people with T2DM also have poor control of blood sugar (CDC, 2014). When compounded by diabetes, an overweight or obese individual's health condition will be more severe and complicated (CDC, 2014). Obesity levels rose significantly worldwide between 1980 and 2014 (WHO, 2016). Some metabolic diseases such as "insulin resistance, dyslipidemia, nonalcoholic fatty liver disease (NAFLD) and hypertension, collectively grouped into the so-called metabolic syndrome" have been linked to obesity (Lazic et al., 2014, p.1). One of the main reasons people develop chronic disease is because they are overweight or obese (Sorkin et al., 2014).

### **Diabetic Versus Non-Diabetic People**

People with T2DM have a higher rate of admissions and stay longer in hospitals compared with nondiabetic people (Khalid et al., 2014). People with T2DM have a higher rate mortality than non-diabetic people (Afkarian et al., 2013). Those with T2DM also have a higher risk of developing mental and physical health problems than those who are not diabetic (Jerant, Bertakis, & Franks, 2015). Moreover, a comparison of T2DM groups and non-diabetic groups provides evidence that people with T2DM scored higher in categories of depression, anxiety, and stress (Balhara, & Sagar, 2011). Comparison also shows that people with T2DM score lower on all quality of life components (Balhara, & Sagar, 2011).

Serval risk factors can affect people 's likely hood of developing T2DM mellitus such as heart disease, and stroke (AHA, 2015; Zaccardi et al, 2015). People can manage or change some of these risk factors such as decreases the BMI and increasing physical activity. Individuals cannot manage or change other risk factors such as age or the family history. However, having a good awareness and knowledge about these risk factors can help people managing and planning their life to lower their risk of developing T2DM (AHA, 2015).

## CHAPTER 3

### METHOD

#### The Hypothesis

The primary hypothesis of the current study is that risk factors for Type 2 Diabetes are associated with the obesity of U.S. diabetic and non-diabetic adults. Within U. S. Adults with Diabetes,

H<sub>1</sub> = Older people are more likely to have higher BMI than younger adults.

H<sub>2</sub>= Females are more likely have higher BMI than males.

H<sub>3</sub>= Racial and ethnic minorities are more likely to have higher BMI than non-racial and ethnic minorities.

H<sub>4</sub>= Higher educated people will have lower BMI than lower educated people.

H<sub>5</sub>= People living in poverty will have a higher BMI than people who are above the poverty level.

H<sub>6</sub>= People from the Southern region are more likely to have a higher BMI than people from other regions of the U. S.

H<sub>7</sub> = Smokers are more likely to have higher BMI than non-smokers.

H<sub>8</sub> = People who report more days of depression will have higher BMIs.

H<sub>9</sub> = physically active people have lower BMIs.

H<sub>10</sub> = Age, Gender, Race and Ethnicity, Smoking, and Physical Activity will be stronger predictors of BMI than, Educational Attainment, Poverty, and Depression.

Within U. S. Adults without Diabetes,

H<sub>11</sub> = Older people are more likely to have higher BMI than younger adults.

H<sub>12</sub>= Females are more likely have higher BMI than males.

H<sub>13</sub>= Racial and ethnic minorities are more likely to have higher BMI than non-racial and ethnic minorities.

H<sub>14</sub>= Higher educated people will have lower BMI than lower educated people.

H<sub>15</sub>= People living in poverty will have a higher BMI than people who are above the poverty level.

H<sub>16</sub>= People from the Southern region are more likely to have a higher BMI than people from other regions of the U. S.

H<sub>17</sub> = Smokers are more likely to have higher BMI than non-smokers.

H<sub>18</sub> = People who report more days of depression will have higher BMIs.

H<sub>19</sub> = physically active people have lower BMIs.

Note: For better understanding for the hypothesis from one to nine see Figure one.

H<sub>20</sub> = Age, Gender, Race and Ethnicity, Smoking, and Physical Activity will be stronger predictors of BMI than, Educational Attainment, Poverty, and Depression.

Note: For an explanation of the relationship between the hypothesis and BMI, see Figure 1.

### **Participants**

One-hundred thousand diabetic and non-diabetic U.S. adults aged 18 to 75 and older from the IHIS survey were chosen using stratified sampling in 2015 from the NHIS. The NHIS used a complex multistage sample design to collect the data (Minnesota Population Center and State Health Access Data Assistance Center, 2016a). The sample size changed when the researcher excluded missing variables and limited the data to diabetic adults. The remaining unweighted sample size reported 3422 participants with diabetes. Of the participants, 54.2% were females, while 45.8 %were males. Twenty-eight thousand seven hundred and two participants reported

that they did not have diabetes. Females represent 55.3% of the non-diabetic participants were, while 44.7 were males (Minnesota Population Center, 2016b).

### **Data Collection**

Of interest to the current project were the variables age, gender, race and ethnicity, educational attainment, poverty, geographical region, smoking, depression, physical activity and body mass index (BMI). The Integrated Health Interview Series (IHIS) data were collected via household face-to-face health interviews. (Minnesota Population Center and State Health Access Data Assistance Center, 2016c).

### **Independent variables**

#### **Socioeconomic Demographic Characteristics**

**Age.** The participants were all required to report their ages in order to participate in the study. Their ages were recorded in years; months since previous birthdays were not included. (Minnesota Population Center, 2016c).

**Gender.** In this section, individuals were asked about their gender to indicate whether they were male or female. Male were coded as 0 and, female as 1 (Minnesota Population center, 2016c).

