Examining the Risk and Prevalence of Gestational Diabetes Mellitus Among Hispanic Population Subgroups in the United States

ABSTRACT

Examining the Risk and Prevalence of Gestational Diabetes Mellitus
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By

Natalie Elizabeth Tripp

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INTRODUCTION: Gestational diabetes mellitus (GDM) is a significant public health problem in the United States because of its implications for both maternal and child health. While it is well documented that Hispanic women are disproportionately impacted by GDM, research and surveillance about GDM among ethnic subgroups is limited. Understanding how racial and ethnic subgroups differ from the general population, and from each other, have important research, policy, prevention and treatment implications.

AIM: This project will determine which Hispanic subgroups in the U.S. have the highest prevalence of GDM and if the associated risk factors for GDM vary among different Hispanic subgroups.

METHODS: Data from the National Vital Statistics System were analyzed using R version 3.5. Vital birth statistics from 2017 were used to determine prevalence rates among Hispanic subgroups. Hispanic group-specific multiple logistic regression analyses were used to test and compare factors associated with GDM.

RESULTS: Among the Hispanic subgroups analyzed, Mexican American women (7.4%) had the highest prevalence of GDM, compared to Central/South Americans (6.5%), Puerto Ricans Americans (6.5%) and Cuban Americans (5.7%). In multivariable models, the risk factors showing greatest variation for GDM among Hispanic ethnic subgroups were maternal age (being 25 years or older), BMI (having an overweight/obese BMI), and nativity (being born outside the U.S.).

CONCLUSION: Maternal age, BMI, and nativity were most strongly, and positively, associated with GDM status among women in all Hispanic subgroups. Nativity is of particular importance, as being born outside of the U.S. has traditionally been recognized as a protective factor against many chronic illnesses. Given that there are higher percentages of Hispanic women having babies who are foreign-born, researchers should strive to promote recruitment and inclusion of minority populations in health research to better inform prevention and treatment programs, and reduce the need to consolidate subgroups for statistical analysis. Ultimately, identifying at-risk populations though subgroup analysis may lead to reductions in disease prevalence and improvements in maternal and child health outcomes.

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Author's Statement Page

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CHAPTER I

INTRODUCTION

I. Description of the public health problem

Racial and ethnic minority populations in the United States continue to experience significant health disparities. Compared to the general population, minority communities often experience lower socioeconomic status, greater barriers to healthcare access, and greater risks for disease (CDC, 2013). Disparities also impact health and healthcare research, including challenges related to poor minority representation and subgroup consolidation (Oh et al., 2015). Consequently, inadequate research diminishes opportunities for improvements to minority health. One of the most prominent health problems disproportionately affecting minority populations in the U.S. is obesity. Hispanics (47.0%) and Non-Hispanic Blacks (NHB) (46.8%) have the highest prevalence rates of obesity (Hales, 2017). The relationship between obesity and minority health is complex; obesity is associated with increased risk for several comorbidities and chronic health conditions, such as hypertension, diabetes, and cardiovascular disease (CDC, 2018a). A common comorbidity associated with obesity in pregnant women is gestational diabetes mellitus (GDM). Currently, an estimated 2% to 10% of pregnancies in the U.S. are affected by GDM and the percentage of women with GDM increased by 56% from 2000 to 2010 (CDC, 2018b; CDC, 2017). Among other complications, GDM increases risk for developing type 2 diabetes mellitus (T2DM) for both mother and child postpartum; T2DM is a chronic condition associated with serious health consequences, such as kidney and heart disease (CDC, 2019a).

Hispanic women, among other minority populations, are disproportionately impacted by GDM, yet research on GDM by Hispanic ethnic subgroup is limited (Fujimoto, Samoa, & Wotring, 2013). Identifying how GDM varies by ethnic subgroup is important because it may help identify specific populations at greater risk. Ultimately, identifying at-risk ethnic sub-populations can lead to targeted strategies and interventions to reduce disease prevalence, healthcare costs, and improve outcomes in maternal and child health.

II. Racial and ethnic health disparities

Racial and ethnic health disparities are a persistent challenge in the U.S. Many minority populations are at higher risk for both worse health outcomes and lack of access to healthcare (USDHHS, 2008). The consequences of disparities not only affect minority groups, but also limit improvements in quality of life and health for the U.S. population overall (USDHHS, 2008). Racial and ethnic minority populations in the U.S. include Asians, NHBs, Hispanics, Native Hawaiians or Other Pacific Islanders, and American Indians or and Alaska Natives (AI/AN) (CMA, 2019). Each minority population can be further divided into subgroups. For example, the U.S. Census uses the term "Hispanic" to describe individuals of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish origin, regardless of race (USCB, 2019). As the U.S. population becomes more diverse, addressing health disparities is increasingly important.

According to the US Department of Health and Human Services, a health disparity is "… a type of health difference that is closely linked with social, economic, and/or environmental disadvantage. Health disparities adversely affect groups of people who have systematically experienced greater social or economic obstacles to health based on … characteristics historically linked to discrimination or exclusion" (USDHHS, 2008). Examples of these characteristics include race, gender, and sexual orientation. In addition to health disparities, minority health outcomes are influenced by a variety of other factors known as social determinants of health (SDOH); SDOH are "…economic and social conditions that influence individual and group differences in health status" (Braveman & Gottlieb, 2014). Examples of conditions that influence health outcomes include economic stability, safe neighborhoods, access to healthy foods, quality education, and access to healthcare. Minorities are disproportionately represented in disadvantaged environments where SDOH are unequally distributed or shaped by poor public policy (Orgera & Artiga, 2018).

Another factor contributing to health outcomes for minority groups are disparities in healthcare. Healthcare disparities are defined as "…differences or gaps in care experienced by one population compared with another population" (AHRQ, 2009). Disparities in healthcare are measured by differences in access to care, quality of care, and cost; examples of these measures include provider availability, patient safety, and timeliness (AHRQ, 2009).

The Affordable Care Act (ACA), through Medicaid expansion and subsidies in the health insurance marketplace, helps to reduce health disparities by providing more affordable healthcare coverage options for people of color and low-income individuals (Orgera & Artiga, 2018). The ACA also has several provisions designed to reduce health and healthcare disparities, including managed care plans, cultural competency training, and community-focused educational outreach (Orgera & Artiga, 2018). Minority populations encounter many barriers to obtaining quality health and healthcare. As a result, individuals may experience poorer health outcomes and greater financial burdens. (Oh et al., 2015). Minority populations are also underrepresented in medical research; they often experience barriers to inclusion, such as cultural and linguistic differences, time and financial restraints, fear of exploitation, and racial/ethnic biases or discrimination (Oh et al., 2015). Researchers may also be poorly trained to conduct studies in minority communities or lack the desire to recruit and retain enough minority participants; funders may even offer less funding to support minority researchers compared to non-Hispanic White (NHW) researchers (Oh et al., 2015). Ignoring the racial/ethnic diversity of the U.S. is a missed opportunity to inform research of all factors contributing to health status. Ultimately, this knowledge can improve both prevention and treatment.

III. Obesity epidemic

Obesity in the U.S. is a complex and multifactorial disease that is a significant challenge for chronic disease prevention and positive health outcomes for adults and children (Hruby & Hu, 2015). The obesity epidemic has been a growing concern since the mid-1980s; as the country developed economically, so did urbanization, sedentary lifestyles, and the consumption of processed foods (Hruby & Hu, 2015). The prevalence of obesity for adults in the U.S. in 2015-2016 was 39.8% (Hales, 2017). Classifications of obesity for adults are derived from body mass index criteria (BMI). BMI is a measure of an individual's weight relative to height; the measurement scale ranges from underweight (<18.5 kg/m^2) to severe obesity (≥ 40 kg/m^2) (Hruby & Hu, 2015). Obesity classification for children differs from adults. Children experience rapid changes in body composition and sexual development and require a separate measurement scale (Hruby & Hu, 2015). The U.S. utilizes the CDC's growth charts to determine age and sex-specific BMI percentiles for children aged 2-19 years; childhood obesity is classified as greater than or equal to the 95th percentile (Hruby & Hu, 2015). Specialized growth charts from the World Health Organization (WHO) are used to determine BMI for U.S. children under the age of 2 years (WHO, 2019).

There are numerous health complications resulting from obesity. Chronic conditions include hypertension, diabetes, cardiovascular disease, colon and pancreatic cancer, and mental health disorders (Hruby & Hu, 2015). Minority populations are disparately impacted by obesity and, consequently, have higher rates of obesity-related complications (Golden, Brown, & Anton, 2012). Ultimately, obesity is a complex issue requiring a complex set of solutions at all socioecological levels. Methods of prevention at the individual level include changes to dietary habits, increased physical activity, and counseling (CDC, 2019b). Policies and programs to address obesity range from taxes on unhealthy foods and safety measures to promote physical activity in urbanized areas to nutrition education for high-risk populations, such as pregnant women and children (Hruby & Hu, 2015).

IV. Gestational diabetes mellitus (GDM)

Obesity increases the risk for both GDM and T2DM and is an important factor affecting the health of women and children. GDM is "…any degree of glucose intolerance with onset or first recognition during pregnancy" (Kim, Deputy, & Robbins, 2018). As the body gains weight to support the development of the fetus, a shift in hormonal balance may result in insulin resistance. The body's need for insulin increases, as does its risk for developing GDM. Current guidelines recommend that women at risk for preexisting diabetes be screened at their first prenatal visit; all women should be routinely tested for GDM at 24 weeks gestation (Garrison, 2015). Primary risk factors for GDM include maternal age and weight at conception, family history of diabetes, and race or ethnicity. Women who are older than 25, have a BMI greater than 25.0, or have a first-degree relative with diabetes are at risk for GDM; women of specific minority populations, including NHB, Hispanic American, AI/AN, Native Hawaiian, or Pacific Islander, are also at risk (CDC, 2019b). Additional risk factors include diagnosis of polycystic ovarian syndrome (PCOS), a previous GDM diagnosis, and a history of delivering an infant weighing more than nine pounds (CDC, 2019b).

Complications resulting from GDM can occur during and after pregnancy. High maternal blood glucose levels may cause the fetus to store excessive amounts of fat during development; the excessive weight gained by the fetus may cause preterm birth, macrosomia, and shoulder damage (ACOG, 2017). Additional complications include respiratory distress syndrome, jaundice, hypoglycemia, seizures, and increased risk for stillbirth (ADA, 2019). Women with GDM may develop high blood pressure and preeclampsia and are more likely to undergo cesarean delivery (Kim et al., 2018). Postpartum complications resulting from GDM for infants include increased risk for childhood obesity and T2DM; women are also at increased risk for T2DM and developing GDM in a future pregnancy (Kim et al., 2018).

