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The Association between History of Gestational Diabetes Mellitus and Current Type 2 Diabetes Status: An Examination of NHANES Data 2011-2014

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ABSTRACT

The Association between History of Gestational Diabetes Mellitus and Current Type 2 Diabetes Status: An Examination of NHANES Data 2011-2014

Background: Diabetes is a growing chronic disease that affects more than 29 million adults in the United States and 422 million adults globally. Women with a history of gestational diabetes (GDM) are identified to be at higher risk for developing subsequent type 2 diabetes mellitus (T2DM). The prevalence of GDM varies based on the data collection method, response rate, and diagnostic criteria. The aim of this study is to examine the association between history of GDM diagnosis and current T2DM status and how the relationship differs based on the participant's age, race, and BMI.

Methods: Data from the 2011-2012 and 2013-2014 National Health and Nutrition Examination Surveys (NHANES) were analyzed to conduct a cross-sectional study of 4,006 U.S. non-pregnant women ages 20 years and older with a history of prior pregnancy. The race/ethnicity of the participants include non-Hispanic Whites, non-Hispanic Blacks, Mexican Americans, non-Hispanic Asians, and "Other" variables. Univariate and multivariate logistic regression analyses were used to determine the association between history of GDM and current T2DM status stratified by age, race, and BMI.

Results: Three hundred and fifteen subjects from a sample size of 4006 were found to have a history of GDM. Of the 315 participants with GDM, 111 (35.2%) were found to develop T2DM. After controlling for age, race, and body mass index (BMI), women with a history of GDM were found to be at greater odds of T2DM (OR=4.71; 95% CI: 3.52-6.28) compared to women without a history of GDM. A multivariate analysis was performed adjusting for other covariates such as age, race, BMI, and cholesterol. When stratified by participant age, women between the ages of 20-44 years with a history of GDM were linked with an increased risk of T2DM (OR= 3.02; 95% CI: 1.88-4.85). Overweight and obese women with a history of GDM have a 2.5-fold risk of developing T2DM (OR=2.51; 95% CI: 1.49-4.23).

Discussion: This study provides further understanding and awareness on the role of GDM during the subsequent risk for T2DM. Our study shows women between the ages of 20 and 44 years and with elevated BMIs ($25 \geq kg/m^2$) are at increased risk of developing subsequent T2DM. Findings suggest the need for health promotion and prevention efforts towards the populations at risk. Early intervention post-pregnancy and education may help prevent women with a history of GDM from developing T2DM.

THE ASSOCIATION BETWEEN HISTORY OF GESTATIONAL DIABETES MELLITUS AND TYPE 2 DIABETES STATUS: AN EXAMINATION OF NHANES DATA 2011-2014

by

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Author's Statement Page

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CHAPTER 1

INTRODUCTION

1.1 Background

Diabetes mellitus (DM) is the seventh leading cause of death in the United States.[1] The increasing number of diabetics in the world is alarming because they are at an increased risk for developing other health complications such as hypertension, cardiovascular disease, stroke, dyslipidemia, blindness, eye disorders, neuropathy, renal disease, dental disease, amputations, and complications of pregnancy.[1] Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels, also known as hyperglycemia.[1,2] This condition is a result of the inability of the pancreas to produce sufficient insulin (type 1 diabetes mellitus or T1DM); the body's incapability to properly use insulin (type 2 diabetes mellitus or T2DM); or both.[2] Insulin is a hormone produced by the pancreas to regulate the blood glucose levels in the blood by assisting in the movement of glucose, a simple sugar used for energy, into the cells of our body.[3]

The global prevalence of diabetes in adults, aged 18 years and older, has escalated from 4.7% in 1980 to 8.5% in 2014.[4] According to the World Health Organization (WHO), the number of adults living with DM globally was 422 million in 2014.[4] The Centers for Disease Control and Prevention (CDC) has reported more than 29 million adults living in the United States had diabetes in 2016.[5] Of those 29 million people, approximately 8.1 million are undiagnosed.[5] Individuals of all ages are affected as the occurrence of diabetes continues to grow, including women of childbearing age who are at greater risk of diabetes during pregnancy.

According to the National Institute of Diabetes and Digestive and Kidney Diseases

(NIDDK), the possibility of developing type 2 diabetes can depend on the individual's risk factors. These risk factors include:[6]

- Overweight or obesity
- Age 45 years or older
- Family history of diabetes
- Prediabetes
- Race/ethnicity is African American, Alaska Native, American Indian, Asian American, Hispanic/Latino, Native Hawaiian, or Pacific Islander
- Hypertension or high blood pressure
- Low level of HDL cholesterol or a high level of triglycerides
- Physical inactivity
- History of heart disease or stroke
- History of gestational diabetes

Gestational diabetes mellitus (GDM) develops during pregnancy in women without a known history of diabetes. Pregnancy increases the metabolic workload of the maternal pancreas which results in increased insulin resistance and insulin insufficiency.[2] GDM affects 1-14% of pregnant women annually in the U.S.[7] The prevalence of GDM varies based on the data collection methods, low response rates, non-random selection of women, and lack of uniformity in the diagnostic criteria.[8] Women with a history of gestational diabetes are at an increased risk of maternal and fetal complications.[7,9] Fetal and infant complications include: macrosomia, birth trauma, premature birth, stillborn birth, hypoglycemia, and a higher risk of developing type 2 diabetes later in life.[9] Maternal complications of GDM during pregnancy

include: elevated blood pressure, preeclampsia, and a higher chance of needing a caesarean section.[7] While gestational diabetes is often considered a temporary condition during pregnancy, these women have an increased risk of having GDM with another pregnancy and a greater risk of developing obesity and type 2 diabetes.[7]

Diabetes is diagnosed with three laboratory tests: glycohemoglobin (HbA1c), fasting plasma glucose, and oral glucose tolerance test. Clinical guidelines changed in 2010 to include glycohemoglobin (HbA1c) as a diagnostic test for diabetes.[10] The HbA1c test measures the average glycated hemoglobin within the past three months. HbA1c levels were standardized to define diabetes as ≥6.5%.[10] The fasting plasma glucose (FPG) test examines a blood sample from an individual after fasting for a minimum of eight hours. According to the American Diabetes Association (ADA) Guideline, a FPG ≥ 126 mg/dL (7.0 mmol/L) is classified as diabetic.[11] The oral tolerance test (OGTT) consists of an eight hour fast. Diabetes is diagnosed if the 2-hour blood glucose is ≥200 mg/dL.[11] It is often recommended each test be repeated before a definitive diagnosis is made.[12]

Prediabetes, also known as impaired glucose tolerance (IGT) or impaired fasting glucose (IFG), is defined by having higher than normal blood glucose level but not high enough to be diagnosed with type 2 diabetes.[13] The HbA1c range for prediabetes is 5.7% -6.4%.[14] An IFG level between 100 mg/dL-125 mg/dL is considered pre-diabetic.[13] Prediabetes can be diagnosed if the OGTT is between 140 mg/dL-199 mg/dL.[13] Individuals diagnosed with prediabetes are at a higher risk of developing type 2 diabetes .[12-15]

1.2 Purpose of the Study

Previous studies have been led to determine the association of T2DM and GDM.