**Race and ethnicity.** Using the October 30, 1997 revision of Statistical Policy Directive No. 15, Race and Ethnic Standards for Federal Statistics and Administrative Reporting, people who responded to the survey provided information on their ethnicity (Minnesota Population Center, 2016c). The data was re-coded, into Hispanic, White, Black, Asian, Native American Indian, other race, and multiple race dummy variables. White is the reference category. The researcher removed the “other race” variable because of too few participants.

**Educational attainment.** Participants reported the highest level of education that they had completed. Participants were given a card listing recognized education categories and asked to select the correct category. The categories included “Never attended/kindergarten only, Grade 1-13 =1, High school graduate or GED equivalent = 2, Some college, no degree=3, A degree: technical/vocational/occupational = 4, Bachelor's degree = 5, Master's degree, Professional degree, Doctoral degree =6” (Minnesota Population Center, 2016c).

**Poverty.** Poverty was represented as a dichotomous variable. The data indicated whether family income was above or below the poverty level. The data were collected by asking the participants to identify the category that most closely matched their family's income before-taxes, total, and combined income from all sources during the preceding calendar year from a card listing broad income. The family income should include all the family members' income. Family members include cohabiting partners and related armed forces members living at home. Family income not included in the study were the price of noncash benefits such as Food Stamps, Medicaid, Medicare, and public housing. Income status was calculated for people who lived alone or with other people with whom they were not related. To categorize the poverty level, the participants' whole family income was compared to the U.S. Census Bureau's poverty thresholds for 2015 (Minnesota Population Center, 2016c). The thresholds were based on income, family size and the number of children who are under the age of 18. The data coded as at or above poverty threshold = 1, Below poverty threshold = 2 (Minnesota Population Center, 2016c).

**Geographical region.** Interviewers reported where the housing unit of survey participants was located to identify the region of the U.S. There were four regions, Northeast, North Central/Midwest, South, and West, that belong to the U.S. regions as identified by the



Census Bureau. The Northeast included: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Pennsylvania. The North Central/Midwest included: Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Kansas, and Nebraska. The South comprised: Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Mississippi, and Alabama, Texas, Arkansas, Oklahoma, and Louisiana. The West included: Washington, Alaska, Oregon, California, Hawaii, Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada” (Minnesota Population Center, 2016c, section.4 var 7). The data were re-coded as dummy variables with the northeast as the reference category (Minnesota Population Center, 2016c).

### **Behaviors**

**Smoking.** The participants answered the question, "Do you NOW smoke cigarettes every day, some days or not at all?" This question was asked to the smokers who claimed that they had smoked 100 cigarettes in their entire lifetime. From the survey, individual’s answers were classified into “not at all = 1, some days = 2, every day = 3” (Minnesota Population Center, 2016c).

**Depression.** Participants described how often they feel depressed. The depression data was gathered for people who completed the Adult Functioning and Disability supplement administered to sample adults “daily = 1, weekly = 2, monthly = 3, a few times a year = 4, never = 5” (Minnesota Population Center, 2016c).

**Physical activity.** The employees at the National Center for Health Statistics (NCHS) designed a recoded variable and named it Frequency of Vigorous Activity 10+ minutes: Times per week (Minnesota Population Center, 2016c). The study used terms of a single time unit such

as times per week. This variable was utilized to indicate the frequency of vigorous leisure-time physical activities, which were defined as, an activity that causes the body to sweat, an increase in breathing, or an increase in heart rate. Examples of vigorous activities include fast walking, fast bicycling, jogging, strenuous swimming or sports play, vigorous aerobic dance, and strenuous gardening” (Minnesota Population Center, 2016c, section.4 var 26). The answers were coded “Never = 1, Day = 2, Week = 3, Month = 4, Year = 5, Unable to do this activity = 6” (Minnesota Population Center, 2016c, section.4 var 26)