Treatment for GDM includes lifestyle modification and pharmacologic treatment. Initial approaches used to lower abnormal blood glucose values are lifestyle modifications, including regular physical activity and dietary changes, such as Medical Nutrition Therapy (MNT) (Yuen, Wong, & Simmons, 2018). Subsequent methods include medication; traditionally, insulin has been the primary medication used to treat GDM, but other oral medications are now in use, such as metformin and glyburide (Garrison, 2015). Management of GDM during pregnancy may require more doctor visits and monitoring of blood sugar levels, while postpartum management requires both short- and long-term follow-up (Garrison, 2015). Women with GDM should be screened at 6 to 12 weeks postpartum and then once every three years for T2DM (Garrison, 2015). Key strategies for preventing GDM include starting preconception care early and maintaining a healthy weight during pregnancy (CDC, 2019b). As minority populations are disparately impacted by GDM, greater efforts should be introduced to improve surveillance and research on GDM by racial and ethnic subgroups.

V. GDM and Hispanic health

Hispanic Americans comprise the largest ethnic minority population (18.1%) in the U.S. (ACS, 2017). All federal agencies, in accordance with the U.S. Office of Management and Budget (OMB), are required to include a minimum of two ethnicities (Hispanic/Non-Hispanic) for collecting and reporting data (USCB, 2019). The OMB recognizes distinct subgroups of the Hispanic population; the term “Hispanic” is defined as an individual of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish origin, regardless of race (USCB, 2019). Research conducted on Hispanic populations is often consolidated due to insufficient data (Oh et al., 2015). As a result, important health information is often lost when subgroups are combined into a single category, reducing the potential impact and ability to target prevention efforts. Analysis of subgroups is critical for both surveillance and research in Hispanic health.

There are a number of identified risk and protective factors associated with increased risk for disease among Hispanic populations, including genetic predisposition, health behaviors, and social/cultural influences; each factor varies by Hispanic subgroup. For example, South American women were more likely to eat greater quantities of vegetables compared to other subgroups (Noia et al., 2016). Hispanic Americans of Mexican descent have greater rates of hyperinsulinemia and insulin resistance compared to NHWs (Golden et al., 2012). Puerto Rican (30%) and Cuban Americans (29%) attain high school diplomas at higher rates than Mexican Americans (26%) (PRC, 2012). Puerto Ricans are more likely to smoke cigarettes compared to other Hispanic subgroups (Kaplan et al., 2014). Obesity rates are significantly higher among U.S.-born compared to immigrant Hispanic Americans (Golden et al., 2012). Interestingly, some research shows that immigrant Hispanic women have higher prevalence of GDM than U.S.-born women (Yuen & Wong, 2015; Hedderson, Darbinian, &Ferrara, 2010; Savitz, Janevic, Engel, Kaufman, & Herring, 2008). Acculturation and maternal nativity are important predictors of Hispanic health outcomes and help explain the Hispanic paradox. This phenomenon refers to the finding that some Hispanic subgroups tend to experience equal or better health outcomes than NHWs despite greater barriers to health-promoting factors, such as lack of access to health insurance (CDC, 2015). According to a 2015 report from the CDC, Hispanics showed a 24% lower all-cause mortality rate compared to NHWs (CDC, 2015). Although Hispanic Americans have lower overall rates of mortality, they have higher rates of morbidity compared to NHWs, especially for chronic conditions, including obesity, T2DM, liver disease, and kidney disease (PRC, 2012). As previously discussed, the relationship between obesity and diabetes is complex. Conducting research on GDM by Hispanic subgroup will help provide more accurate information to inform and target prevention efforts, reduce the incidence of GDM, and help minimize other chronic diseases among Hispanic populations.

VI. Research questions

This study will address the following research questions using data from the National Vital Statistic System: 1) Does GDM occur at different rates among different Hispanic subgroups? 2) Do risk factors for developing GDM vary by Hispanic subgroups?

CHAPTER II

LITERATURE REVIEW

I. Health disparities and disparities in minority representation in health research

Achieving health equity requires addressing disparities in health and healthcare. Numerous reports have documented disparities based on race and ethnicity, geography, socioeconomic status, and other social determinants of health (CMA, 2019; Orgera & Artiga, 2018; USDHHS, 2008). A study by Singh, et al. (2017), looking at national survey data from 1935 to 2016, reviews many of these disparities. The study points out the 12-year gap in life expectancy between Asian/Pacific Islanders and NHBs as well as the 2.3-fold higher infant mortality rate for NHB infants (11.7 per 1,000 live births) compared to NHW infants (4.9). Infant and child mortality rates were also higher in rural areas compared to urban areas (Singh et al., 2017). They pointed out that diabetes prevalence was also highest among AIANs (20.9%), NHBs (13.1%), and Hispanics (12.2%), and these higher rates were also associated with lower socioeconomic status and southern geographical location (Singh et al., 2017).

Other reports also document disparities in healthcare access and quality. Minority populations experience more barriers to healthcare access and are also less likely to feel satisfied with healthcare provider interactions, compared with NHWs (Hall et al., 2015). The 2013 National Healthcare Disparities Report revealed that minority patients receive worse quality care than NHW patients, including less patient-centered patient- providers interactions (AHRQ, 2013). While advances in healthcare have continued to develop, disparities in health and healthcare by race and ethnicity persist.

Improving minority representation in healthcare research is a critical step to informing and addressing healthcare disparities. A review by Nicholson, Schwirian, & Groner (2015) examined recruitment and retention strategies for low-income, minority, and underserved populations in clinical research studies with health outcomes from 2004 to 2014. During this period, improvements were made in the inclusion of racial/ethnic minorities, but the authors reported significant remaining deficiencies. Of the 165 articles included in their study, 41.8% focused on NHB populations, followed by Latinos/Latinas/Hispanics (29.1%), and Native Americans (2.4%); other articles focused more generally on minority (25.5%), low-income/underserved (12.1%), rural (6.7%), and multiethnic (1.2%) populations (Nicholson et al., 2015). The study also highlighted prominent themes discovered in their literature review. Barriers to recruitment and retention was among the most prominent themes, specifically minority participation, language barriers, and participant perceptions (trust/mistrust). Several studies illustrated minorities' perceptions regarding informed consent, believing that it renounces an individual's rights rather than protecting them (Nicholson et al., 2014). Other identified barriers to participation in health research by minorities include lack of access to information, fear of discrimination, stigma surrounding mental or genetic disorders, fear of deportation, and time/financial constraints (George, Duran, & Norris, 2014).

Disparities in minority research participation are also the result of poor promotion by principal investigators and poorly trained researchers. A 2014 study, conducted in South Carolina, disseminated an online survey to clinical trial principal investigators (PIs) working at the state's main academic medical centers. PIs were asked to rate their experience in recruiting and retaining patients for clinical trials in general, from NHB communities, and from rural communities. PIs reported recruiting and retaining patients from rural communities the most difficult, followed by the general public, and then NHB communities (Tanner, Kim, Friedman, Foster, & Bergeron, 2014). Additionally, authors found PIs were more likely to recruit through their existing patient pool and local doctors, compared to other modes of communication, such as community organizations, social service providers, health centers, or faith-based organizations (Tanner et al., 2014). This study portrays the importance of educating investigators and other members of research teams about best practices for promoting clinical trials to underrepresented communities.

II. Obesity as a confounder for chronic and adverse pregnancy outcomes

Obesity is a major confounding factor for many chronic diseases, especially among minority populations (CDC, 2018a). Linked to increased risk for hypertension, diabetes, cardiovascular disease, and metabolic syndrome, obesity is a serious condition from which minority populations are disparately affected (CDC, 2018a). For example, a population-based retrospective cohort study, utilizing data from the 1985 to 2011 California Behavioral Risk Factor Survey (CA BRFS), observed trends in the prevalence of obesity and its association with chronic conditions among minority populations. The CDC partnered with the California Department of Public Health (CDPH) to develop CABRFS, which evaluates trends in health-related behaviors among Californians 18 years or older. The study found that obesity prevalence was highest in NHBs (33.3%) and Hispanics (28.8%) and lowest in Asians (9.0%) (Wong, Chou, & Ahmed, 2014). Additionally, compared to NHWs, the odds of obesity were greater for NHBs (OR = 1.51) and Hispanics (OR= 1.18), and lower for Asians (OR =0.37) (Wong et al., 2014). Higher odds of obesity were significantly associated with the presence of diabetes (OR =2.35) and hypertension (OR =2.28) (Wong et al., 2014).

Not only does obesity prevalence vary by race and ethnicity, it also affects these populations throughout the lifespan. A study of repeated cross-sections of the National Health and Nutrition Examination Survey (NHANES), from 1999 to 2012, revealed significant differences in obesity prevalence among children, ages 2 to 19, by race/ethnicity (Skinner & Skelton, 2014). Increasing obesity prevalence rates among Hispanic females and NHB males showed a linear trend (Skinner & Skelton, 2014). Sarathy, et al. (2016) analyzed NHANES data from 1999 to 2010 to observe the relationships between race, abdominal obesity, and chronic kidney disease (CKD) among young adults aged 20 to 40 years. The study also reports that abdominal obesity is present in one-third of all young adults but more prevalent among NHBs (45.4%) and Mexican Americans (40.6%) than NHWs (37.4%) (Sarathy et al., 2016). Additionally, Mexican American young adults with abdominal obesity had higher odds of having albuminuria (OR= 4.5), a marker for CKD, compared to NHWs (Sarathy et al., 2016). Yang & Zhang (2014) evaluated the impact of overweight and obesity on long-term care (LTC) and Medicaid financing using nationally representative Cost and Use Files of the Medicare Current Beneficiary Survey from 1997 to 2005. Based on their analysis, the authors predict that, at the population level, overweight and obesity would generate 1.3 billion or more LTC patient days and $68 billion or more in Medicaid costs among baby boomers in 2012 (Yang & Zhang, 2014). In addition, regression model results indicated that race (NHB versus NHW) is a predictor for increased use of a LTC facility and increased Medicaid costs (Yang & Zhang, 2014).