However there is limited information on the recent prevalence of the two with the growing population. This study targets to examine the current diabetes status of women who have ever been pregnant with and without a history of gestational diabetes. The purpose of this study is to perform a cross-sectional analysis using data from the 2011-2012 and 2013-2014 National Health and Nutrition Examination Surveys (NHANES), a nationally representative survey, to identify the association between history of gestational diabetes and the current diabetes status. Women with a history of GDM are at an increased risk of developing T2DM. Therefore, it is imperative we have a better understanding of the association between GDM and T2DM. This study will identify higher risk populations of developing T2DM following a GDM diagnosis during pregnancy. This study will further evaluate the distribution of history of GDM and current T2DM status by age, race, and BMI. Demographic and metabolic characteristics, such as history of hypertension, HDL, LDL, total cholesterol, and triglyceride, will also be included.

1.3 Research Questions

1. What is the relationship between previous gestational diabetes diagnosis and current type 2 diabetes status?

2. How does this relationship vary by age, race, and BMI?

CHAPTER II

REVIEW OF THE LITERATURE

2.1 Diabetes

T1DM was previously known as juvenile diabetes and insulin-dependent diabetes because it develops primarily in children and requires daily administration of insulin. T1DM is characterized by an inadequate production of insulin due to idiopathic or autoimmune destruction of β-cells.[2] People living with T1DM account for 5-10% of the disease.[2]

T2DM was previously known as non-insulin-dependent or adult-onset diabetes. T2DM is characterized by your body's inability to properly use insulin. Insulin resistance can develop if the body's target cells become resistant to the effects of insulin.[2] These target cells become less responsive to insulin and require more insulin in order to have its typical effects. To compensate, the pancreas will increase its insulin production until the pancreas is unable to meet the body's demand. This causes glucose to build up and blood sugar levels to elevate.[15] T2DM accounts for 90-95% of all diabetics.[2] Menke et al. conducted a cross-sectional study using NHANES 1988-2012 to examine the prevalence and trends of diabetes among adults in the United States.[16] The authors determined there was a 12-14% prevalence of diabetes in the population from 2011 to 2012.[16]

2.2 Risk Factors for DM

Risk factors for diabetes comprise of both non-modifiable and modifiable risk factors. Non-modifiable risk factors are factors outside our control and cannot be changed.[17] Non-modifiable risk factors of diabetes include: family history of diabetes, age, race/ethnicity, and history of gestational diabetes.[17] The American Heart Association categorizes

overweight/obesity, physical inactivity, hypertension, and abnormal cholesterol/ lipid levels as modifiable risk factors.[17] Modifiable risk factors can be changed with lifestyle choices to reduce the risk of developing T2DM.[17]

Age: The United States is an aging population. The number of people ages 65 years and older has steadily increased since the 1960s[18]. In 2014, there were 46 million people ages 65 years and older living in the United States and is projected to double by the year 2060.[18] With this said, the risk for developing diabetes increases with age.[19] Older adults may be at a higher risk because their metabolism slows down, functionality decreases, and body composition changes.[20] Type 2 diabetes generally occurs after the age of 45 years.[17] According to the 2017 National Diabetes Statistics Report, approximately 355,000 new cases of diabetes in 2015 were among adults aged 45-64 years.[21] The average age of T2DM onset is 60 years of age with a prevalence rate of 15% among people over 65 years of age. [22]

Race: The diversity of race and ethnicity plays a role in he rise in diabetes prevalence. In 2014, more than 97% of the total population identified themselves as one race. Race categories were broken down to: 62.2% as non-Hispanic White, 13.2% as Black or African American, 5.4 % as Asian, and 17.4% as Hispanic.[23] According to the 2011 US Census, the Hispanic population grew by 43% from 2000 to 2010. Asian Americans increased by 43% from 2000 to 2010, making them the fastest growing race in the US. [24] While the non-Hispanic White population continues to grow, its proportion of the population has declined in the same year reference from 69% to 64%.[24] The prevalence of diabetes differs between race and ethnicities. According to the American Diabetes Association, the rates of diagnosed diabetes by race/ethnic background are of the following: non-Hispanic Whites (7.4%), Asian Americans (8.0%), Hispanics (12.1%), non-

Hispanic Blacks (12.7%), and American Indian/Alaskan Natives (15.1%).[5] Genetics can account for increase prevalence of T2DM in minority groups.[25] There is ongoing research on identifying the genes linking to diabetes.[26] As of 2010, genome-wide association studies have identified approximately 40 loci for which variants increase risk of T2DM .[26] Previous studies also show diabetes disparities among racial/ethnic minorities in health outcomes and quality of life.[27] Some of the disparity is due to lack of awareness, treatment and quality of care in the minority groups.[28] For example, a population based assessment found Puerto Rican adults with DM were less likely than non-Hispanic Whites to receive annual glycohemoglobin testing (73% versus 85%).[29]

BMI: The prevalence of obesity in the U.S. is increasing. The World Health Organization defines overweight and obesity as the abnormal or excessive fat accumulation that may impair health.[30] Body mass index (BMI) is commonly used as a screening tool to classify overweight and obesity in adults. BMI is calculated from a person's weight in kilograms divided by the square height in meters (kg/m^2).[30] Weight is classified as: [31]

- Underweight if BMI is < 18.5 kg/m^2
- Normal if BMI is 18.5 to < 25 kg/m^2
- Overweight if BMI is 25 to <30 kg/m^2
- Obese if BMI is 30 kg/m^2 or higher
- Extremely obese if BMI is ≥ 40 kg/m^2

According to the NIDDK, 35.7% of adults aged 20 and older are obese[32], and 6.3% are considered to have extreme obesity.[33] Being overweight or obese is a main risk factor for T2DM.[34] A cross-sectional study was conducted in 2008 to examine the risk of diabetes among

people 20-64 years of age with BMIs of 25-29 kg/m^2 and >30 kg/m^2.[35] The authors concluded more than 50% of the women could have avoided diabetes by maintaining a normal weight.[35] A cross-sectional examination of NHANES 1999-2008 was conducted to examine the prevalence and trend of obesity and overweight in the US. The prevalence of obesity was over 30% for every age and sex group. The age-adjusted prevalence of diabetes in women was 35.5%.[36]