### **Dependent variable**

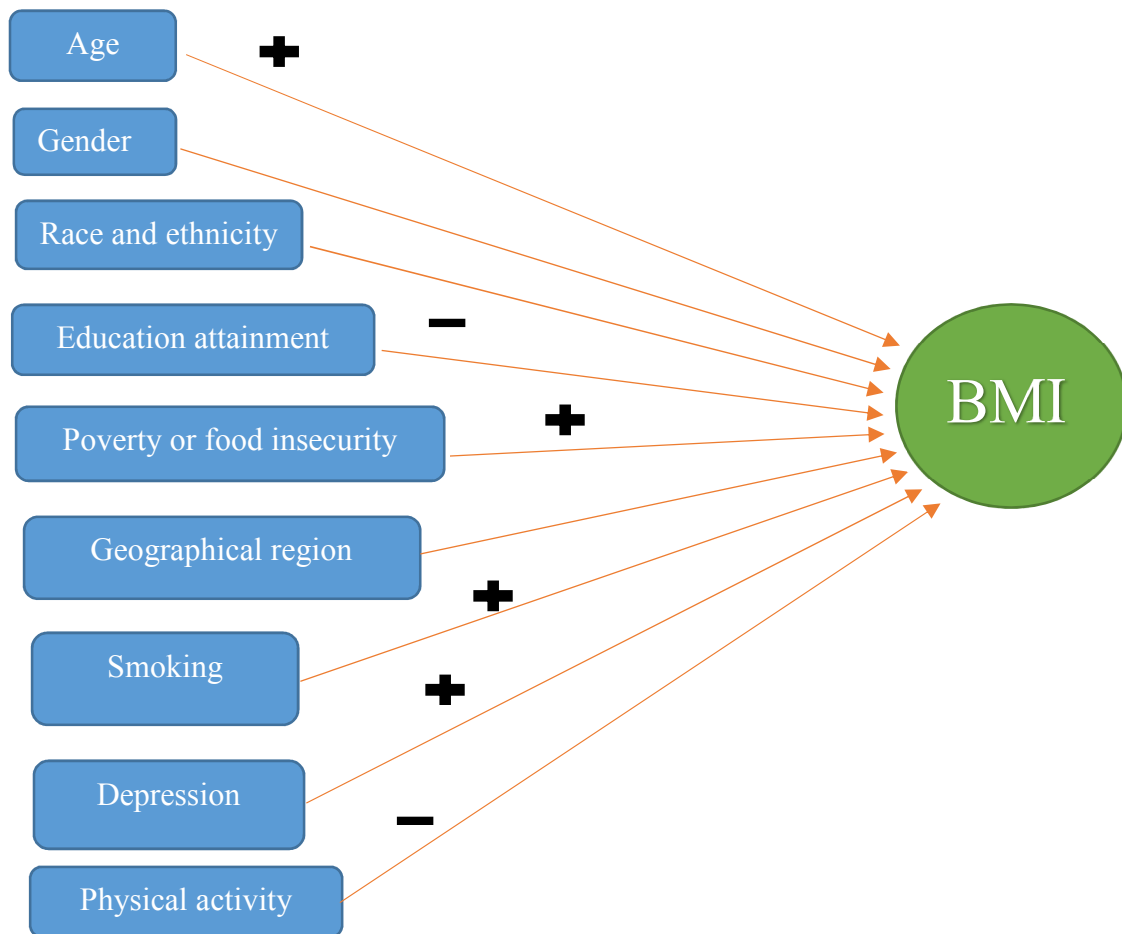
**Body mass index.** To measure the body fat for adult males and females, BMI was calculated. The height and weight of participants were self-reported. Conversion factors such as 1 kg = 2.205 pounds; 1 meter (m) = 39.37 inches were utilized (Minnesota Population Center, 2016c) to calculate BMI.

### **Diabetes**

A question about diabetes was used in the survey to inquire if a physician or other health professional had ever diagnosed the sample adults with “diabetes or sugar diabetes”. The question for male adults was, "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" and for the females the question was followed by the phrase, "Other than during pregnancy" to eliminate the cases of gestational diabetes. Adults replied were yes, no, and borderline, or pre-diabetes (Minnesota Population Center and State Health Access Data Assistance Center, 2016). The participant’s answers were “No or not mentioned = 1, Yes or mentioned = 2” (Minnesota Population Center, 2016c).

### **Data Analysis**

The study focused on the population of adults aged 18 to 75 and older with diabetes who were able to exercise. This data was collected using a complex stratified sampling method (for more details see the IHIS data documentation) Because the controlling variable BMI was weighted by sample person weight, according to the user note in IHIS data web site all observations variable should be weight by sample person weight (Minnesota Population Center and State Health Access Data Assistance Center, 2016b). For the data analysis, the researcher used multiple regression to predict the value of BMI based on the values of two or more risk factors by using SPSS software (International Business Machines Corporation, 2015). Complex sample general linear model analysis was also used because of the sampling techniques and large sample size. To account for the complex sampling design, the cluster that researcher used was the "PSU" variable, and the strata variable was the "STRATA." After that, the researcher conducted Estimated Regression Coefficients in SAS software in order to standardize the estimation variables. The independent variables were gender, race and ethnicity, education attainment, poverty, geographical region, smoking, depression, and physical activity in diabetics. The dependent variable was the BMI score. In order to run the statistical analysis, the categories variables were re-coded as dummy variables.



*Figure 1:* The purported relationship between the hypotheses and BMI

## CHAPTER 4

### RESULTS

**For the diabetic individuals.** Table one shows the sample design information for diabetic adults. Unweighted cases, such as invalid number of participants (370), which is the number of people with missing data, the valid (3052), which is the number of participants with complete information, and the total number of the participants (3422). Moreover, Table 1 provided the population size, which is the sum of weights 19457701 along with the strata 298 and cluster 572 that researcher used to conduct the complex sampling design. The researcher used 274 as degrees of freedom.

Table 1

<i>Sample Design Information; for diabetic adults</i>		
		N
Unweighted Cases	Invalid	370
	Valid	3052
	Total	3422
Population Size		19457701
Stage 1	Strata	298
	Units	572
Sampling Design Degrees of Freedom		274

The age variable for diabetic adults ranged from 18 to 85 and older. Age of participants categorized from 18 to 25 was 27(.8 %), 26 to 35 was 101 (3.0%), 36 to 45 was 261 (7.6%), 46 to 55 was 575 (16.8%), 56 to 65 was 927 (27.1%), 66 to 75 was 931 (27.2%), and 75 or older was 600 (17.5%). The gender variable was divided into two; females represented 1854 (54.2%) of the participants, while males 1568 (45.8%). The racial and ethnic minorities variable categorized Hispanic with 597 participants or 17.4%, White with 2439 participants or 71.3%, African Americans with 670 participants or 19.6%, Native American with 62 or 1.8 participants,

Asian with 167 or 4.9% participants, and multiple-race with 74 participants or 2.2 %.