Among minority populations, obesity is also a risk factor for complications during pregnancy and adverse pregnancy outcomes. Cavicchia, et al. (2014) assessed race-specific proportions of GDM attributable to overweight and obesity in South Carolina. Birth certificate and hospital discharge data from 2004 to 2006 were analyzed. The prevalence of GDM was higher among NHB women (18.1%), compared to NHW (14.0%) and Hispanic women (9.6%) (Cavicchia et al., 2014). The percent of GDM attributable to obesity for all racial groups was approximately 12% (Cavicchia et al., 2014). Tien, Villines, & Parilla (2014) examined the effects of pre-

pregnancy obesity and gestational weight gain on adverse pregnancy outcomes among women who visited the OB/GYN Treatment Center at the Advocate Illinois Masonic Medical Center in Chicago. Women with a singleton pregnancy and pre-pregnancy BMI of 30 or greater were included in the analysis. After stratification for ethnicity, they found that NHB women (58.6%) and Mexican American women (44.3%) had higher rates of obesity, compared to NHW women (18.3%) (Tien et al., 2014). NHB women also had the highest BMI at delivery, were more likely to have 1 or more maternal complications (37.8%), and were more likely to have 1 or more fetal complications (30.9%) than NHW women (Tien et al., 2014). Lastly, Anderson, Spicer, & Peercy (2016) examined the relationship between obesity, diabetes, and birth outcomes among AI/AN populations using U.S. birth data from 2009 to 2013. The rates of obesity (26.4%), pre-pregnancy diabetes (1.1%), and GDM (4.3%) were higher among AI/AN than NHW (obese = 19.2%, diabetes= 0.6%, GDM= 4.0%). Additionally, obese AI/AN women (11.3%) were more likely to have preterm births than NHW (8.8%) and Hispanic women (10.3%), and were more likely to have infants with macrosomia than all other groups (AI/AN=8.7%, NHW=8.2%, NHB=3.8%, Hispanic=5.5%) (Anderson et al., 2016).

III. GDM and disparities in minority health

GDM disproportionately impacts minority populations in the U.S., especially among Asian and Hispanic populations. For instance, a retrospective cohort study examined the racial/ethnic differences in GDM prevalence and the contribution of common risk factors among pregnant women, aged 18 to 45, in California between 2007 and 2012 (Pu et al., 2015). Data was identified through California birth certificates and linked with electronic health records from the study healthcare organization. In addition to examining NHB and Hispanic populations, the study also disaggregated Asian Americans into 6 subgroups (Asian Indian, Chinese, Filipino, Japanese, Korean, and Vietnamese). With the exception of those from Korea (12.9%) and Japan (9.7%), age-adjusted GDM prevalence was highest among Asian Americans (Asian Indians (19.3%), Filipinos (19.0%), Vietnamese (18.8%), and Chinese (15.3%)), followed by Hispanics (13.3%), NHW (7.0%), and NHBs (4.9%) (Pu et al., 2015). Relative risk of GDM was still higher for Asian subgroups and Hispanics compared to NHWs after controlling for maternal education, parity, smoking, and insurance type; NHBs had a significantly lower risk of GDM compared with NHWs (Pu et al., 2015).

Other minority population group risk factors analyzed in research of GDM assessed maternal age, initiation of prenatal care, and insurance coverage. Liu, Lamerato, & Misra (2019) analyzed the relationship between race/ethnicity, maternal age at delivery, and the risk of GDM. Female patients of the Henry Ford Health System who were diagnosed with GDM and delivered a singleton infant between 2010 to 2015 were included in the analysis. Older maternal age at delivery was associated with significantly higher odds of GDM (OR= 5.02) (Liu et al., 2019). GDM diagnosis, after controlling for age, BMI, parity, previous GDM, smoking status, and neighborhood family income, was significantly higher among Asians (OR= 2.81), Hispanics (OR= 1.27), and Arab Americans (OR= 1.46), and lower among NHBs (OR =0.64) compared to NHWs (Liu et al., 2019). Other studies, though not including Hispanic populations, demonstrate the variation in GDM risk factors and prevalence among other minority subpopulations. Sanchalicka & Teresa (2015) examined the difference in prevalence, risk factors, and complications of GDM among South Asian immigrants living in New Jersey (NJ), including immigrants from India, Bangladesh, Pakistan, and Sri Lanka. Hospitalization data from 1999 to 2002 was linked to NJ birth certificates. The authors found minor differences in prevalence and risk of GDM among the subgroups; Sri Lankan women had the highest rates of GDM (12.5%)

compared to other South Asian subgroups (Sanchalicka & Teresa, 2015). A retrospective cohort study was conducted using Hawaiian Pregnancy Risk Assessment Monitoring System (PRAMS) data from 2009 to 2011, linked with Hawaiian birth certificates to examine the associations between GDM, macrosomia, and race/ethnicity (Tsai, Roberson, & Dye, 2013). Asian and Pacific Islander (API) subpopulations included in analysis were Hawaiian, Samoan, Guamanian, Filipina, Japanese, Chinese, Korean, Vietnamese, Asian Indian, and other Asian women. Minor differences in prevalence of GDM existed between subgroups; Filipina women had the highest prevalence of GDM (13.1%) compared to other API subgroups (Tsai et al., 2013).

IV. GDM and Hispanic subgroups

Hispanic women are disproportionately impacted by GDM. U.S. Hispanic women experience GDM rates two to four times higher than NHW women (Perera et al., 2018; DeSisto, Kim, & Sharma, 2014). Race and ethnicity are non-modifiable risk factors that directly and indirectly impact risk for GDM and contribute to maternal and child health. Among 12 states reporting GDM by race/ethnicity in 2015, Hispanic women had the highest relative increase in GDM deliveries (66%) from 2000 to 2010 (Bardenheier et al., 2015). Research conducted on the prevalence of GDM by Hispanic subgroups is limited, but previous subgroup analysis does demonstrate differences among Hispanic populations. A cross-sectional study from the 2008 to 2011 Hispanic Community Health Study/Study of Latinos (HCHS/SOL) examined the prevalence of GDM and cardiovascular risk factors among U.S. Hispanics/Latinas. Subgroups included in this analysis identified as Mexican, Dominican, Puerto Rican, Cuban, Central American, and South American. Dominican women had the highest prevalence of GDM (5.1%), followed by Puerto Rican (5.0%), Mexican (4.8%), Central American (2.5%), South American

(1.8%), and Cuban (1.8%) (Perera et al., 2018). In this study, cardiovascular risk factors for GDM were not analyzed by Hispanic subgroup, but by history of GDM.

Examining risk factors by Hispanic subgroups is important because Hispanic women are expected to have the largest increase in births during the next decade compared to other ethnic groups in the U.S. (Kim et al., 2013). Kim, et al. (2013) calculated the percentages of racial/ethnic-specific GDM attributable to overweight and obesity in California during 2007 to 2009. Data from birth certificates linked with hospital discharge records of women aged 20 years or older with live, singleton births and diagnosis of GDM were used for analysis. Among other minority subgroups, Hispanics were categorized as Mexican, Central/South American, Puerto Rican, and Cuban. The highest prevalence of GDM was found among Mexicans (8.7%), followed by Central/South Americans (7.4%), Puerto Ricans (6.6%), and Cubans (5.5%) (Kim et al., 2013). After adjusting for age, parity, and nativity, Cubans (RR =3.3) had the highest risk of GDM attributable to obesity compared to other Hispanic subgroups (Kim et al., 2013). Another study in Florida observed similar prevalence among Hispanic subgroups after analyzing birth certificate and hospital discharge data from 2004 to 2007 (Kim et al., 2012). Race/ethnicity subgroups included Mexican, Puerto Rican, Central/South American, and Cuban. Prevalence of GDM was highest for Mexicans (6.0%), followed by Puerto Ricans (5.3%), Central/South American (4.6%), and Cubans (4.4%) (Kim et al., 2012). After adjusting for age and parity, Puerto Rican women (RR =3.2) had consistently higher risk of GDM attributable to obesity compared to other Hispanic subgroups (Kim et al., 2012).

Other risk factors, such as maternal nativity, vary by Hispanic subgroup. Hedderson et al. (2010) examined the associations between maternal country of birth and risk factors for GDM. Hispanic subgroups were combined into two groups: Mexicans and other Hispanics. The other

Hispanics category included Central/South Americans, Puerto Ricans, Cubans, and other Hispanic origin not stated. Mexicans had a higher prevalence rate (7.1%) compared to the other combined subgroups (5.4%) (Hedderson et al., 2010). Mexican women born outside the U.S. were also more likely to have GDM (31.4%) than U.S. born Mexican women (17.5%) (Hedderson et al., 2010).

Adverse pregnancy outcomes also vary by Hispanic group. Mocarski & Savitz (2012) examined the ethnic variation in the impact of GDM on birth outcomes using 2001 to 2006 birth certificate data from New York City. Hispanic ethnicities included Mexican, Caribbean (i.e. Cuban and Puerto Rican), and Central/South American. Prevalence of GDM was highest among Central/South Americans (17.9%), followed by Mexicans (11.0%), and Caribbean women (8.4%) (Mocarski & Savitz, 2012). Four major birth outcomes were included in analysis: pregnancy-induced hypertensive disorder (PIHD), macrosomia, preterm birth, and cesarean delivery. Among Hispanic women with GDM, Caribbean women had the highest adjusted odds for all birth outcomes analyzed, except for preterm birth, compared to other Hispanic subgroups without GDM (PIHD: aOR= 2.9; macrosomia: aOR =1.8; cesarean delivery: aOR =1.8). The adjusted odds for preterm birth among women with GDM was the same for all three Hispanic subgroups (aOR =1.8), compared to women without GDM (Mocarski & Savitz, 2012). More research on GDM by Hispanic subgroup is needed to understand all the factors contributing to the disease.

CHAPTER III

METHODS AND PROCEDURES

I. Data source and approval

Data used for this analysis were obtained from the 2017 vital birth statistics datafile from the National Vital Statistics System (NVSS). The NVSS is a division within the National Center for Health Statistics (NCHS). The data is collected by vital registration systems throughout the U.S. and compiled by the NVSS. Registration systems are established in all 50 states, 2 cities (Washington D.C. and New York City), and 5 territories (Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands) (CDC, 2016). Vital birth statistics from 2017, the data utilized for this project, were collected from live birth certificates. The file contains information on demographic characteristics of the mother and father and the medical/public services utilized throughout the pregnancy, as well as maternal and infant health characteristics, such as mother's BMI, cigarette smoking during pregnancy, and congenital abnormalities of the infant (NCHS, 2017). The file utilized for this thesis contains secondary public use data and does not require International Review Board (IRB) approval. Vital birth statistics from the NVSS is an exempt data source, as established by the IRB policies and procedures at Georgia State University (GSU, 2019).

II. Inclusion/exclusion criteria

The 2017 datafile of vital birth statistics contained 3,864,754 observations and 240 variables. The population of interest included women of Hispanic origin whose report indicated they were diagnosed with, or without, GDM. As a point of comparison, NHW women whose report indicated they were diagnosed with, or without, GDM were also included in the final sample. Women whose report indicated race/ethnicity or GDM status was unknown were excluded from analysis. Additionally, women whose report indicated unknown information regarding other study variables were excluded from analysis. The final sample size used for this project included 2,575,271 observations.