Hypertension and Cholesterol: Blood pressure is measured by two numbers. The first number, called the systolic blood pressure (SBP), measures the pressure in the blood vessel when the heart beats.[37] The second number, called the diastolic blood pressure (DBP), measures the pressure in the blood vessels when the heart is at rest between beats. [37] An individual is diagnosed with high blood pressure, hypertension, if blood is pumping through the heart and blood vessels with too much force.[38] The American Heart Association defines blood pressure levels above 140/90 mmHg as hypertensive.[39] Cholesterol is made up of a group of fat called low-density-lipoprotein (LDL) and high-density-lipoprotein (HDL).[40] LDL makes up the majority of cholesterol in the blood and can cause plaque buildup in the arteries.[40] HDL helps remove cholesterol from our arteries.[41] Triglyceride is another type of fat found in the body that is used for energy.[40] Total cholesterol is made up of the combined numbers of LDL, HDL, and triglyceride. Cholesterol is classified as:[41-42]

	HDL	LDL	Triglyceride	Total Cholesterol
Desirable	> 60 mg/dL	< 100 mg/dL	< 200 mg/dL	< 150mg/dL
Borderline High	40-59 mg/dL	100-159 mg/dL	200-239 mg/dL	150-199 mg/dL
High	__	≥ 160 mg/dL	≥ 240 mg/dL	≥ 200 mg/dL

Low	<40 mg/dL	__	__	__

Diabetes tends to lower HDL levels and raise LDL and triglyceride levels.[6] The significance of correlation between hypertension and diabetes is unknown, but approximately 26% of adults have multiple chronic conditions.[38,43] Song et al. analyzed the trend of concurrent diabetes, hypertension, and hypercholesterolemia using NHANES 1999-2012.[43] The prevalence of concurrent diabetes, hypertension and hypercholesterolemia increased from 3% in 1999-2000 to 6.3% in 2011-2012.[43]

2.3 Gestational Diabetes

The American Diabetes Association defines gestational diabetes mellitus (GDM) as "any degree of glucose intolerance with onset or first recognition during pregnancy."[44] GDM is associated with increased maternal and infant complications such as increased cesarean delivery, infant macrosomia, infant respiratory distress, neonatal hypoglycemia, and increased risk for T2DM for both mother and child.[45] GDM complicates approximately 4-7% of pregnancies annually in the United States.[27] According to the CDC, the incidence rate of diagnosed diabetes has increased for women ages 18-44 and 45-64 years. Among women ages 18-44 years, the incidence rate had increased from 2.2 to 3.5 per 1,000 population from the year 1997 to 2014. During the same time period, the incidence rate of diagnosed diabetes for women ages 45-64 increased from 7.0 to 10.0 per 1,000 population.[46]

The prevalence of GDM is growing. Correa et al.[9] conducted a study using NIS, the largest publicly available inpatient healthcare database, to describe the trends in diabetes prevalence among delivery hospitalization in the United States from 1993 to 2009.[47] Between

the given years, the authors discovered an increase in prevalence of GDM from 3.09 to 5.57 per 100 deliveries.[9] A 2014 analysis conducted by the CDC examined GDM as reported on birth certificates and Pregnancy Risk Assessment Monitoring System (PRAMS) questionnaires. The analysis reported the prevalence of GDM was as high as 9.2%.[7]

Women who have a family or personal history of prediabetes or gestational diabetes, are obese, older than 25 years of age, of non-White race (African, American Indian, Asian, Hispanic, or Pacific Islander), or have a family or personal health history of prediabetes or gestational diabetes are at an increased risk for developing gestational diabetes.[44]

Age: The risk of GDM increases with advancing age.[20,28] A retrospective study conducted between 1988 and 2000 revealed a strong association between advancing maternal age and the development of GDM. The mean age of the women who developed GDM was greater than the comparison group (29.6± 5.2 years versus 26.8 ± 5.1 years).[48] In another study, the pregnancy outcome in women ages 45 year and older was evaluated. The study showed the rate of GDM among women 45 years and older was higher in comparison to the whole sample (17.0% versus 5.6%).[49]

Race: GDM also differs by race/ethnicity. In 2004, the percentages of live births were 56%, 14%, 23% and 6% to non-Hispanic White, Hispanic, non-Hispanic Black Hispanic, and non-Hispanic Asians, respectively.[50] From 1990 to 2001, a trend study using birth certificates saw a significant GDM increase in all major racial/ethnic groups except non-Hispanic White women.[51] Asian American and Hispanics had a significantly higher prevalence of GDM compared to non-Hispanic White.[52]

BMI: GDM risk increases with increasing body mass index (BMI). Kim et al. used the

Pregnancy Risk Assessment Monitoring System to calculate the percentage of GDM attributable to overweight and obesity. They discovered the overall population-attributable fraction for overweight, obese, and extremely obese was 46.2%.[53] The risk of GDM can be reduced with diet and exercise. There have been several studies conducted in the past that evaluated weight gain, diet, and physical activity in association to GDM. A descriptive-comparison study was conducted to determine the dietary style and physical activity level of women with and without GDM.[54] In this study, the authors found a significant difference in the mean moderate activity duration between the healthy pregnant women and women with gestational diabetes. Moderate to intense physical activity can lead to a 27% reduction of developing elevated blood glucose levels during pregnancy.[54]

Pregnant women with any of the risk factors of diabetes listed above are recommended get testing for undiagnosed T2DM at their first prenatal visit. Gestational diabetes is generally diagnosed in the second or third trimester. Pregnant women without prior knowledge of diabetes are advised to get testing for GDM between 24-28 weeks of gestation. In the United States, the most clinical test is the two-step approach.[55] Five to ten percent of women continue to have hyperglycemia after delivery.[44]

The ADA recommends women with GDM to get tested for the oral glucose tolerance test (OGTT) at the 6- to 12-week postpartum visit. If the OGTT is normal, ADA recommends these women get tested again every one to three years.[11] Oza-Frank et al. used data from the Pregnancy Risk Assessment Monitoring System (PRAMS) 2009-2010, a population based survey, to measure the frequency of postpartum diabetes testing among women with previous GDM.[56] The study disclosed only 51.7% of PRAM respondents with GDM attended a postpartum visit

and actually had the postpartum test for diabetes.[56] Nabuco et al. studied the accuracy of the OGTT 48-72 hours postpartum in attempts to increase the number of postpartum screening. The authors concluded early OGTT testing is helpful in identifying the women who require the 6-week postpartum testing.[57]

A study was previously conducted in Sydney, Australia to understand the relationship between T2DM and GDM. In this study, medical records of women with T2DM in pregnancy were reviewed retrospectively to assess whether these women had GDM. The data indicated that 44% of women with T2DM in pregnancy had a history of previous GDM.[58] Women with a history of GDM have a 30-84% increased risk of developing GDM in subsequent pregnancies.[58] It is important to understand the prevalence of GDM in the most recent years in order to identify and reduce the individual's risks of recurrent GDM and the progression to type 2 diabetes.