Educational attainment was categorized into never attended/kindergarten only, grade 1-13, with 358 participants or 10.5%, high school graduate or GED equivalent, with 395 participants or 11.5%, some college, no degree, with 981 participants or 28.7%. An Associate degree: technical/vocational/occupational and an Associate degree: academic program, with 996 participants or 29.1%, bachelor's degree, with 440 participants or 12.9%, master's degree, professional degree, doctoral degree, with 239 participants or 7.0%.

Poverty was represented as two categories; at or above poverty threshold with 2609 participants or 76.2% and 640 participants or 18.7% below poverty threshold. Geographical region recoded into Northeast with 520 participants or 15.2%, Central-Midwest with 691 participants or 20.2%, South 1339 participants or 39.1%, and West with 872 participants or 25.5%.

For the question about the frequency of smoking, the response was “not at all” 1071 or 31.3%, “some days” 112 or 3.3%, and “every day” 422 or 12.3%. The number of participants were asked how often they felt depressed. One hundred seventeen participants or 3.4% replied daily, 112 or 3.3% replied weekly, 99 or 2.9% replied monthly, 394 or 11.5% replied a few times a year, and 856 or 25.0% replied never. The question regarding frequency of vigorous activity indicated 2622 participants or 76.6% answered for never, 145 or 4.2 answered every day, 555 or 16.2% answered once a week, 77 or 2.3% answered once a month, and 23 or .7% answered once a year. For the BMI variable, 25 people (.7%) below 18.5 were underweight, 480 people (14.0%) from 18.5 to 24.99 were normal weight, 988 people (28.9%) from 25 to 29.99 were overweight, 1891 or 55.3% 30 and over were obese.

The results of the regression analysis indicated that the model was statistically significant ( $F= 23.31$ ,  $p = <.0001$ ) with 10 % of the variance in BMI explained by the independent variables. Of the independent variables and based on the t-statistic (unstandardized estimate), six variables significantly predicted BMI (Table 2). They were age, gender, being Asian, being Hispanic, being a smoker, and physical activity. The BMIs for the age variable decreased when people aged. Females tended to have higher BMIs than males. An unexpected result was in the Hispanic and Asian variables, which had lower BMIs than Whites. Diabetic adults who smoked had lower BMIs than diabetic adults who did not smoke. People with diabetes who are more physically active, had lower BMIs than people less physically active. Based on the standardized regression coefficient the strongest predictor of BMI was being Asian followed by age and gender (Figure 2).