III. Independent/dependent variables

The independent variables used for this project included race/ethnicity, nativity (U.S. or foreign born), maternal age, maternal education level, BMI category, month of gestation prenatal care began, number of prenatal visits, cigarette use during pregnancy, and enrollment in WIC (Special Supplemental Nutrition Program for Women, Infants, and Children) services. Race/ethnicity categories included NHW, Mexican, Puerto Rican, Cuban, and Central/South American. NHW was the reference category. The age range for mothers was 10 to 54 years; maternal age was recoded into three categories: less than 25 years, 25 to 34 years, greater than 35 years. The reference category for maternal age was less than 25 years. Maternal education level was recoded into three categories: less than high school, high school graduate/GED, and greater than high school. Greater than high school was the reference category.

BMI was recoded into two categories: under/normal weight, overweight/obese; BMI data was determined using pre-pregnancy weight. The BMI range for the under/normal weight category was <18.5 to 24.9 kg/m^2 and the BMI range for overweight/obese category was 25.0 to >40 kg/m^2. The reference category for BMI was under/normal weight. Cigarette use and WIC enrollment were dichotomous variables coded as either Yes or No and the reference category for both variables was No. Month prenatal care began was divided into three categories: No prenatal care, 1^{st} trimester (prior to week 13 of gestation), and later than 1^{st} trimester (week 13 or later). The reference category was 1^{st} trimester. Number of prenatal visits was the only continuous numeric variable, with a range of 0 to 98. The dependent variable for this study was GDM diagnosis.

Recognizing that there can be overlap and multiple associations between variables for this analysis, they've been classified into two groups: critical and non-critical covariates. Critical covariates are variables expected to be causal or expected to have a strong relationship with the dependent variable based on review of the literature. The critical covariates included for this analysis are race/ethnicity, maternal age, education level, BMI, and enrollment in WIC services. Enrollment in WIC services is used as a proxy for income level, as individuals enrolled in WIC services tend to come from low-income families. A non-critical covariate is a variable expected to be considered in the model based on research convention, rather than review of the literature or a priori reasoning. The non-critical covariates included for this analysis are cigarette use during pregnancy, month prenatal care began and number of prenatal visits.

IV. Statistical analysis

Exploratory analysis included frequency distributions for categorical variables and measures of central tendency and dispersion for numeric variables. Pearson's chi-square (X^2) test was used to compare rates of categorical study variables across racial/ethnic subgroups. Kruskal-Wallis with Mann-Whitney U post-hoc was used to compare mean values of continuous study variables across racial/ethnic groups. Odds ratios from univariate logistic regression analysis were calculated to estimate risk of GDM due to each independent study variable. NHW and Hispanic group-specific multiple logistic regression analyses were used to test and compare factors associated with GDM. Multivariate regression analyses only included statistically significant variables in the model. Multivariate regression models allow for the control of confounders by applying statistical correction methods during analysis. Similarly, multivariate regression techniques allow for adjustment of different independent variables, such as age, in the model to determine the prevalence of GDM. Odds ratios from each multivariate regression table were compiled into one table to compare how risk factors for developing GDM varied by racial/ethnic group. Odds ratios greater than 2 were considered to have substantive magnitude for this project. Statistical analysis for this study was conducted using R, version 3.5. Statistical significance was determined using both 95% confidence intervals and $P<.05$.

CHAPTER IV

RESULTS

I. Population of women having live births for analysis

The inclusion and exclusion criteria for this project are reflected in Table 4.1. For the purposes of this project, racial/ethnic groups were divided into four categories: non-Hispanic White, Hispanic, other non-Hispanic, and those with unknown Hispanic origin. As reflected in Table 4.1, among the 3,864,754 women having live births in 2017, 1,993,312 (51.6%) were NHW, 932,771 (24.1%) were other non-Hispanic, 759,008 (25.3%) were Hispanic, and 179,663 (4.7%) were women with unknown Hispanic origin. Women categorized as other non-Hispanic or having unknown Hispanic origin were excluded from analysis. As reflected in Table 4.1, both NHW and Hispanic women with unknown values for any study variable were excluded from analysis. The proportions of unknown values for each study variable category were approximately the same for NHW and Hispanic women; additionally, for both categories, the highest percentages of missing information were found among BMI, month prenatal care began, and number of prenatal visits. In total, approximately one-third of the observations, 1,361,655 (35.3%), were excluded due to alternate racial/ethnic categories (24.1%) and missing information (11.2%). The final sample size for this project was 2,575,271, and included NHW and Hispanic women, both diagnosed with, and without, GDM. The total number of live births among NHW women after excluding all missing study variable observations was 1,873,192. Among the total number of live births for NHW women, 1,765,519 (68.6%) were not diagnosed with GDM, and 107,673 (4.2%) were diagnosed with GDM. The total number of live births among Hispanic women after excluding all missing study variable observations was 702,079. Among the total number of live births for Hispanic women, 652,381 (25.2%) were not diagnosed with GDM, and 49,698 (1.9%) were diagnosed with GDM.

Table 4.1. Inclusion and exclusion criteria and missing responses.

Race/ethnicity (n=3,864,754)	**Count (%)**
Total number of Non-Hispanic White (NHW) women	1,993,312 (51.6)
Total number of other Non-Hispanic women (Black, Asian, etc.)	932,771 (24.1)
Total number of Hispanic women	759,008 (19.6)
Total number of women with unknown/unstated Hispanic origin	179,663 (4.7)
NHW women with missing observations, by variable* (n=1,993,312)	
Total number of NHW women with unknown nativity	2,517 (0.1)
Total number of NHW women with unknown education level	9,983 (0.5)
Total number of NHW women with unknown BMI status	39,083 (2.0)
Total number of NHW women with unknown cigarette use during pregnancy	8342 (0.4)
Total number of NHW women with unknown WIC status	19,777 (1.0)
Total number of NHW women where month prenatal care began is unknown	42,238 (2.1)
Total number of NHW women where number of prenatal visits is unknown	44,531 (2.2)
Total number of NHW women with unknown GDM status	1,702 (0.1)
Total number of missing observations for NHW women	168,173 (8.4)
Hispanic women with missing observations, by variable* (n=759,008)	
Total number of Hispanic women with unknown nativity	789 (0.1)
Total number of Hispanic women with unknown education level	9,480 (1.3)
Total number of Hispanic women with unknown BMI status	21,707 (2.9)
Total number of Hispanic women with unknown cigarette use during pregnancy	3530 (0.5)
Total number of Hispanic women with unknown WIC status	7,070 (0.9)
Total number of Hispanic women where month prenatal care began is unknown	19,133 (2.5)
Total number of Hispanic women where number of prenatal visits is unknown	18,784 (2.5)
Total number of Hispanic women with unknown GDM status	555 (0.1)
Total number of missing observations for Hispanic women	81,048 (10.7)
NHW women GDM cases after removal (n=1,873,192)	
Total number of NHW women without GDM	1,765,519 (94.3)
Total number of NHW women with GDM	107,673 (5.7)
Hispanic women GDM cases after removal (n=702,079)	
Total number of Hispanic women without GDM	652,381 (93.0)
Total number of Hispanic women with GDM	49,698 (7.0)

*No missing observations for study variables race or maternal age.

II. Percent of demographic and behavioral characteristics

Demographic and behavioral characteristics among all women included in the study were different between Hispanic subgroups and compared with NHWs (see Table 4.2). Mexican American women had the highest percentage of GDM (7.4%) compared to NHWs (5.8%), and Cubans (5.7%), with the lowest percentage. Foreign-born status was highest among CSA women (82.5%) but was substantially higher compared to other Hispanic subgroups (range 28%-55.9%) and NHWs (6.6%). Puerto Rican American women (36.2%) had the highest percentage of women under the age of 25 and NHWs reported the lowest (20.8%). Cuban American women (62.6%) had the greatest percentage of women aged 25 to 34, while Puerto Rican Americans (50.5%) had the lowest. CSA women (22.3%) had the highest percentage of women aged 35 or older, compared to the lowest among Puerto Rican Americans (13.3%). CSA women (37.7%) also had the greatest percentage of women who had less than a high school education, while NHWs (7.1%) had the lowest. Among women who completed high school, Cuban American (34.5%) and Mexican American (34.4%) had the highest percentages, compared to the lowest among NHWs (21.1%). NHW women (71.8%) had the greatest percentage of women who pursued education after high school and Mexican American women (36.8%) had the lowest.

Sixty-two percent of Mexican American women were classified as overweight/obese based on their BMI. In other Hispanic subgroups this ranged from 50.2%-59.7%, compared to NHWs at 49.9%. NHW women had considerably higher percentages of smoking during pregnancy (10%), compared to 0.5%-5.9% for Hispanic subgroups. Hispanic subgroups also had higher percentages for use of WIC services during pregnancy. This was greatest for Mexican American women (59.1%), ranging from 52.3%-57.2% for other Hispanic subgroups compared to 25% for NHWs. Among women who began prenatal care during the first trimester NHW (82.7%) and

Cuban American women (82.4%) had the highest percentages, compared to the lowest among CSA women (68.3%). CSA women (29.5%) had the highest percentage of women who began prenatal care later than the first trimester, compared to the lowest among Cuban Americans (16.5%) and NHWs (16.3%). Mexican American women (2.4%) had the highest percentage of women who did not receive prenatal care during pregnancy and NHWs (1%) had the lowest. The median number of prenatal visits was highest among NHW (12) and Cuban American women (12), compared to the lowest among CSA women (11). Differences across racial/ethnic groups for all study characteristics exceeded traditional thresholds for statistical significance ($p<0.05$). Additional tables comparing racial/ethnic groups among women who were diagnosed with GDM and women who were not diagnosed with GDM were generated to evaluate the data from different perspectives (see Appendix I).

Table 4.2. Demographic and behavioral characteristics of NHW and Hispanic subgroups of women (n=2,575,271).