CHAPTER III

METHODS

3.1 Data Source

Data was obtained from the National Health and Nutrition Examination Survey (NHANES), a survey to assess the health and nutritional status of people living in the United States.[59] Health interviews are conducted in the respondents' home and physical examinations are conducted in specially designed mobile centers. The survey takes a nationally representative sample of 5,000 people annually and reports every 2 years. Data was obtained from two two-year cycles, NHANES 2011-2012 and 2013-2014. NHANES is a publically available secondary data source and is currently approved by the IRB as not human subject research.[60-61] NHANES is on the list of pre-approved publicly available datasets and does not require GSU IRB approval.

3.2 Variables

Demographics

Age: Participants between the ages of 1 and 79 years at the time of screen were reported in terms of age in years. Those who are 80 years and older were coded as "80." The age was calculated based on the participant's date of birth or the age reported. Women ages 20 year and older were included in the analysis.

Race: A new variable was added to the NHANES survey in 2011 to include non-Hispanic Asians. Prior to 2011, Asians were included in the "other" category. The NHANES 2011-2014 sample design included an oversample of Asian Americans in addition to the ongoing oversampling of non-Hispanic Black, and persons 60 years and over.[60] The oversampling of

these subgroups increased the reliability of the estimates of health status indicators for these populations.[60] Even with the oversampling, Asian and Mexican Americans constitute 11-17 percent of the un-weighted examined sample for NHANES 2011-2014. The NHANES Analytic Guidelines advised caution when performing analysis due to limited sample size and suggested it might be necessary to examine all four years for reliable analysis.[59-61] The categories of the self-identified race were: Mexican American, other Hispanics, non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, and "Other" Race. There were no missing values for race. For the purpose of the study, Mexican American and other Hispanics were combined to create five race categories: Mexican American, non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, and Other.

Education: This variable will inform us of the highest level of education completed by adult participants, 20 years and older. The categories of education was divided into: less than 9th grade, 9-11th grade, high school graduate/GED or equivalent, some college or AA degree, or college graduate or above. Participants that refused to answer or did not know were coded as "missing".

Income: Income was based on the total annual household income based on dollar range. If a household was comprised of a single family or individual, the reported family income was used as household income.

Pregnancy

Information of variables related to pregnancy was gathered in the reproductive health questionnaire. This dataset contains records for variables related to pregnant for women between the ages of 20 and 44 years. Women 19 years old or younger and women over 45

years were excluded from this dataset due to disclosure risks. Questions used from the reproductive health questionnaire were, “Have you ever been pregnant?”, “Are you pregnant now?”, “During pregnancy, were you ever told by a doctor or other health professional you had diabetes, sugar diabetes or gestational diabetes (not including diabetes that you have known before the pregnancy)?”, and “How old were you when you were first told you had diabetes during pregnancy?”. Women with a history of pregnancy were included in this study. Participants that were currently pregnant at the time of interview and examination were excluded. Individuals that answered yes to the “during pregnancy, were told by a doctor or other health professional you have diabetes” question were coded for having a positive history of GDM.

Diabetes

The diagnosis of diabetes was defined based on the self-reported response to the diabetes questionnaire and laboratory variables. Questions obtained in the diabetes questionnaire were “{Other than during pregnancy}, have you ever been told by a doctor of health professional that you have diabetes or sugar diabetes?”, “ Have you ever been told by a doctor or other health professional that you have prediabetes, impaired fasting glucose, impaired glucose tolerance, borderline diabetes or that your blood sugar is higher than normal but not high enough to be called diabetes or sugar diabetes?”, “How old were you when a doctor or other health professional first told you that you had diabetes or sugar diabetes?”, “Are you now taking diabetic pills to lower your blood sugar?”. The laboratory measures that tested for diabetes were Glycohemoglobin (%), Two Hour Glucose (OGTT) (mg/dL) and Fasting Plasma Glucose (mg/dL).

BMI

NHANES uses body measures data to monitor and estimate the prevalence of overweight and obesity in the population. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). A BMI of 24.9 kg/m^2 or less was considered normal weight. BMI of 25.0-29.9 kg/m^2 and 30.0 kg/m^2 and above, were considered overweight and obese, respectively.[32]

Cholesterol

The variables related to cholesterol were obtained from the laboratory variable list. The variables examined were: Direct-HDL-Cholesterol (mg/dL), LDL-Cholesterol (mg/dL), Triglyceride (mg/dL), and Total Cholesterol (mg/dL). HDL-cholesterol was categorized as normal if HDL was greater than or equal to 40 mg/dL and elevated if HDL was less than 40 mg/ dL. A LDL level of 160 mg/dL or lower was classified as normal. Total cholesterol of less than 240 mg/dL and triglyceride of less than 200 mg/dL were considered within the normal range.

3.3 Inclusion and Exclusion Criteria

As this is a study focused on previous gestational diabetes status, males were excluded. The participants must have responded yes to the question “during pregnancy, was told you had diabetes”. Women reporting pregnancy at the time of the exam was excluded from the study. The responses from the diabetes questionnaire were used to determine history of diabetes. Diabetes was diagnosed if the participants responded yes to the “told by a doctor or health professional you have diabetes” question or to the “taking diabetic pills to lower your blood sugar” question. Undiagnosed cases were classified as having diabetes if one of the laboratory measures for diabetes was met: a glycohemoglobin of 6.5% or higher, a fasting plasma glucose

of 126 mg/dL or higher, or a two-hour glucose tolerance test of 200 mg/dL or higher.[11] Participants that reported age diagnosed with diabetes prior to age diagnosed with gestational diabetes were excluded.

3.4 Statistical Procedures

Statistical Analysis System (SAS) version 9.4 was used to prepare and analyze the data. Descriptive statistics were derived from the demographic and metabolic variables using SAS. Univariate and multivariate logistic regression analyses were performed on women with and without a history of gestational diabetes to determine association with current diabetes status, age, race, BMI, and cholesterol. Ages 20-44 years, non-Hispanic Whites, and BMI < 25 kg/m^2 were used as the reference groups. Multivariate logistic regression analysis was performed and stratified by GDM history and current T2DM diagnosis by age, race, and BMI. A p-value <0.05 was used to establish statistical significance.