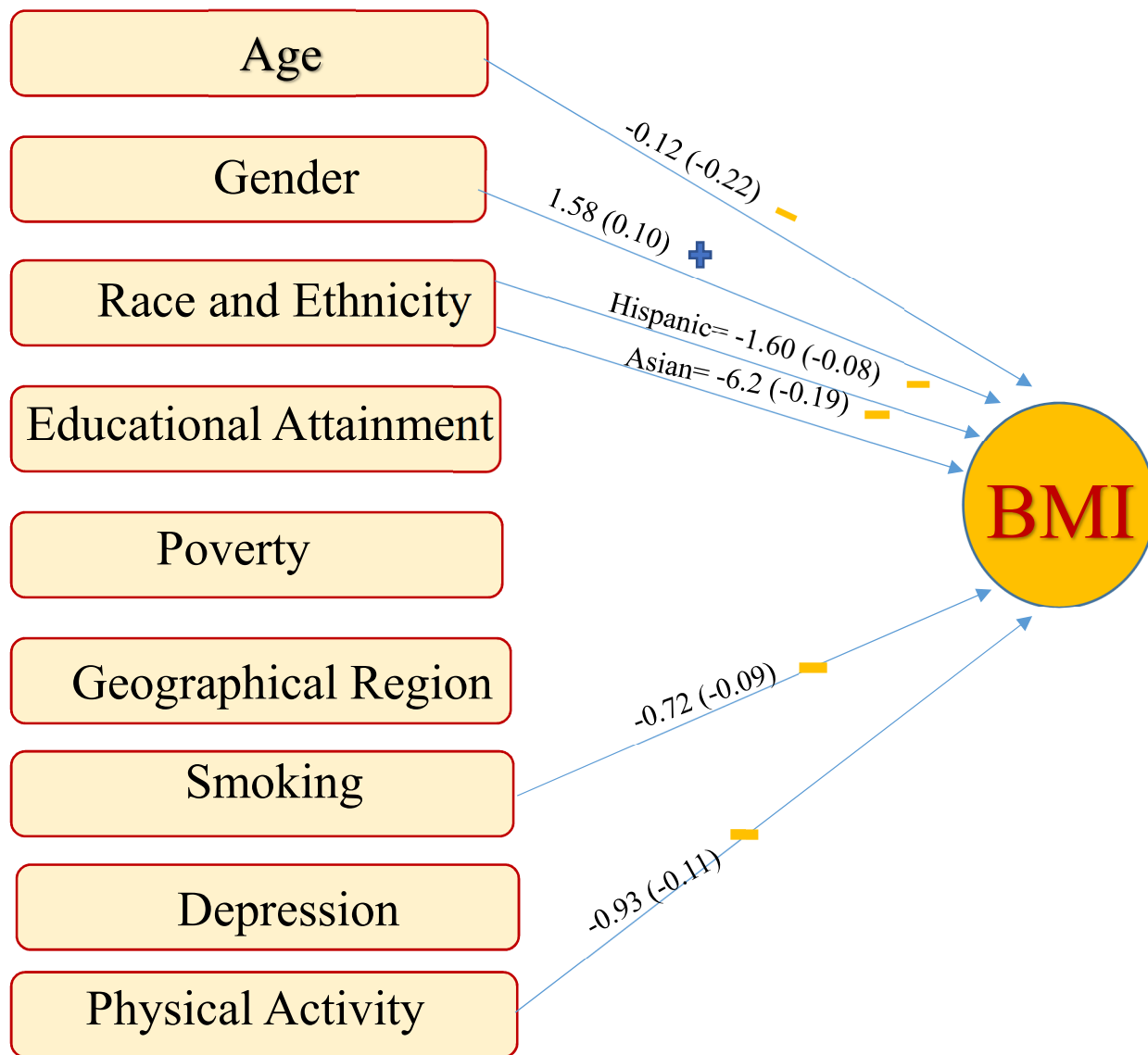


Figure 2: Significant relationship for the diabetic (Estimate and Standardized Estimate)



Table 2

<i>Estimated Regression Coefficients: for diabetic adults</i>							
Parameter	Estimate	Standard Error	Standard Error	t Value	Pr >  t	95% Confidence Interval	
Intercept	40.18	0.00	1.40	28.63	<.00	37.42	42.95
Age	-0.12	-0.22	0.01	-8.64	<.00	-0.14	-0.09
Gender	1.58	0.10	0.33	4.74	<.00	0.92	2.23
Hispanic	-1.60	-0.08	0.46	-3.43	0.00	-2.51	-0.68
African American	-0.07	0.00	0.42	-0.18	0.85	-0.91	0.76
Native American	0.00	0.00	1.55	0.00	0.99	-3.06	3.06
Asian	-6.20	-0.19	0.47	-12.97	<.00	-7.14	-5.25
Multiple-Race	1.37	0.02	1.20	1.14	0.25	-1.00	3.75
Education	0.12	0.02	0.12	1.01	0.31	-0.12	0.37
Poverty	0.07	0.00	0.51	0.14	0.9	-0.94	1.09
Central-Midwest	0.26	0.01	0.49	0.53	0.6	-0.71	1.23
South	0.20	0.01	0.47	0.42	0.67	-0.74	1.14
West	0.69	0.03	0.55	1.25	0.21	-0.39	1.77
Smoking	-0.72	-0.09	0.16	-4.51	<.00	-1.03	-0.4
Depression	0.00	0.00	0.07	-0.10	0.92	-0.15	0.13
Physical Activity	-0.93	-0.11	0.20	-4.58	<.00	-1.34	-0.53

**For non-diabetic adults.** Table 3 shows the sample design information for non-diabetic adults. Unweighted cases, such as invalid number of participants (3179), which is the number of people with missing data, the valid (25523), which is the number of participants with complete information, and the total number of the participants (28702). Moreover, Table 3 provided the population size, which is the Sum of Weights 186239078 along with the Strata 300 and cluster 600 that the researcher used to conduct the complex sampling design. The researcher used 300 as the degrees of freedom.

Table 3

<i>Sample Design Information; for non-diabetic adults</i>		
		N
Unweighted Cases	Valid	25523
	Invalid	3179
	Total	28702
Population Size		186239078
Stage 1	Strata	300
	Units	600
Sampling Design Degrees of Freedom		300

The age variable for diabetic adults ranged from 18 to 85 and older. Age of participants categorized from 18 to 25 was 3391 (11.8 %), 26 to 35 was 5553 (19.3%), 36 to 45 was 4908 (17.1%), 46 to 55 was 4761 (16.6%), 56 to 65 was 4465 (15.6%), 66 to 75 was 3201 (11.2%), and 75 or older was 2423 (8.4%). The gender variable was divided into two; females represent 15867 (55.3%) of the participants, while males 12835 (44.7%). The racial and ethnic minority variable categorized 4787 participants (16.7%) as Hispanic, 22227 participants (77.4%) as White, 3764 participants (13.1%) as African Americans, 300 participants (1.0%) as Native American, 1747 participants (6.1%) as Asian, 584 participants (2.0%) as multiple-race. Educational attainment was categorized into never attended/kindergarten only, Grade 1-13, with 1330 participants or 4.6%, high school graduate or GED equivalent, with 2297 participants or 8.0%, some college, no degree, with 6904 participants or 24.1 %. An Associate degree: technical/vocational/occupational and an Associate degree: academic program, with 8966 participants or 31.2 % bachelor's degree, with 5621 participants or 19.6%, master's degree, professional degree, doctoral degree, with 3461 participants or 12.1%.

Poverty was represented as two categories: at or above poverty threshold with 23180 participants or 80.8% above poverty threshold and 4117 participants or 14.3% below poverty threshold. Geographical region recoded into Northeast with 4700 participants or 16.4%, Central-

Midwest with 6120 participants or 21.3%, South 9733 participants or 33.9%, and West with 8149 participants or 28.4%.

For the question about the frequency of smoking, the response was not at all 6279 or 21.9%, some days 1125 or 3.9%, and every day 3474 or 12.1%. The following are results for the question of how often the participants felt depressed: 427 or 1.5% replied daily, 653 or 2.3% replied weekly, 804 or 2.8% replied monthly, 2970 or 10.3 % replied a few times a year, 8443 or 29.4% replied never. The other question was about the frequency of vigorous activity, where 15141 participants or 52.8% answered for never, 1919 or 6.7 answered for once a day, 10520 or 36.7% answered for once a week, 913 or 3.2% answered for once a month, and 209 or .7% answered for once a year. For the BMI variable, there were 504 people or 1.8 % below 18.5 underweight, 9843 people (34.3%) 18.4 to 24.99 were normal weight, 9454 people (32.9%) 25 to 29.99 were overweight, 8517 (29.7%) 30 and over were obese.