	Count (%)						
	Non-Hispanic White 1,873,192 (72.7)	**Central/South American** 130,907 (5.1)	**Cuban** 21,527 (0.8)	**Mexican** 485,479 (18.9)	**Puerto Rican** 64,166 (2.5)	**Total** 2,575.271	**p-value***
Gestational Diabetes							<.0001
No	1,765,519 (94.3)	122,346 (93.5)	20,293 (94.3)	449,730 (92.6)	60,012 (93.5)	2,417,900 (93.9)	
Yes	107,673 (5.8)	8,561 (6.5)	1,234 (5.7)	35,749 (7.4)	4154 (6.5)	157,371 (6.1)	
Nativity							<.0001
U.S. born	1,748,990 (93.4)	22,851 (17.5)	9,489 (44.1)	266,501 (54.9)	46,196 (72.0)	2,094,027 (81.3)	
Foreign born	124,202 (6.6)	108,056 (82.5)	12,038 (55.9)	218,978 (45.1)	17,970 (28.0)	481,244 (18.7)	
Maternal age							<.0001
Less than 25	389,505 (20.8)	31,797 (24.3)	4,516 (21.0)	162,657 (33.5)	23,250 (36.2)	611,725 (23.8)	
25 to 34	1,150,663 (61.4)	69,958 (53.4)	13,478 (62.6)	247,415 (51.0)	32,395 (50.5)	1,513,909 (58.8)	
35 or older	333,024 (17.8)	29,152 (22.3)	3,533 (16.4)	75,407 (15.5)	8,521 (13.3)	449,637 (17.5)	
Education							<.0001
Greater than high school	1,345,889 (71.8)	50,500 (38.6)	12,299 (57.1)	178,645 (36.8)	32,210 (50.2)	1,619,543 (62.9)	
High school grad/GED	394,821 (21.1)	30,988 (23.7)	7,418 (34.5)	167,052 (34.4)	21,188 (33.0)	621,467 (24.1)	
Less than high school	132,482(7.1)	49,419 (37.7)	1,810 (8.4)	139,782 (28.8)	10,768 (16.8)	334,261 (12.9)	
Body mass index (BMI)							<.0001
Under/Normal weight	938,999 (50.1)	59,195 (45.2)	10,714 (49.8)	183,759 (37.9)	25,838 (40.3)	1,218,505 (47.3)	
Overweight/Obese	934,193 (49.9)	71,712 (54.8)	10,813 (50.2)	301,720 (62.1)	38,328 (59.7)	1,356,766 (52.7)	
Cigarette use during pregnancy							<.0001
No	1,685,747 (90.0)	130,270 (99.5)	21,127 (98.1)	478,720 (98.6)	60,404 (94.1)	2,376,268 (92.3)	
Yes	187,445 (10.0)	637 (0.5)	400 (1.9)	6,759 (1.4)	3,762 (5.9)	199,003 (7.7)	
Enrollment in WIC services							<.0001
No	1,405,292 (75.0)	56,059 (42.8)	10,267 (47.7)	198,476 (40.9)	28,035 (43.7)	1,698,129 (65.9)	
Yes	467,900 (25.0)	74,848 (57.2)	11,260 (52.3)	287,003 (59.1)	36,131 (56.3)	877,142 (34.1)	
Month prenatal care began							<.0001
1st trimester	1,549,754 (82.7)	89,379 (68.3)	17,740 (82.4)	348,705 (71.8)	48,957 (76.3)	2,054,535 (79.8)	
Later than 1st trimester	304,152 (16.3)	38,646 (29.5)	3,553 (16.5)	125,223 (25.8)	14,373 (22.4)	485,947 (18.9)	
No prenatal care	19,286 (1.0)	2,882 (2.2)	234 (1.1)	11,551 (2.4)	836 (1.3)	34,789 (1.3)	
	Median (IQR)						
Number prenatal visits	12 (10-14)	11 (8-13)	12 (10-15)	11 (9-13)	11 (9-13)	12 (10-14)	<.0001

*Pearson's chi-square and Kruskal-Wallis with Mann-Whitney U post hoc tests used to determine statistical significance.

III. Unadjusted univariate logistic regression models

The odds of GDM among all women were estimated for each study variable using several unadjusted univariate logistic regression models (see Table 4.3). Compared to NHWs, the odds of GDM were higher among Mexican American (OR = 1.30), CSA (OR = 1.15), and Puerto Rican American women (OR = 1.14), and lower among Cuban American women (OR = 0.99). Maternal age and BMI had the highest odds ratios of each independent study variable among all women. Compared to women under the age of 25, the odds of GDM were higher among women aged 25 to 34 (OR = 1.86) and women 35 or older (OR = 3.25). Similarly, overweight and obese women had greater odds of GDM compared to women classified as underweight or normal weight (OR = 2.84). Women who used cigarettes had lower odds of GDM compared to women who did not (OR = 0.97). Study variables identified as having a less strong association with GDM included: nativity, education, enrollment in WIC services, month prenatal care began, and number of prenatal visits.

Table 4.3. Results of unadjusted univariate logistic regression models exploring relationships between each study variable and GDM status among all women.

Variable	Odds Ratio	95% Confidence Interval	
		Lower	**Upper**
Race/ethnicity			
Non-Hispanic White	Reference		
Central/South American	1.147	1.122	1.174
Cuban	0.997	0.941	1.056
Mexican	1.304	1.288	1.320
Puerto Rican	1.135	1.099	1.172
Nativity			
Born in the U.S.	Reference		
Born outside the U.S.	1.416	1.399	1.433
Maternal age			
Less than 25	Reference		
25 to 34	1.859	1.831	1.888
35 or greater	**3.253**	3.198	3.308
Education			
Greater than high school	Reference		
High school grad/GED	1.003	0.990	1.015
Less than high school	1.164	1.147	1.181
Body mass index (BMI)			
Under/Normal weight	Reference		
Overweight/Obese	**2.836**	2.804	2.870
Cigarette use during pregnancy			
No	Reference		
Yes	0.967	0.948	0.985
Enrollment in WIC services			
No	Reference		
Yes	1.156	1.143	1.168
Month prenatal care began			
1st trimester	Reference		
Later than 1st trimester	0.913	0.901	0.925
No prenatal care	0.390	0.364	0.417
Number of prenatal visits	1.069	1.068	1.070

IV. Adjusted multivariate logistic regression models

The odds of GDM among all women were estimated for all study variables using an adjusted multivariate logistic regression model as reflected in Table 4.4. Compared to NHWs, Cuban American and CSA women had lower odds of GDM (Cuban: OR = 0.85; CSA: OR = 0.87) while Mexican and Puerto Rican American women had greater odds of GDM (Mexican: OR = 1.08; Puerto Rican: OR = 1.05). Maternal age, BMI, and nativity had the strongest association with GDM among the study variables for all women. Compared to women under the age of 25, the odds of GDM were higher among women aged 25 to 34 (OR = 1.93) and women 35 or older (OR = 3.26). Women with lower educational attainment also had greater odds of GDM. Compared to women born in the U.S. with an underweight/normal BMI, the odds of GDM was higher for foreign-born women with underweight/normal BMI (OR = 1.45), higher for U.S.-born women with overweight/obese BMI (OR = 2.78), and highest for foreign-born women with overweight/obese BMI (OR = 3.33). Study variables identified as having less strong associations with GDM included: education, cigarette use during pregnancy, enrollment in WIC services, month prenatal care began, and number of prenatal visits.

Table 4.4. Results of adjusted multivariate logistic regression model exploring relationships between each study variable and GDM status among all women.*

		95% Confidence Interval	
Variables	**Odds Ratio**	**Lower**	**Upper**
Race/ethnicity			
Non-Hispanic White	Reference		
Central/South American	0.872	0.849	0.895
Cuban	0.845	0.797	0.897
Mexican	1.080	1.063	1.097
Puerto Rican	1.052	1.017	1.087
Maternal age			
Less than 25	Reference		
25 to 34	1.926	1.895	1.957
35 or greater	**3.263**	3.204	3.323
Education			
Greater than high school	Reference		
High school/GED	1.101	1.086	1.117
Less than high school	1.163	1.142	1.184
Cigarette use during pregnancy			
No	Reference		
Yes	1.120	1.097	1.143
Enrollment in WIC services			
No	Reference		
Yes	1.137	1.123	1.152
Month prenatal care began			
1st trimester	Reference		
Later than 1st trimester	1.129	1.113	1.145
No prenatal care	0.895	0.835	0.959
Number of prenatal visits	1.067	1.065	1.068
Nativity_BMI**			
U.S. Born and Under/Normal weight	Reference		
Foreign Born and Under/Normal weight	1.446	1.411	1.482
U.S. Born and Overweight/Obese	**2.782**	2.744	2.820
Foreign Born and Overweight/Obese	**3.330**	3.263	3.399

*Multivariate model adjusted for nativity, maternal age, education, BMI, cigarette use during pregnancy, WIC services, month prenatal care began, and number of prenatal visits

**Interaction term between nativity and BMI

The odds of GDM among NHW women were estimated for each study variable using an adjusted multivariate logistic regression model (see Table 4.5). Maternal age, BMI, and nativity had the highest odds ratios among all study variables for NHW women. Compared to women under the age of 25, the odds of GDM were higher for both women aged 25 to 34 and women aged 35 years or older (OR = 1.77 and 2.86, respectively). Compared to women born in the U.S. with an underweight/normal BMI, the odds of GDM was higher for foreign-born women with underweight/normal BMI (OR = 1.42), higher for U.S.-born women with overweight/obese BMI (OR = 2.78), and highest for foreign-born women with overweight/obese BMI (OR = 3.32). Study variables identified as having less strong associations with GDM included: education, cigarette use during pregnancy, enrollment in WIC services, month prenatal care began, and number of prenatal visits.

Table 4.5. Results of adjusted multivariate logistic regression model exploring relationships between each study variable and GDM status among NHW women.*

		95% Confidence Interval	
Variables	**Odds Ratio**	**Lower**	**Upper**
Maternal age			
Less than 25	Reference		
25 to 34	1.767	1.732	1.804
35 or greater	**2.857**	2.792	2.923
Education			
Greater than high school	Reference		
High school/GED	1.075	1.057	1.093
Less than high school	1.021	0.992	1.051
Cigarette use during pregnancy			
No	Reference		
Yes	1.118	1.094	1.143
Enrollment in WIC services			
No	Reference		
Yes	1.169	1.150	1.187
Month prenatal care began			
1st trimester	Reference		
Later than 1st trimester	1.109	1.088	1.130
No prenatal care	0.917	0.832	1.010
Number of prenatal visits	1.067	1.065	1.069
Nativity_BMI**			
U.S. Born and Under/Normal weight	Reference		
Foreign Born and Under/Normal weight	1.424	1.373	1.477
U.S. Born and Overweight/Obese	**2.779**	2.739	2.820
Foreign Born and Overweight/Obese	**3.315**	3.210	3.425

*Multivariable model adjusted for nativity, maternal age, education, BMI, cigarette use during pregnancy, WIC services, month prenatal care began, and number of prenatal visits

**Interaction term between nativity and BMI

The odds of GDM among CSA women were estimated for each study variable using an adjusted multivariate logistic regression model (see Table 4.6). Maternal age, BMI, and nativity had the highest odds ratios among all study variables for CSA women. Compared to women under the age of 25, the odds of GDM was higher among women aged 25 to 34 (OR = 2.36), and women aged 35 years or older (OR = 4.27). Compared to CSA women born in the U.S. with an underweight/normal BMI, the odds of GDM was higher for foreign-born women with underweight/normal BMI (OR = 1.30), higher for U.S.-born women with overweight/obese BMI (OR = 2.65), and highest for foreign-born women with overweight/obese BMI (OR = 2.88). Study variables identified as having less strong associations with GDM included: education, cigarette use during pregnancy, month prenatal care began, and number of prenatal visits.