CHAPTER IV

RESULTS

4.1 Descriptive Statistics

The sample size of this study was n=4,006, of which n=315 participants (7.9%) had a history of GDM. The basic characteristics of the study sample based on GDM history are shown in Table 1. Compared to women without a known history of GDM, the women with a history of GDM had significantly higher percentages in the 20-44 year age category (56.2% versus 32.1%; $p<0.0001$), BMI ≥ 25 kg/m^2 (80.0% versus 70.9%; p=0.0006), HDL < 40 mg/dL category (19.3% versus 9.8%; p<0.0001), and triglyceride ≥ 200 mg/dL category (18.1% versus 8.9%; p=0.0003). In comparison, there was a significantly greater percentage of women without a known history of GDM in the 70 years and older age category (20.1% versus 3.2%; p<0.0001). The distribution based on race, education, and income categories were similar across GDM status. In terms of proportion of the population at risk for diabetes, women with a history of GDM were more likely than women without a history of GDM to have T2DM as indicated by: self-reported history of prediabetes (13.8% versus 5.9%; p<0.0001), told by a healthcare professional (27.3% versus 12.5%; p<0.0001), HbA1c ≥ 6.5% (23.3% versus 10.1%; p<0.0001), FPG ≥ 126mg/dL (25.0% versus 10.4%; p<0.0001), and OGTT ≥ 200 mg/dL (13.8% versus 7.4%; p=0.0244).

Of the n=315 participants with a GDM history, n=111 women (35.2%) presented with current diagnosis of T2DM. In comparison, 664 participants (18%) without a history of GDM presented with current diagnosis of T2DM. The proportion of women with and without a history of GDM who developed T2DM is presented in Table 2. Over half of the participants with current diabetes were between the ages of 45 and 69 years. More than half of this population

graduated from high school or had some college education. Approximately 70% had less than a $55,000 annual income. Approximately 85.7% and 80.2% (p=0.0442) of the participants, with and without a known history of GDM, respectfully, were overweight or obese (BMI ≥ 25 kg/m^2). There were more women with a known history of hypertension among those without a known history of GDM compared to women with a history of GDM (73.5% versus 60%, p=0.0002).

4.2 Univariate Analysis

Univariate analysis was conducted to determine the association between each independent variable with GDM history and current T2DM status (Table 2). Women with a history of GDM had a 2.49 (CI: 1.95-3.18; p<0.0001) odds of subsequent T2DM compared to those without a history of GDM. Subjects in the age groups of 45-69 and 70+ years had much increased odds ratios of T2DM, as evidenced by (OR=4.24; 95% CI: 3.34-5.38; p<0.0001) and (OR=6.99; 95% CI: 5.38-9.08; p<0.0001), respectively. The odds of subsequent T2DM were higher among non-Hispanic Black (OR=1.59; 95% CI: 1.30-1.93) and Hispanic-Mexican origin (OR=1.51; 95% CI: 1.23-1.85) versus non-Hispanic White origin. Women within the sample population with a BMI ≥25 kg/m^2 had a higher risk of T2DM compared to women with a BMI <25 kg/m^2 (OR=3.54; 95% CI: 2.83-4.43).

4.3 Multivariate Analysis

After adjusting for age, race, and BMI, women with a history of GDM had 4.71 (95% CI: 3.52-6.28) higher odds of developing subsequent T2DM compared with women without a history of GDM (Table 4). Compared to non-Hispanic White, participants of non-Hispanic Black, Mexican American, and non-Hispanic Asian had 1.92 (95% CI: 1.55-2.40), 1.90 (95% CI: 1.51-2.38), and 1.95 (95% CI: 1.41-2.69) greater odds of T2DM, respectively. Compared to

participants with normal weight (BMI < 25 kg/m^2), being overweight or obese (BMI ≥ 25 kg/m^2) was associated with increased odds for subsequent T2DM (OR=2.74; 95% CI: 2.19-3.51).

Table 5 shows the association between history of GDM and current T2DM status stratified by age using multivariate analysis. The analysis was adjusted for race, BMI, history of hypertension, HDL, LDL, total cholesterol, and triglyceride. In the age-stratified analysis, women between in the 20-44 age group with a known history of GDM had 3.02 (95% CI: 1.88-4.85) increased odds of T2DM, but was not significantly associated with T2DM in 45-69 and 70 age groups. Within the 20-44 age group, women with HDL < 40 mg/dL had 2.46 (95% CI: 1.65-3.69) increased odds of T2DM than those with HDL ≥ 40 mg/dL. Participants between the ages of 45 and 69 years had increased odds of T2DM if they had a history of hypertension (OR=1.72; 95% CI: 1.41-2.10), elevated total cholesterol (OR=1.89; 95% CI: 1.22-2.94) and triglyceride levels (OR=1.54; 95% CI: 1.54-2.21). Women in the 70+ age group had increased odds of T2DM if they had a known history of hypertension (OR=4.92; 95% CI: 3.73-6.49).

Table 6 shows the association between history of GDM and current T2DM status stratified by race after adjusting for age, BMI, history of hypertension, HDL, LDL, total cholesterol, and triglyceride. Women of non-Hispanic Asian and Other race origin with a history of GDM were associated with 1.68 (95% CI: 0.94-3.00) and 1.86 (95% CI: 0.75-4.60) increased odds of T2DM compared to women without a known history of GDM. Non-Hispanic White women in the 70+ age category were associated with 3.03 (95% CI: 2.23-4.13) increased odds of T2DM than those in the 20-44 age category. Non-Hispanic Black and Mexican American participants with BMI ≥ 25 kg/m^2 have 2.33 (95% CI: 1.73-3.15) and 2.29 (95% CI: 1.71-3.06) greater odds of T2DM than those with normal weight (BMI < 25 kg/m^2). Non-Hispanic Black

participants with a history of hypertension (OR=2.16; 95% CI: 1.68-2.80) and elevated LDL levels (OR=1.95; 95% CI: 1.03-3.72) were associated with increased odds of T2DM. Non-Hispanic White participants with elevated total cholesterol (OR= 1.88; 95% CI: 1.20-2.95) and triglyceride (OR=1.58; 95% CI: 1.11-2.25) levels were associated with increased odds of T2DM.