The results of the regression analysis indicated that the model was statistically significant ( $F= 72.61$ ,  $p = <.0001$ ) with 4% of the variance in BMI explained by the independent variables. Of the independent variables and based on the t-statistic (unstandardized estimate), 10 variables significantly predicted BMI (Table 4). Those variables were Age, Gender, being Hispanic, being Black, being Native American Indian, being Asian, education attainment, living in the Northeast, and Central-Midwest region, being a smoker, and participating in physical activity. The BMIs for the age variable increased when people aged. Females tended to have lower BMIs than males. The Hispanic, Black, and Native American Indian population showed higher BMIs, however, the Asian population had lower BMIs than White. People with higher education have lower BMI. The Central-Midwest population had higher BMIs. Non-diabetic adults who smoked had lower BMIs than non-diabetic adults who did not smoke. People who are more

physically active had lower BMIs than people who are not as physically active. Based in the standardized regression coefficient the strongest predictor of BMI was ethnicity followed by education attainment (Figure 3).

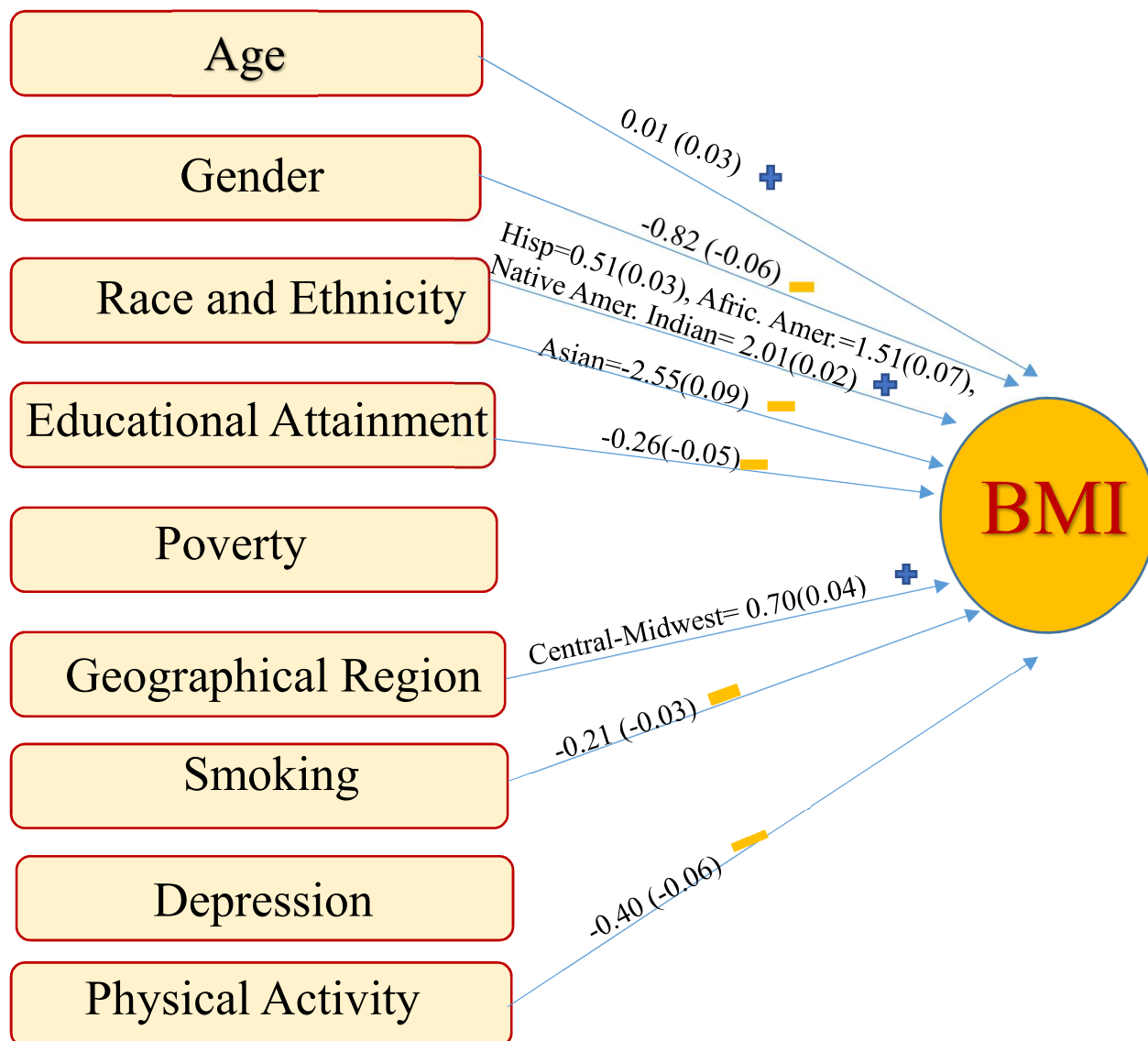


Figure 3: Significant relationship for non-diabetic (Estimate, and Standardized Estimate)