Table 4.6. Adjusted multivariate logistic regression model results exploring relationships between each study variable and GDM status among Central/South American women.*

		95% Confidence Interval	
Variables	**Odds Ratio**	**Lower**	**Upper**
Maternal age			
Less than 25	Reference		
25 to 34	**2.357**	2.183	2.545
35 or greater	**4.274**	3.943	4.633
Education			
Greater than high school	Reference		
High school grad/GED	1.294	1.217	1.376
Less than high school	1.420	1.343	1.501
Cigarette use during pregnancy			
No	Reference		
Yes	1.743	1.317	2.309
Month prenatal care began			
1st trimester	Reference		
Later than 1st trimester	1.209	1.146	1.275
No prenatal care	0.759	0.583	0.989
Number of prenatal visits	1.073	1.067	1.079
Nativity_BMI**			
U.S. Born and Under/Normal weight	Reference		
Foreign Born and Under/Normal weight	1.295	1.126	1.490
U.S. Born and Overweight/Obese	**2.648**	2.286	3.069
Foreign Born and Overweight/Obese	**2.883**	2.514	3.306

*Multivariate model adjusted for nativity, maternal age, education, BMI, cigarette use during pregnancy, month prenatal care began, and number of prenatal visits.

**Interaction term between nativity and BMI.

The odds of GDM among Cuban American women were estimated for each study variable using an adjusted multivariate logistic regression model (see Table 4.7). Maternal age, BMI, and nativity had the highest odds ratios among all study variables for Cuban American women. Compared to women under the age of 25, the odds of GDM was higher among women aged 25 to 34 and women aged 35 years or older (OR = 1.73 and 3.07, respectively). Compared to Cuban American women born in the U.S. with an underweight/normal BMI, the odds of GDM were higher for foreign-born women with underweight/normal BMI (OR = 1.68), higher for U.S.-born women with overweight/obese BMI (OR = 3.11), and highest for foreign-born women with overweight/obese BMI (OR = 3.55). Additionally, among Cuban American women, for every one-unit increase in number of prenatal visits, the odds of GDM increased by 0.053 (OR = 1.05).

Table 4.7. Adjusted multivariate logistic regression model results exploring relationships between each study variable and GDM status among Cuban American women.*

		95% Confidence Interval	
Variables	**Odds Ratio**	**Lower**	**Upper**
Maternal age			
Less than 25	Reference		
25 to 34	1.734	1.438	2.091
35 or greater	**3.072**	2.501	3.773
Number of prenatal visits	1.054	1.039	1.070
Nativity_BMI**			
U.S. Born and Under/Normal weight	Reference		
Foreign Born and Under/Normal weight	1.677	1.333	2.109
U.S. Born and Overweight/Obese	**3.106**	2.498	3.862
Foreign Born and Overweight/Obese	**3.553**	2.869	4.400

*Multivariable models adjusted for nativity, maternal age, BMI, and number of prenatal visits

**Interaction term between nativity and BMI

The odds of GDM among Mexican American women were estimated for each study variable using an adjusted multivariate logistic regression model (see table 4.8). Maternal age, BMI, and nativity had the strongest associations with GDM. Compared to women under the age of 25, the odds of GDM are higher for women aged 25 to 34 (OR = 2.18) and for women aged 35 years or older (OR = 4.10). Compared to Mexican American women born in the U.S. with an underweight/normal BMI, the odds of GDM were higher for foreign-born women with underweight/normal BMI (OR = 1.46), higher for U.S.-born women with overweight/obese BMI (OR = 2.77), and highest for foreign-born women with overweight/obese BMI (OR = 3.33). Study variables identified as having less strong associations with GDM included: education, cigarette use during pregnancy, month prenatal care began, and number of prenatal visits.

Table 4.8. Results of adjusted multivariate logistic regression model exploring relationships between each study variable and GDM status among Mexican American women.*

		95% Confidence Interval	
Variables	**Odds Ratio**	**Lower**	**Upper**
Maternal age			
Less than 25	Reference		
25 to 34	**2.182**	2.113	2.254
35 or greater	**4.103**	3.957	4.253
Education			
Greater than high school	Reference		
High school grad/GED	1.137	1.106	1.170
Less than high school	1.259	1.221	1.297
Cigarette use during pregnancy			
No	Reference		
Yes	1.208	1.097	1.330
Enrollment in WIC services			
No	Reference		
Yes	1.085	1.059	1.111
Month prenatal care began			
1st trimester	Reference		
Later than 1st trimester	1.166	1.135	1.199
No prenatal care	0.919	0.821	1.029
Number of prenatal visits	1.065	1.062	1.068
Nativity_BMI**			
U.S. Born and Under/Normal weight	Reference		
Foreign Born and Under/Normal weight	1.463	1.389	1.540
U.S. Born and Overweight/Obese	**2.772**	2.654	2.896
Foreign Born and Overweight/Obese	**3.261**	3.117	3.413

*Multivariable models adjusted for nativity, maternal age, education, BMI, cigarette use during pregnancy, WIC services, month prenatal care began, and number of prenatal visits

**Interaction term between nativity and BMI

The odds of GDM among Puerto Rican American women were estimated for each study variable using an adjusted multivariate logistic regression model (see Table 4.9). Maternal age and BMI had the highest odds ratios among all study variables for Puerto Rican American women. Compared to women less than 25 years, the odds of GDM were higher for women aged 25 to 34 and women aged 35 years or older (OR = 2.01 and 3.70, respectively). Women classified as overweight/obese BMI had higher odds of GDM compared to women with underweight/normal BMI (OR = 2.69). Study variables having less strong associations with GDM included: enrollment in WIC services, month prenatal care began, and number of prenatal visits.

Table 4.9. Results of adjusted multivariate logistic regression model exploring relationships between each study variable with GDM status among Puerto Rican American women.*

Variables	Odds Ratio	95% Confidence Interval	
		Lower	**Upper**
Maternal age			
Less than 25	Reference		
25 to 34	**2.013**	1.848	2.192
35 or greater	**3.694**	3.343	4.083
Body mass index (BMI)			
Under/Normal weight	Reference		
Overweight/Obese	**2.694**	2.486	2.918
Enrollment in WIC services			
No	Reference		
Yes	1.144	1.071	1.223
Month prenatal care began			
1st trimester	Reference		
Later than 1st trimester	1.107	1.017	1.204
No prenatal care	0.767	0.480	1.226
Number of prenatal visits	1.059	1.052	1.067

*Multivariate models adjusted for maternal age, BMI, WIC services, and number of prenatal visits

V. Comparison of odds ratios

Odds ratios from each multivariate regression table were compared to describe how risk factors for developing GDM varied by Hispanic subgroups (see Table 4.10). The study variables with the greatest magnitude effect across all groups were maternal age, BMI, and nativity; odds ratios greater than 2 were considered to reflect strong associations with GDM for this project. Compared to women under 25 years of age, the odds of GDM for women aged 25 to 34 among Cuban American and NHW women did not exceed 2. CSAs had the highest odds of GDM among women aged 25 to 35 (OR = 2.3), followed by Mexican American women (OR = 2.19), and Puerto Rican American women (OR 2.01). Compared to women under 25 years of age, the odds of GDM for women aged 35 years or older was highest for CSAs (OR = 4.27) and lowest among NHWs (OR = 2.85). Compared to women born in the U.S. with underweight/normal BMI, the odds ratios for GDM among foreign-born women with underweight/normal BMI across all racial/ethnic groups did not exceed 2. Alternatively, compared to women born in the U.S. with underweight/normal BMI, the odds of GDM among U.S.-born women with overweight/obese BMI was highest for Cuban American women (OR = 3.11) and lowest among CSA women (OR = 2.65). Similarly, compared to women born in the U.S. with underweight/normal BMI, the odds of GDM among foreign-born women with overweight/obese BMI was highest for Cuban American women (OR = 3.55) and lowest among CSA women (OR = 2.88). A figure containing box and whisker plots comparing the odds ratios and corresponding 95% confidence intervals for the study variable Nativity_BMI by each racial/ethnic subgroup is shown in Appendix II. The multivariable regression model for Puerto Rican American women did not include nativity as a statistically significant variable; therefore, the interaction term between nativity and BMI was not included. BMI, however, was included as a statistically significant variable. Compared to Puerto Rican American women with an underweight/normal BMI, the odds of GDM was higher among women with overweight/obese BMI (OR = 2.69). The remaining study variables included in the multivariate racial/ethnic models showed little variation of odds ratios between groups, did not generate an odds ratio with substantial magnitude (greater than 2), or weren’t included as a significant predictor of GDM in more than one model.

Table 4.10. Comparison of odds ratios for each independent study variable by Hispanic subgroups.**

Variables	**Non-Hispanic White**			**Central/South American**			**Cuban**			**Mexican**			**Puerto Rican**		
	Odds ratio	**95% CI Lower**	**Upper**	**Odds ratio**	**95% CI Lower**	**Upper**	**Odds ratio**	**95% CI Lower**	**Upper**	**Odds ratio**	**95% CI Lower**	**Upper**	**Odds ratio**	**95% CI Lower**	**Upper**
Maternal Age															
Less than 25	Reference														
25 to 34	1.767	1.732	1.804	**2.357***	2.183	2.545	1.734	1.438	2.091	**2.182***	2.113	2.254	**2.013***	1.848	2.192
35 or greater	**2.857***	2.792	2.923	**4.274***	3.943	4.633	**3.072***	2.501	3.773	**4.103***	3.957	4.253	**3.694***	3.343	4.083
Education															
Greater than high school	Reference														
High school grad/GED	1.075	1.057	1.093	1.294	1.217	1.376	---	---	---	1.137	1.106	1.170	---	---	---
Less than high school	1.021	0.992	1.051	1.420	1.343	1.501	---	---	---	1.259	1.221	1.297	---	---	---
Body mass index (BMI)															
Under/Normal													Reference		
Overweight/Obese	---	---	---	---	---	---	---	---	---	---	---	---	**2.694***	2.486	2.918
Cigarette use during pregnancy															
No	Reference														
Yes	1.118	1.094	1.143	1.743	1.317	2.309	---	---	---	1.208	1.097	1.330	---	---	---
Enrollment in WIC services															
No	Reference														
Yes	1.169	1.150	1.187	---	---	---	---	---	---	1.085	1.059	1.111	1.144	1.071	1.223
Month prenatal care began															
1st trimester	Reference														
Later than 1st trimester	1.109	1.088	1.130	1.209	1.146	1.275	---	---	---	1.166	1.135	1.199	1.107	1.017	1.204
No prenatal care	0.917	0.832	1.010	0.759	0.583	0.989	---	---	---	0.919	0.821	1.029	0.767	0.480	1.226
Number of prenatal visits	1.067	1.065	1.069	1.073	1.067	1.079	1.073	1.067	1.079	1.065	1.062	1.068	1.059	1.052	1.067
Nativity_BMI***															
U.S. Born and Under/Normal	Reference														
Foreign Born and Under/Normal weight	1.424	1.373	1.477	1.295	1.126	1.490	1.677	1.333	2.109	1.463	1.389	1.540	---	---	---
U.S. Born and Overweight/Obese	**2.779***	2.739	2.820	**2.648***	2.286	3.069	**3.106***	2.498	3.862	**2.772***	2.654	2.896	---	---	---
Foreign Born and Overweight/Obese	**3.315***	3.210	3.425	**2.883***	2.514	3.306	**3.553***	2.869	4.400	**3.261***	3.117	3.413	---	---	---