Table 7 shows the association between history of GDM and current T2DM status stratified by BMI after adjusting for age, race, hypertension, HDL, LDL, total cholesterol, and triglyceride. Overweight and obese women with a history of GDM were associated with 2.51 (95% CI: 1.49-4.23) increased odds of T2DM compared to women without a known history of GDM. Overweight and obese women of Mexican American (OR=2.33; 95% CI: 1.73-3.15) and non-Hispanic Black origin (OR=2.29; 95% CI: 1.71-3.06) were associated with greater odds of T2DM than those of normal weight. Non-Hispanic Asian participants with normal weight were associated with increased odds for T2DM compared to non-Hispanic Whites (OR=4.55; 95% CI: 3.15-6.56). Overweight and obese participants with a history of hypertension (OR=2.33; 95% CI: 1.68-2.80), low HDL levels (OR=2.95; 95% CI: 1.66-5.24), elevated LDL levels (OR=3.01; 95% CI: 1.63-5.57), and elevated triglyceride levels (OR=1.90; 95% CI: 1.16-3.11) were associated with increased odds of T2DM.

Chapter V

Discussion and Conclusion

5.1 Discussion

This study sought to determine the association between having a history of GDM and current T2DM status among American women. Previous literature revealed women with a history of GDM have an increased risk of developing T2DM, but the risk varied between studies. The reported incidence rate of T2DM following GDM history varied from 2.6-70 % with a follow up period of 6 weeks to 28 years postpartum.[53] The succeeding aim of the study was to determine if the association differed based on participant age, race, and BMI. The influence of variables such as race, age, body mass index, hypertension, HDL, LDL, total cholesterol, and triglycerides were also examined.

NHANES was used for this study because it is a national representation of the non-institutionalized population of residents in the U.S. The NHANES 2011-2012 and 2013-2014 datasets contained the latest released data. Based on the NHANES 2011-2014 datasets, approximately 34.2% of women with a self-reported history of GDM developed T2DM. When controlled for age, race, and BMI, women with a history of GDM had a strong association for developing subsequent T2DM. These findings support previous evidence that GDM increases the risk of developing T2DM in subsequent years.[56]

When stratified by age, women with a history of GDM between the ages of 20-44 years had 3.02 (95% CI: 1.88-4.85) increased odds of subsequent T2DM than women without a history of GDM. Previous literature suggests the progression to T2DM increases sharply within the first 5 years postpartum and then plateaus after 10 years.[53,62] The WHO classifies

reproductive age between the ages of 15 and 44 years.[63] There may be a greater odds ratio in the 20-44 age group because these women are within the reproductive age range. These results were different that what I expected. Earlier studies showed the risk of T2DM to increase as an individual matures.[17, 19] I expected the ORs of developing subsequent T2DM to increase as the age categories to increase.

Previous studies examined the relationship between non-Hispanic White, non-Hispanic Black, and Hispanics races with GDM and T2DM, but there is limited information about the non-Hispanic Asian population living in the United States. NHANES started stratifying race to include Non-Hispanic Asians for the first time in the 2011-2012 two-year cycle. The multivariate analysis used to examine the associated of GDM history and current T2DM status did not show statistical significance when stratified by race. The results indicated that women of non-Hispanic Asian (OR=1.68; 95% CI: 0.94-3.00) and Other race (OR=1.86; 95% CI: 0.75-4.60) origin with a history of GDM have increased odds of developing subsequent T2DM, but the odds ratios does not show statistical significance. Previous literature indicates there are racial and ethnic differences in the association between GDM history and risk for T2DM.[64] One would expect to see increased ORs among the minority groups.[65]

When stratified by BMI, overweight and obese individuals with a history of GDM had 2.51 (95% CI: 1.49-4.23) increased odds to currently have T2DM than overweight and obese women without GDM. These results are consistent with previous literature.[35, 53] Individuals with higher BMIs are at greater risk of T2DM.

The risk of T2DM is multifactorial so it must also be examined as such. Non-Hispanic Black and Mexican American has a 2.33 (95% CI: 1.73-3.15) and 2.29 (95% CI: 1.71-3.06), respectively,

increased odds of T2DM if their BMI ≥ 25 kg/m^2. There was also a significant association between elevated BMI (≥ 25 kg/m^2) with low HDL, high total cholesterol, and high triglyceride levels. Cholesterol levels, especially HDL < 40 mg/dL, LDL > 160 mg/dL, and total cholesterol >200 mg/dL, were also statistical significant for women with a BMI ≥ 25 kg/m^2, indicating women with any of the listed conditions are at increased odds of developing T2DM. Hypertension showed statistical significance among women 45 years and older, non-Hispanic Black, Other Race, and with a BMI ≥ 25 kg/m^2.

5.2 Limitations

This was a cross-sectional study using secondary data from NHANES 2011-2014. Cross-sectional studies by definition only provide a snapshot of the population and can only show association, not causal inferences. A limitation with NHANES is responses to the questionnaires were self-reported. There may have been recall or self-reported bias. Diabetes was not classified based on type (1 or 2) in the diabetes questionnaire. T2DM was classified, based on the participant's responses to the questions noted in the methods section. Women with at least one of the laboratory measures that met the diabetes criteria were considered new diabetics for this study. Repeat testing would have been required to be truly diagnostic.[12] NHANES data provided a nationally representative sample, but the results may not be representative of the general population due to the sampling method. The results of this study should also be carefully interpreted due to the lack of confounding factors, such as smoking status, diet, and physical activity, not examined.

5.3 Implications of Findings

Women between the ages of 20 and 44 years with a history of GDM have a strong association with subsequent T2DM. The time after delivery is most important for preventing T2DM from developing. Clinical implications from our study include the need for clinicians who manage the care of postpartum women with a history of GDM to be cognizant of the elevated risk of T2DM. These clinicians can provide these women with additional information and resources for postpartum interventions to reduce modifiable risks of T2DM, such as BMI, which also has a strong association.

5.4 Conclusion

This analysis provides further insight on the role of GDM and its risks for the development of subsequent T2DM. The study shows that women with increased risks of T2DM are: between the ages of 20 and 44 years and have a BMI $\geq$ 25 kg/m^2. The result of this study suggests the need for health promotion and prevention effects tailored to women with a history of GDM within these populations. Early intervention post-pregnancy may help prevent women with a history of GDM from developing T2DM. Future studies should expand on this study and include other confounding factors not mentioned in this study. Future research should also include examining future NHANES datasets in a similar fashion to determine trend of association between history of gestational diabetes and current T2DM status.