Table 4

<i>Estimated Regression Coefficients; for non-Diabetic adults</i>							
Parameter	Estimate	Standardized Estimate	Standard Error	t Value	Pr >  t	95% Confidence Interval	
Intercept	29.05	0.00	0.46	62.61	<.00	28.14	29.96
Age	0.01	0.03	0.00	4.07	<.00	0.00	0.01
Gender	-0.82	-0.06	0.10	-8.16	<.00	-1.02	-0.62
Hispanic	0.51	0.03	0.16	3.06	0.00	0.18	0.84
African Americans	1.51	0.07	0.17	8.65	<.00	1.16	1.85
Native Ameren	2.01	0.02	0.73	2.72	0.00	0.55	3.46
Asian	-2.55	-0.09	0.16	-15.42	<.00	-2.88	-2.22
Multiple-Race	0.80	0.01	0.45	1.75	0.08	-0.09	1.69
Education	-0.26	-0.05	0.04	-6.32	<.00	-0.35	-0.18
Income	0.02	0.00	0.16	0.15	0.88	-0.30	0.35
Central-Midwest	0.70	0.04	0.19	3.62	0.00	0.32	1.09
South	0.19	0.01	0.18	1.08	0.28	-0.16	0.54
West	-0.21	-0.01	0.17	-1.21	0.22	-0.56	0.13
Smoking	-0.21	-0.03	0.05	-3.76	0.00	-0.33	-0.10
Depression	-0.02	-0.01	0.02	-1.19	0.23	-0.07	0.01
Physical Activity	-0.40	-0.06	0.05	-6.83	<.00	-0.51	-0.28

## CHAPTER 5

### DISCUSSION

**Diabetic adults.** Data from the 3422 diabetic individuals included from the IHIS demonstrated significant relationships between BMI and the following variables: Age, gender, race and ethnicity (Hispanic, Asian), physical activity, and smoking. Based on these data, the first hypothesis was rejected. In this study, older adults with diabetes had lower BMIs, which runs counter to the science of the normal aging process where a decrease of lean body mass and an increase in fat mass occurs and there is no association between BMI and mortality after age 75 years (Tabloski, 2014). The data supports the second hypothesis that females with diabetes are more likely to have higher BMI than diabetic males. The data did not support the third hypothesis and had unexpected results with the Asian diabetic having the lowest rate of BMIs followed by the Hispanic diabetic as compared with Whites. This result was then tested controlling for gender and age. However, the results were unchanged. The fourth hypothesis, that more educated people will have lower BMIs than less educated people, was not supported. The hypothesis that people living in poverty will have a higher BMI than people who are above the poverty level (the fifth hypothesis) was also not supported by the data. The sixth hypothesis, people from the Southern region are more likely to have a higher BMI than people from other regions of the U. S., was not supported by the data. The seventh hypothesis, smokers with diabetes tended to have higher BMIs than non-smoking diabetic people, was also not supported. The eighth hypotheses, people who report more days of depression will have higher BMIs, was not supported by the data. The data supported the ninth hypothesis, which indicated that physically active people with diabetes have lower BMIs than less active people. The tenth hypothesis was mostly supported as age, gender,

race and ethnicity, being a smoker, and being physically active were stronger predictors of BMI for people with diabetes than educational attainment, poverty, and depression.

**Non-diabetic adults.** The data of 28,702 non-diabetic individuals from the IHIS survey showed that the findings were significant based on the variables: age, gender, race, ethnicity, educational attainment, geographical region, being physically active, and being a smoker. In terms of geographical regions, the Midwest U.S. respondents in the IHIS had higher BMIs than Whites. The results supported hypothesis 11, that older adult respondents tended to have higher BMIs. Hypothesis 12 was not supported by the data because female respondents in the IHIS were less likely to have higher BMIs than males. The 13<sup>th</sup> hypothesis was mostly supported as ethnicity was significantly positively related to BMI for Hispanics, African Americans, and Native American Indians compared to Whites and significantly negatively related to BMI for Asians as compared to Whites. Data supported hypothesis 14, people with higher education had a lower BMI. The 15<sup>th</sup> hypothesis, that people living in poverty will have a higher BMI than people who are above the poverty level, was also not supported. The results did not support hypothesis 16. These study findings indicated that people from the Central-Midwest region are more likely to have a higher BMI than people from Northeast region of the U. S. Moreover, people from the Northeast region are more likely to have lower BMI than people from other regions. Hypothesis 17 was not supported as respondents in the IHIS who were smokers tended to have lower BMIs than non-smokers. People who report more days of depression would have higher BMIs, was not significant (Hypothesis number 18). Hypothesis 19 was supported by the data. More physically active people have lower BMIs than non-active people do. Hypothesis 20 was partially supported. Race and ethnicity, educational attainment were stronger predictors of BMI on non-diabetic adults. Therefore, being Asian was associated with a lower BMIs. Conversely, being Hispanic,

African American, and Native American Indian was associated with a higher BMIs. Moreover, having more education was associated with having a lower BMIs. There were other significant predictors for the BMI such as age, gender, smoking, and physical activity; however, these predictors were not as strong as race and ethnicity and educational attainment.