*Bolded values represent a substantive magnitude OR value equal to or greater than 2.
**Empty cells did not have specific study variable included in the final model for the given racial/ethnic group.
***Interaction term between nativity and BMI

CHAPTER V

DISCUSSION

I. Discussion of research questions

Analysis of 2017 vital birth statistics data revealed statistically significant differences in the percentage of women with GDM among Hispanic subgroups. Mexican American women had the highest percentage (7.4%), followed by CSAs (6.5%), Puerto Rican Americans (6.5%), and Cuban Americans (5.7%). Cuban American women actually had a slightly lower percentage of GDM than NHW women (5.8%). This analysis shows statistically significant differences for GDM between racial/ethnic groups and there is a 1.7% difference between the highest and lowest percentages. These results are consistent with the previous literature showing higher incidence of GDM among Mexican American women compared to other Hispanic subgroups (Kim et al., 2013; Kim et al., 2012; Hedderson et al., 2010). This analysis shows higher incidence of GDM in all Hispanic subgroups except for Cuban Americans, compared to NHWs.

Preliminary analysis of descriptive statistics also highlights differences in demographic and behavioral characteristics among Hispanic subgroups. CSA women (82.5%) had the highest percentage of being foreign-born; they were approximately three times more likely to be foreign-born than Puerto Rican Americans (28%) who had the lowest percentage of being foreign-born. All Hispanic subgroups had higher percentages of foreign-born women having live births compared to NHW women. CSA women having live births had the highest percentage aged 35 years or older (22.3%), with almost twice as many women in that category compared to Puerto Rican Americans (13.3%) who had the lowest percentage. A majority of Cuban and Puerto Rican American women had educational attainment greater than a high school diploma (57.1% and 50.2%, respectively), in contrast to CSAs (38.6%) and Mexican Americans (36.8%). All groups had lower educational attainment than NHWs, with 70.2% attaining greater than a high school diploma. This finding is consistent with a 2012 report from the Pew Research Center that listed Puerto Rican (30%) and Cuban Americans (29%) having higher rates of education compared to other Hispanic subgroups (PRC, 2012). All Hispanic ethnic subgroups also had higher percentages of overweight/obese BMIs compared to NHWs. Across the Hispanic subgroups, there was an 11.9% difference between the highest (Mexican Americans: 62.1%) and lowest (Cuban Americans: 50.2%) percentages. All Hispanic subgroups also had a lower percentage of cigarette use during pregnancy compared to NHWs. Puerto Rican American women, however, were approximately 3 to 12 times more likely to use cigarettes during pregnancy than other Hispanic subgroups. This is consistent with a cross-sectional study of smoking habits among U.S. Hispanic adults in 2014 that showed Puerto Ricans had a higher prevalence of smoking compared to other Hispanic subgroups (Kaplan et al., 2014).

All Hispanic subgroups had higher percentages of enrollment in WIC services compared to NHWs. However, there was limited variation between Hispanic subgroups with only a 6.8% difference between the highest (Mexican Americans: 59.1%) and lowest (Cuban Americans: 52.3%) percentages. Cuban Americans (82.4%) had approximately the same percentage of women who began prenatal care in the first trimester as NHWs (82.7%), compared to Puerto Rican Americans (76.3%), Mexican Americans (71.8%), and CSAs (68.3%). Lastly, although analysis revealed statistically significant differences for number of prenatal visits between racial/ethnic groups, there was little variability with only a 1.2% difference between the highest and lowest averages; additionally, NHWs (mean = 11.8) and Cuban American women (mean = 11.8) had approximately the same number of prenatal visits.

Analysis of multivariate logistic regression models revealed moderate variation in some risk factors for GDM by Hispanic subgroups. The study variables with the greatest differences were maternal age, BMI, and nativity. Among maternal age categories, women 35 years or older had higher odds of GDM compared to those aged 25 to 34 and those under 25 years of age. The odds ratio was greatest for CSA women (OR = 4.27 95% CI 3.94, 4.63) and Mexican American women (OR = 4.10, 95% CI 3.96, 4.25). Additionally, women from each Hispanic subgroup aged 35 or older had higher odds of GDM compared to NHW women in the same age category. This is consistent with previous research by Liu et al (2019) citing advanced maternal age as a consistent predictor of GDM.

BMI has also been identified as an important variable influencing GDM diagnosis (Cavicchia et al., 2014; Tien et al., 2014; Kim et al., 2013). The multivariate model for Puerto Rican American women was the only model to utilize BMI as a sole predictor (not interacting with nativity) for GDM status. The model revealed that the odds of GDM were higher for Puerto Rican American women with overweight/obese BMIs compared to women with underweight/normal BMIs (OR = 2.69, 95% CI 2.49, 2.92). The remaining multivariate models observed the effect of BMI and nativity together on GDM status. Nativity is another important risk factor that has been identified for GDM (Yuen & Wong, 2015; Hedderson et al., 2010; Savitz et al., 2008). The combination of being foreign-born and having an overweight/obese BMI yielded the highest odds ratios for all ethnic subgroups. This actually contradicts what has traditionally been recognized as the Hispanic paradox, the finding that Hispanic Americans often experience equivalent or better health outcomes compared to NHWs (CDC, 2015). Instead of being foreign-born acting as a protective factor against disease, these results suggest that it is positively associated with GDM. Savitz et al (2008) reported similar results for Hispanic women; foreign-born women consistently had higher risk for GDM compared to U.S.-born women. Golden et al (2012) also observed obesity rates as being significantly higher among U.S.-born women compared to immigrant Hispanic Americans.

II. Strengths and limitations

One of the major strengths of this study was the reliability and representativeness of the data. Vital birth statistics are recorded through national registries and are less subject to typical sources of bias common in survey data, such as non-response, recall, or interviewer bias. The data is also representative, as it includes total births in the U.S. for 2017. The data also allowed for subgroup analysis across a number of domains. A primary limitation of this study was its cross-sectional design. This type of study design cannot be used to determine cause and effect, only generate hypotheses. Another major limitation of the study was the analysis of only four subgroups of the U.S. Hispanic population. A final limitation for this project was the amount of missing data. Both NHW and Hispanic women with unknown values for any study variable were excluded from analysis. In total, approximately a tenth of the original observations were excluded. Ultimately, this exclusion may have reduced the representativeness of the sample and slightly distorted the study results.

III. Implications of study findings and recommendations for future research

The data from this study demonstrate significant differences in the percentage of women developing GDM among Hispanic subgroups. Additionally, certain risk factors show moderate variation between Hispanic subgroups. Specifically, variation in advanced maternal age, BMI, and nativity appear to be more strongly associated with differences in GDM outcomes than other factors that were studied. Nativity is of particular importance, as being born outside of the U.S. has traditionally been recognized as a protective factor for Hispanic Americans against many chronic illnesses. However, among Hispanic Americans with GDM, being born outside the U.S.

is a risk factor. Nativity is especially important, given the relatively high number of foreign-born Hispanic women giving birth in the U.S. Thus, researchers should strive to promote inclusion and recruitment of minority populations in health research in order to better inform prevention and treatment programs. These methods could include cultural competency as a required component of research training and creating greater opportunities for community engagement between minority populations and institutions and agencies performing public health or medical research. Future studies should also explore additional variables that may impact the risk of GDM, such as geographic identifiers, types of health insurance, income level, parity, and mother's length of stay in the U.S. Researchers could use geographic identifiers to identify states or counties with abnormally high prevalence of GDM by Hispanic subgroup. Type of health insurance and income level could highlight differences in access and quality of healthcare among subgroups with GDM. Studies might include parity as a predictor of GDM, as women having more pregnancies, in combination with increasing maternal age and past GDM pregnancies, may be more susceptible to GDM. Lastly, studying mother's length of stay in the U.S. could help distinguish GDM risk attributable to acculturation versus maternal nativity. Examining each of these factors may provide greater insight into the risk factors for GDM among subgroups of Hispanic women.

IV. Conclusion

This study contributes to existing literature by providing additional data on the prevalence and risk factors for GDM by Hispanic ethnic subgroup. Additionally, this study adds to the literature showing foreign-born nativity as a risk, rather than protective factor for GDM for specific Hispanic subgroup populations. Hispanic women are disproportionately impacted by GDM, yet research on GDM by Hispanic ethnic subgroup is limited. Resolving disparities in health research is a crucial step to improving disparities in health and healthcare. Increased efforts to include, recruit, and retain minority populations in health research will help improve minority representation and reduce the need to consolidate subgroups for analysis. Ultimately, identifying at-risk populations though subgroup analysis may inform more targeted preventive and treatment approaches, ultimately leading to reductions in disease prevalence and improvements in maternal and child health outcomes.

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Appendix I

Table 4.11. Demographic and behavioral characteristics of NHW and Hispanic subgroups of women without GDM (n=2,417,900).