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APPENDICES

Table 1: Basic Characteristics of Study Population Based on GDM History

	GDM (%)	No GDM (%)	P-value
Total	n=315	n=3691	
Age (years)			
20-44	56.2	32.2	
45-69	40.6	47.6	**<0.0001**
70+	3.2	20.2	
Race			
NH White	35.3	41.7	
NH Black	27.3	21.4	
Mexican American	18.7	24.6	**0.0003**
NH Asian	14.9	9.6	
Other Race	3.8	2.7	
Education			
Less than High School	21.0	23.7	
HS Graduate or some college	55.6	54.3	0.5303
College Graduate or more	23.5	22.1	
Income			
Less than $25,000	26.6	35.1	
$25,000 to $54,999	31.6	30.4	**0.0186**
$55,000 to $74,999	12.8	10.1	
$75,000 or more	29.0	24.5	
BMI (kg/m^2)			
BMI < 25 kg/m^2	20.0	29.1	
BMI ≥ 25 kg/m^2	80.0	70.9	**0.0006**
History of Hypertension			
No	63.4	56.6	
Yes	36.6	43.4	**0.0206**
HDL-Cholesterol (mg/dL)			
HDL ≥40 mg/dL	80.7	90.2	
HDL <40 mg/dL	19.3	9.8	**<0.0001**
LDL-Cholesterol (mg/dL)			
LDL <160 mg/dL	93.5	90.6	
LDL ≥160 mg/dL	6.5	9.4	0.2597
Total Cholesterol (mg/dL)			
Tchol < 240 mg/dL	88.0	86.0	
Tchol ≥240 mg/dL	12.0	14.0	0.3282
Triglyceride (mg/dL)			
Trig <200 mg/dL	81.9	91.1	
Trig ≥200 mg/dL	18.1	8.9	**0.0003**
Diabetes			
Told you had Prediabetes?			

No	86.2	94.1	
Yes	13.8	5.9	**<0.0001**
Told you were diabetic?			
No	72.7	87.5	
Yes	27.3	12.5	**<0.0001**
Take diabetic pills to lower blood sugar?			
No	53.4	52.1	
Yes	46.6	47.9	0.7902
Glycohemoglobin (%)			
HbA1c <6.5 %	76.7	89.9	
HbA1c ≥6.5 %	23.3	10.1	**<0.0001**
FPG mg/dL			
FPG <126 mg/dL	75.0	89.6	
FPG ≥126 mg/dL	25.0	10.4	**<0.0001**
OGTT mg/dL			
OGTT <200 mg/dL	86.2	92.6	
OGTT ≥200 mg/dL	13.8	7.4	**0.0244**

Table 2: The Demographic and Metabolic Characteristics of Current T2DM Status by GDM History

	GDM (%)	No GDM (%)	P-value
(n=775)	**(n=111)**	**(n=664)**	
Age (years)			
20-44	34.2	7.8	**<0.0001**
45-69	58.6	55.7	
70+	7.2	36.4	
Race			
NH White	36.0	34.0	
NH Black	31.5	24.4	0.2547
Mexican American	20.7	30.6	
NH Asian	9.9	8.9	
Other Race	1.8	2.1	
Education			
Less than High School	29.7	36.4	0.3494
HS Graduate or some College	59.5	52.4	
College or more	10.8	11.1	
Income			
Less than $25,000	32.7	46.2	
$25,000-$54,999	31.8	31.0	**0.0188**
$55,000-$74,999	14.0	9.8	
$75,000 or more	21.5	13.0	
BMI (kg/m^2)			
BMI < 25 kg/m^2	14.3	19.8	
BMI ≥ 25 kg/m^2	85.7	80.2	**0.0442**
Hypertension			
No	40.0	26.5	
Yes	60.0	73.5	**0.0002**
HDL-Cholesterol (mg/dL)			
HDL ≥40 mg/dL	78.9	86.2	
HDL <40 mg/dL	21.1	13.8	0.0501
LDL-Cholesterol (mg/dL)			
LDL <160 mg/dL	93.0	89.8	
LDL ≥160 mg/dL	7.0	10.2	0.4526
Total Cholesterol (mg/dL)			
Tchol < 240 mg/dL	85.3	86.2	
Tchol ≥240 mg/dL	14.7	13.8	0.8176
Triglyceride (mg/dL)			
Trig <200 mg/dL	72.1	83.3	
Trig ≥200 mg/dL	27.9	16.7	**0.0384**
Diabetes			

Told you had Prediabetes?			
No	63.2	76.6	
Yes	36.8	23.4	0.2599
Told you were diabetic?			
No	22.5	30.5	
Yes	77.5	69.5	0.0888
Take diabetic pills to lower blood sugar?			
No	36.7	32.4	
Yes	63.3	67.6	0.4011
Glycohemoglobin (%)			
HbA1c <6.5%	35.5	43.6	
HbA1c ≥6.5%	64.5	56.4	0.1115
Fasting Plasma Glucose (mg/dL)			
FPG <126 mg/dL	41.0	48.4	
FPG ≥126 mg/dL	59.0	51.6	0.2837
OGTT (mg/dL)			
OGTT <200 mg/dL	27.8	25.0	
OGTT ≥200 mg/dL	72.2	75.0	0.7775

Table 3: Univariate Association of GDM History and Current T2DM Status

Variables	**OR**	**95% CI**	**P-value**
Gestational DM			
No	Ref	Ref	Ref
Yes	2.49	(1.95-3.18)	**<0.0001**
Age (year)			
20-44	Ref	Ref	Ref
45-69	4.24	(3.34-5.38)	**<0.001**
70+	6.99	(5.38-9.08)	**<0.001**
Race			
NH White	Ref	Ref	Ref
NH Black	1.59	(1.30-1.93)	**<0.0001**
Mexican American	1.51	(1.23-1.85)	**<0.0001**
NH Asian	1.10	(0.82-1.46)	0.5339
Other	0.87	(0.50-1.50)	0.6078
BMI (kg/m^2)			
BMI<25 kg/m^2	Ref	Ref	Ref
BMI ≥ 25 kg/m^2	3.54	(2.83-4.43)	**<0.0001**

Table 4: Multivariate Association of GDM History and Current T2DM Status

Variables	**OR**	**95% CI**	**P-value**
Gestational DM			
No	Ref	Ref	Ref
Yes	4.71	(3.52-6.28)	**<0.0001**
Age (years)			
20-44	Ref	Ref	Ref
45-69	5.35	(4.13-6.94)	**<0.0001**
70+	12.68	(9.41-17.09)	**<0.0001**
Race			
NH White	Ref	Ref	Ref
NH Black	1.92	(1.55-2.40)	**<0.0001**
Mexican American	1.90	(1.51-2.38)	**<0.0001**
NH Asian	1.95	(1.41-2.69)	**0.0026**
Other	1.56	(0.87-2.81)	0.1359
BMI (kg/m^2)			
BMI<25 kg/m^2	Ref	Ref	Ref
BMI ≥ 25 kg/m^2	2.74	(2.19-3.51)	**<0.0001**

Table 5: Multivariate Association of GDM History and Current T2DM Status Stratified by Age