**Relationship with previous literature.** The study results for diabetic people indicated that older adults with diabetes have lower BMIs than younger adults with diabetes. The previous literature indicated that older adults tend to have a higher chance of developing T2DM than younger adults (Kirkman et al., 2012). However, both the study and the previous literature showed that people aged 45 to 64 were the group most frequently diagnosed with T2DM (CDC & NCCDPHP, 2014). The study findings are consistent with other studies that indicated females with diabetes are more likely to have higher BMIs than diabetic males (Ekpenyong et al., 2012). In contrast to Sorkin et al. (2014), which indicated that Hispanic Americans are at higher risk of developing diabetes than any other group in the U.S., this study provides evidence that Hispanic Americans have lower BMIs than any other group in the U.S. Moreover, this study provides that active smokers have lower BMIs when compared to non-smokers. This study is congruent with other research regarding the negative relationship between physical activity, BMI, and subsequent T2DM risk (Aune et al, 2015; Lavie et al., 2014; Liese et al., 2013). The results for non-diabetic people indicated that older adults have higher BMIs than younger people, which is similar to the previous literature, which indicated that older adults tend to have a higher chance of developing T2DM than other adults (CDC & NCCDPHP, 2014). The findings were not consistent with other studies that indicated that females are more likely to have higher BMIs than males (Ekpenyong et al., 2012). The results of this study demonstrated that males have a higher BMIs than females. Similar to Sorkin et al. (2014), this study showed that Hispanic Americans



have higher BMIs than Whites in the U.S. In contrast, this study showed that active smokers have lower BMIs when compared to non-smokers. This study also supports the notion that, among non-diabetic people with more education, BMIs will be lower (Al-Rasheedi, 2014; Walker et al., 2011). Like previous literature, these results suggest that being physically active will decrease the BMI (Aune et al, 2015; Lavie et al.,2014; Liese et al., 2013).

**Limitations.** A limitation of this study is that the research was conducted by NHIS researchers, thus these results are from existing data. Therefore, the current researcher was not able to obtain information about the genetic factors using the 2015 data. Moreover, the NHIS collected data for a U.S. population only. Thus, the findings cannot be generalized to a global population. In addition, there was slightly more than the distribution of poverty in the nation as a whole, which in 2014 was estimated to be 14% for persons 18 and older (U.S. Census Bureau, 2015). While the complex sampling survey methods used in the NHIS allows for generalization to the U.S., caution should be used in generalizing to subpopulations.” In the future, studies should focus on the development of T2DM in conjunction with other related diseases, particularly kidney failure, non-traumatic lower limb amputations, heart disease, and stroke. Another limitation was the self-report of the height and weight of the study participants used to calculate the dependent variable, BMI. It is likely that females tended to under estimate their weight, while males over estimated their height (Pursey, Burrows, Stanwell, & Collins, 2014). Another limitation was the use of BMI to measure the obesity in diabetic and non- diabetic adults instead of using a more valid technique, such as the DEXA Scan (Dual X-ray Absorptiometry; Micklesfield, Goedecke, Punyanitya, Wilson, & Kelly, 2012).

**Implications.** Diabetic individuals in the U.S. have easy access to health education, including awareness of diabetes, how to manage it, and what a person should include or exclude

from his or her diet through websites like the AHA and ADA (ADA, 2014a; ADA, 2014b; ADA, 2015a; ADA, 2015b; ADA, 2016a, ADA, 2016b; AHA 2015). Other sources of information include the National Diabetes Prevention Program (CDC, 2016b) and the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK; 2016). Additionally, diabetic education when patient transition from the hospital to home is common and has proven effective 12 months after discharge (Wexler et al., 2012). However, diabetic individuals must have the ability and willingness to change their lifestyle to be successful (Venditti & Kramer, 2012). People with diabetes need to be involved in at least 30 minutes of physical activity each day (Van Dijk, Tummers, Stehouwer, Hartgens, & Van Loon, 2012). Exercising plays a large role in decreasing blood sugar levels and reducing cardiovascular risk factors, including weight loss and improving overall well-being (Van Dijk et al., 2012). Education is an important factor that can be implemented by health care providers (Wexler et al., 2012).

### **Conclusions**

In this project, the researcher studied the relationship nine T2DM risk factors—age, gender, race and ethnicity, educational attainment, poverty, geographical region, smoking, depression, and physical activity—and their relationship to obesity in diabetic and non-diabetic U.S. adults. The study findings for the diabetic population indicated that there are five predictors of obesity. These independent were age, gender, race and ethnicity, smoking, and physical activity. For the non-diabetic population, there were seven predictors of obesity. That were age, gender, race and ethnicity, educational attainment, geographical region, smoking, and physical activity. However, these findings cannot address whether or not other risk factors are predictors of the obesity because of the data limitations. As mentioned previously, further research should include additional information about the population's nature. An unexpected result of the study

was for diabetic adults and indicated that Asian and Hispanic populations have lower BMIs than the Whites. Therefore, further study should include information about immigration pattern, such as first, second and third generation U.S. There were also other risk factors and information that could have been included and might have changed the study's results. Factors such as the lack of information about the population's health history, genetic factor, diet, and social relationships should be included in future studies. As mentioned in the introduction, diabetes is a global phenomenon. Due to population growth, aging population, and life style changes associated with urbanization, the number of people with diabetes will increase worldwide (Chen et al., 2012; Li et al., 2015).

As a student from Saudi Arabia, the researcher is interested in replicating the NHIS project in other countries. Because there were no such studies in Saudi Arabia, nor are there physical activity classes in girls' schools or sports activity access for females, in general, a study similar to the NHIS would be a great opportunity to demonstrate the importance of being physically active and having an ideal body weight Saudi's children and adults, diabetic and non-diabetic alike. In Saudi Arabia there is currently a push for females to be more active and launching a national study is a logical next step.

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