	Count (%)						
	Non-Hispanic White 1,765,519 (73.0)	**Central/South American** 122,346 (5.1)	**Cuban** 20,293 (0.8)	**Mexican** 449,730 (18.6)	**Puerto Rican** 60,012 (2.5)	**Total** 2,417,900	**p-value***
Nativity							<.0001
U.S. born	1,649,754 (93.4)	21,695 (17.7)	8,990 (44.3)	250,914 (55.8)	43,260 (72.1)	1,974,613 (81.7)	
Foreign born	115,765 (6.6)	100,651 (82.3)	11,303 (55.7)	198,816 (44.2)	16,752 (27.9)	443,287 (18.3)	
Maternal age							<.0001
Less than 25	376,135 (21.3)	30,960 (25.3)	4,380 (21.6)	157,327 (39.9)	22,477 (37.5)	591,279 (24.5)	
25 to 34	1,085,821 (61.5)	65,535(53.6)	12,726 (62.7)	228,273 (50.8)	30,088 (50.1)	1,422,443 (58.8)	
35 or older	303,563 (17.2)	25,851 (21.1)	3,187 (15.7)	64,130 (14.3)	7,477 (12.4)	404,178 (16.7)	
Education							<.0001
Greater than high school	1,266,762 (71.7)	47,538 (38.9)	11,575 (57.1)	166,786 (37.1)	29,890 (49.8)	1,522,551 (63.0)	
High school grad/GED	372,514 (21.1)	28,988 (23.7)	6,987 (34.4)	155,748 (34.6)	19,923 (33.2)	584,160 (24.2)	
Less than high school	126,243 (7.2)	45,820 (37.5)	1,731 (8.5)	127,196 (28.3)	10,199 (17.0)	311,189 (12.9)	
Body mass index (BMI)							<.0001
Under/Normal weight	909,488 (51.5)	57,013 (46.6)	10,350 (51.0)	177,073 (39.4)	25,049 (41.7)	1,178,973 (48.8)	
Overweight/Obese	856,031 (48.5)	65,333 (53.4)	9,943 (49.0)	272,657 (60.6)	34,963 (58.3)	1,238,927 (51.2)	
Cigarette use during pregnancy							<.0001
No	1,589,073 (90.0)	121,766 (99.5)	19,915 (98.1)	443,449 (98.6)	56,497 (94.1)	2,230,700 (92.3)	
Yes	176,446 (10.0)	580 (0.5)	378 (1.9)	6,281 (1.4)	3,515 (5.9)	187,200 (7.7)	
Enrollment in WIC services							<.0001
No	1,325,920 (75.1)	52,559 (43.0)	9,695 (47.8)	184,889 (41.1)	26,184 (43.6)	1,599,247 (66.1)	
Yes	439,599 (24.9)	69,787 (57.0)	10,598 (52.2)	264,841 (58.9)	33,828 (56.4)	818,653 (33.9)	
Month prenatal care began							<.0001
1st trimester	1,458,270 (82.6)	83,326 (68.1)	16,683 (82.2)	322,053 (71.6)	45,630 (76.0)	1,925,962 (79.7)	
Later to 1st trimester	288,409 (16.3)	36,200 (29.6)	3,380 (16.7)	116,477 (25.9)	13,565 (22.6)	458,031 (18.9)	
No prenatal care	18,840 (1.1)	2,820 (2.3)	230 (1.1)	11,200 (2.5)	817 (1.4)	33,907 (1.4)	
	Median (IQR)						
Number prenatal visits	12 (10-14)	11 (8-13)	12 (10-15)	11 (9-13)	11 (9-13)	12 (10-14)	<.0001

*Pearson's chi-square and Kruskal-Wallis with Mann-Whitney U post hoc tests used to determine statistical significance.

Percentages of demographic and behavioral characteristics among women without GDM were different across racial/ethnic groups (see table 4.11). Foreign-born status was highest among CSA women (82.3%), but was substantially higher compared to other Hispanic groups (range 27.9% – 55.7%) and lowest among NHWs (6.6%). Mexican American women (39.9%)

had the highest percentage of women under the age of 25 and NHWs reported the lowest (21.3%). Cuban American women (62.7%) had the greatest percentage of women aged 25 to 34, while Puerto Rican Americans (50.1%) had the lowest. CSA women (21.1%) reported the highest percentage of women aged 35 or older, compared to the lowest among Puerto Rican Americans (12.4%). CSA women (37.5%) also had the greatest percentage of women who had less than a high school education, while NHWs (7.2%) had the lowest. Among women who completed high school, Mexican Americans (34.6%) and Cuban Americans (34.4%) had the highest percentages, compared to the lowest among NHWs (21.1%). NHW women (71.7%) had the greatest percentage of women who pursued education after high school and Mexican American women (37.1%) had the lowest.

Sixty-one percent of Mexican American women were classified as having an overweight/obese BMI. In other Hispanic subgroups this ranged 49% – 58.3%, compared to NHWs at 48.5%. Ten percent of NHW women reported considerably higher rates of smoking during pregnancy, compared 0.5%-5.9% for Hispanic subgroups. Hispanic subgroups also reported higher use of WIC services during pregnancy. This was greatest for Mexican American women (58.9%), ranging from 52.2%-58.9% for other Hispanic subgroups, compared to 24.9% for NHWs. Among women who began prenatal care during the first trimester NHW (82.6%) and Cuban American women (82.2%) had the highest percentages, compared to the lowest among CSA women (68.1%). CSA women (29.6%) reported the highest percentage of women who began prenatal care later than the first trimester, compared to the lowest among Cuban Americans (16.7%) and NHWs (16.3%). Mexican American women (2.5%) had the highest percentage of women who did not receive prenatal care during pregnancy, compared to the lowest among NHWs (1.1%) and Cuban American women (1.1%). The average number of prenatal visits was highest among NHW (12) and Cuban American women (12), compared to the lowest among CSA women (11). Differences across racial/ethnic groups for all study characteristics exceeded traditional thresholds for statistical significance ($p<0.05$).

Table 4.12. Demographic and behavioral characteristics of NHW and Hispanic subgroups of women with GDM (n=157,371).

	Count (%)						
	Non-Hispanic White 107,673 (68.4)	**Central/South American** 8,561 (5.4)	**Cuban** 1,234 (0.8)	**Mexican** 35,749 (22.7)	**Puerto Rican** 4,154 (2.6)	**Total** 157,371	**p-value***
Nativity							<.0001
U.S. born	99236 (92.2)	1156 (13.5)	499 (40.4)	15587 (43.6)	2936 (70.7)	119414 (75.9)	
Foreign born	8437 (7.8)	7405 (86.5)	735 (59.6)	20162 (56.4)	1218 (29.3)	37957 (24.1)	
Maternal age							<.0001
Less than 25	13370 (12.4)	837 (9.8)	136 (11.0)	5330 (14.9)	773 (18.6)	20446 (13.0)	
25 to 34	64842 (60.2)	4423 (51.7)	752 (60.9)	19142 (53.6)	2307 (55.5)	91466 (58.1)	
35 or older	29461 (27.4)	3301 (38.5)	346 (28.1)	11277 (31.5)	1074 (25.9)	45459 (28.9)	
Education							<.0001
Greater than high school	79127 (73.5)	2962 (34.6)	724 (58.7)	11859 (33.2)	2320 (55.8)	96992 (61.6)	
High school grad/GED	22307 (20.7)	2000 (23.4)	431 (34.9)	11304 (31.6)	1265 (30.5)	37307 (23.7)	
Less than high school	6239 (5.8)	3599 (42.0)	79 (6.4)	12586 (35.2)	569 (13.7)	23072 (14.7)	
Body mass index (BMI)							<.0001
Under/Normal weight	29511 (27.4)	2182 (25.5)	364 (29.5)	6686 (18.7)	789 (19.0)	39532 (25.1)	
Overweight/Obese	78162 (72.6)	6379 (74.5)	870 (70.5)	29063 (81.3)	3365 (81.0)	117839 (74.9)	
Cigarette use during pregnancy							<.0001
No	96674 (89.8)	8504 (99.3)	1212 (98.2)	35271 (98.7)	3907 (94.0)	145568 (92.5)	
Yes	10999 (10.2)	57 (0.7)	22 (1.8)	478 (1.3)	247 (6.0)	11803 (7.5)	
Enrollment in WIC services							<.0001
No	79372 (73.7)	3500 (40.9)	572 (46.4)	13587 (38.0)	2303 (55.4)	98882 (62.8)	
Yes	28301 (26.3)	5061 (59.1)	662 (53.6)	22162 (62.0)	1851 (44.6)	58489 (37.2)	
Month prenatal care began							<.0001
1st trimester	91484 (85.0)	6053 (70.7)	1057 (85.7)	26652 (74.6)	3327 (80.1)	128573 (81.7)	
Later to 1st trimester	15743 (14.6)	2446 (28.6)	173 (14.0)	8746 (24.5)	808 (19.5)	27916 (17.7)	
No prenatal care	446 (0.4)	62 (0.7)	4 (0.3)	351 (0.9)	19 (0.4)	882 (0.6)	
	Median (IQR)						
Number prenatal visits	12 (10-15)	12 (9-14)	13 (10-15)	12 (10-14)	12 (10-14)	12 (10-15)	<.0001

*Pearson's chi-square and Kruskal-Wallis with Mann-Whitney U post hoc tests used to determine statistical significance.

Percentages of demographic and behavioral characteristics among women with GDM were different across racial/ethnic groups (see table 4.12). Foreign-born status was highest among CSA women (86.5%), but was substantially higher compared to other Hispanic groups (range 29.3% – 59.6%) and lowest among NHWs (7.8%). Puerto Rican American women (18.6%) had the highest percentage of women under the age of 25 and CSAs reported the lowest (9.8%). Cuban American women (60.9%) had the greatest percentage of women aged 25 to 34, while CSAs (51.7%) had the lowest. CSA women (38.5%) reported the highest percentage of women aged 35 or older, compared to the lowest among Puerto Rican Americans (25.9%). CSA women (42%) also had the greatest percentage of women who had less than a high school education, while NHWs (5.8%) had the lowest. Among women who completed high school, Cuban Americans (34.9%) had the highest percentages, compared to the lowest among NHWs (20.7%). NHW women (73.5%) had the greatest percentage of women who pursued education after high school and Mexican American women (33.2%) had the lowest.

Eighty-one percent of Mexican American women and 81% of Puerto Rican American women were classified as having an overweight/obese BMI. In other Hispanic subgroups this ranged 70.5%-74.5%, compared to NHWs at 72.6%. Ten percent of NHW women reported considerably higher rates of smoking during pregnancy, compared 0.7%-6% for Hispanic subgroups. Hispanic subgroups also reported higher use of WIC services during pregnancy. This was greatest for Mexican American women (62%), ranging from 44.6%-59.1% for other Hispanic subgroups, compared to 26.3% for NHWs. Among women who began prenatal care during the first trimester, Cuban American women (85.7%) and NHWs (85%) had the highest percentages, compared to the lowest among CSA women (70.7%). CSA women (28.6%) reported the highest percentage of women who began prenatal care later than the first trimester, compared to the lowest among NHWs (14.6%) and Cuban American women (14%). Mexican American women (0.9%) had the highest percentage of women who did not receive prenatal care during pregnancy, compared to the lowest among Cuban American women (0.3%). The average number of prenatal visits was highest among Cuban American women (13), compared to the lowest among CSA women (12). Differences across racial/ethnic groups for all study characteristics exceeded traditional thresholds for statistical significance ($p<0.05$).

Appendix II

Figure 4.1. Box and whisker plots comparing odds ratios and corresponding 95% confidence intervals for study variable Natvitiy_BMI by Hispanic subgroup.