	Age		
	20-44 Years	**45-69 Years**	**70+ Years**
Variables	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Gestational DM			
No	Ref	Ref	Ref
Yes	3.02 (1.88-4.85)	0.71 (0.50-1.03)	0.13 (0.05-0.36)
Race			
NH White	Ref	Ref	Ref
NH Black	1.60 (1.19-2.14)	1.52 (1.18-1.95)	0.28 (0.20-0.40)
Mexican American	1.06 (0.80-1.42)	1.69 (1.31-2.17)	0.39 (0.27-0.55)
NH Asian	1.15 (0.79-1.68)	1.74 (1.23-2.45)	0.31 (0.18-0.52)
Other Race	1.88 (0.93-3.79)	1.23 (0.65-2.31)	0.31 (0.12-0.83)
BMI kg/m^2			
BMI <25 kg/m^2	Ref	Ref	Ref
BMI ≥ 25 kg/m^2	1.06 (0.82-1.37)	1.19 (0.95-1.50)	0.68 (0.50-0.83)
History of Hypertension			
No	Ref	Ref	Ref
Yes	0.15 (0.11-0.19)	1.72 (1.41-2.10)	4.92 (3.73-6.49)
HDL-Cholesterol (mg/dL)			
HDL ≥40 mg/dL	Ref	Ref	Ref
HDL <40 mg/dL	2.46 (1.65-3.69)	0.77 (0.54-1.11)	0.37 (0.20-0.69)
LDL-Cholesterol (mg/dL)			
LDL <160 mg/dL	Ref	Ref	Ref
LDL ≥160 mg/dL	0.88 (0.45-1.72)	1.09 (0.66-1.79)	0.96 (0.50-1.84)
Total Cholesterol (mg/dL)			
Tchol < 240 mg/dL	Ref	Ref	Ref
Tchol ≥240 mg/dL	0.25 (0.14-0.45)	1.89 (01.22-2.94)	1.37 (0.78-2.40)
Triglyceride (mg/dL)			
Trig <200 mg/dl	Ref	Ref	Ref
Trig ≥200 mg/dl	0.64 (0.41-1.01)	1.54 (1.54-2.21)	0.86 (0.53-1.40)

Table 6: Multivariate Association of GDM History and Current T2DM Status Stratified by Race

	Race				
	NH White	**NH Black**	**Mexican American**	**NH Asian**	**Other**
Variables	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**
Gestational DM					
No	Ref	Ref	Ref	Ref	Ref
Yes	0.83 (0.59-1.26)	0.81 (0.52-1.27)	1.02 (0.67-1.55)	1.68 (0.94-3.00)	1.86 (0.75-4.60)
Age (years)					
20-44	Ref	Ref	Ref	Ref	Ref
45-69	0.98 (0.78-1.23)	0.80 (0.61-1.05)	1.25 (0.96-1.63)	1.13 (0.78-1.64)	0.68 (0.34-1.39)
70+	3.03 (2.23-4.13)	0.34 (0.23-0.51)	0.72 (0.49-1.07)	0.53 (0.30-0.94)	0.41 (0.14-1.22)
BMI (kg/m^2)					
BMI <25 kg/m^2	Ref	Ref	Ref	Ref	Ref
BMI ≥ 25 kg/m^2	0.82 (0.66-1.02)	2.33 (1.73-3.15)	2.29 (1.71-3.06)	0.16 (0.11-0.22)	0.54 (0.28-1.04)
History of Hypertension					
No	Ref	Ref	Ref	Ref	Ref
Yes	0.85 (0.60-1.06)	2.16 (1.68-2.80)	0.59 (0.46-0.77)	0.80 (0.54-1.17)	1.62 (0.81-3.24)
HDL-Chol (mg/dL)					
HDL ≥40 mg/dL	Ref	Ref	Ref	Ref	Ref
HDL <40 mg/dL	1.40 (0.98-2.01)	0.70 (0.45-1.10)	0.95 (0.63-1.45)	0.73 (0.35-1.53)	1.20 (0.43-3.32)
LDL-Chol (mg/dL)					
LDL <160 mg/dL	Ref	Ref	Ref	Ref	Ref
LDL ≥160 mg/dL	0.67 (0.40-1.11)	1.95 (1.03-3.72)	0.67 (0.37-1.22)	2.05 (0.80-5.26)	1.85 (0.31-10.97)
Total Chol (mg/dL)					
Tchol < 240 mg/dL	Ref	Ref	Ref	Ref	Ref
Tchol ≥240 mg/dL	1.88 (1.20-2.95)	0.50 (0.27-0.94)	1.17 (0.69-1.7)	0.40 (0.17-0.97)	0.39 (0.07-2.32)
Triglyceride (mg/dL)					
Trig <200 mg/dL	Ref	Ref	Ref	Ref	Ref
Trig ≥200 mg/dL	1.58 (1.11-2.25)	0.31 (0.18-0.54)	1.13 (0.75-1.70)	1.31 (0.68-2.50)	1.49 (0.54-4.10)

Table 7: Multivariate Association of GDM History and Current T2DM Status Stratified by BMI

	BMI	
	< 25 kg/m^2	**≥ 25 kg/m^2**
Variables	**OR**	**OR**
Gestational DM		
No	Ref	Ref
Yes	0.40 (0.24-0.67)	2.51 (1.49-4.23)
Age (years)		
20-44	Ref	Ref
45-69	0.95 (0.73-1.25)	1.05 (0.80-1.38)
70+	1.44 (1.01-2.04)	0.70 (0.49-0.99)
Race		
NH White	Ref	Ref
Hispanic	0.45 (0.33-0.62)	2.22 (1.61-3.07)
NH Black	0.47 (0.34-0.64)	2.12 (1.55-2.90)
NH Asian	4.55 (3.15-6.56)	0.22 (0.15-0.32)
Other Race	1.65 (0.85-3.24)	0.61 (0.31-1.18)
History of Hypertension		
No	Ref	Ref
Yes	0.43 (0.33-0.56)	2.33 (1.79-3.02)
HDL-Cholesterol (mg/dL)		
HDL ≥40 mg/dL	Ref	Ref
HDL <40 mg/dL	0.34 (0.19-0.60)	2.95 (1.66-5.24)
LDL-Cholesterol (mg/dL)		
LDL <160 mg/dL	Ref	Ref
LDL ≥160 mg/dL	0.33 (0.18-0.62)	3.01 (1.63-5.57)
Total Cholesterol (mg/dL)		
Tchol < 240 mg/dL	Ref	Ref
Tchol ≥240 mg/dL	1.69 (1.03-2.79)	0.59 (0.36-0.98)
Triglyceride (mg/dL)		
Trig <200 mg/dL	Ref	Ref
Trig ≥200 mg/dL	0.53 (0.32-0.86)	1.90 (1.16-3.11)