HEALTH SCREENINGS BEYOND THE HISTORY OF GESTATIONAL DIABETES MELLITUS: A SECONDARY ANALYSIS OF THE BEHAVIORAL RISK FACTOR SURVEILLANCE SYSTEM

by

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ABSTRACT

HEALTH SCREENINGS BEYOND THE HISTORY OF GESTATIONAL DIABETES MELLITUS: A SECONDARY ANALYSIS OF THE BEHAVIORAL RISK FACTOR SURVEILLANCE SYSTEM

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Gestational diabetes mellitus (GDM) affects over 200,000 women in the United States each year placing them at a sevenfold risk of developing type 2 diabetes mellitus within a decade of delivery as compared to women without GDM. Diabetes has been projected to become more epidemic among women yet, a paucity of research has examined glucose screening trends beyond the postpartum period and longitudinal studies are few among those with a reproductive history of GDM. Suboptimal glucose screening and delayed diabetes detection can lead to an increased risk of cardiometabolic morbidity and mortality. Therefore, this study was designed to examine the health screening follow-up gap beyond the post-delivery period among this vulnerable group of women.

This secondary analysis of data from the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System 2008 described associations among demographic characteristics, gynecological care, and post-pregnancy glucose screening tests among a large representative sample of women who self-reported a history of gestational diabetes.

Analyses revealed hGDM women in this sample (*n*= 1,772) who engage in annual gynecological care, which included an annual cervical cancer screening test was associated

with completion of glucose screening tests and participants were almost twice as likely to have completed glucose screening tests in compliance with current evidence based guidelines as compared to those who had not completed annual Pap tests. However, there were no significant differences in the report of glucose screening regardless of any of the specified demographic characteristics including race, ethnicity, education level, age, BMI, or health insurance.

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CHAPTER 1

INTRODUCTION

A costly and progressively debilitating disease, diabetes mellitus (DM) is the seventh leading cause of death affecting 12.6 million women in the United States [U.S.] (Agency for Healthcare Research & Quality [AHRQ], 2005a; Centers for Disease Control and Prevention [CDC], 2011). One in ten American adults has been diagnosed with diabetes and as many as one in three are projected to be affected by 2050 if epidemic trends continue (Boyle, Thompson, Gregg, Barker, & Williamson, 2010; CDC, 2010). Gestational diabetes mellitus (GDM), a common complication of pregnancy affecting approximately 200,000 women annually, contributes significantly to the expanding national diabetes epidemic (Albrecht et al., 2010; American Diabetes Association [ADA], 2007; Fink, 2006; Mokdad, Ford, et al. 2001). Often a history of "transient" GDM precedes overt, chronic DM in women. Thus, GDM has been referred to as the "unmasking" of future diabetes (Cheung & Helmink, 2006), accentuating the need for population health screening among these women.

The increasing incidence and prevalence of DM is especially troubling for women, as disease rates increased among women by 76% between 1989 and 2005 (CDC, 2008). Projections forecast women will account for the majority of DM cases between 2010 and 2050 (AHRQ, 2006b). These disturbing trends emphasize the need for research regarding primary care prevention and screening for early disease detection among the growing number of women with reproductive health histories of GDM. Research addressing the epidemic increases in the incidence and prevalence of DM among high risk populations is an important focus of the national health agenda and the *Healthy People 2020* framework (United States Department of Health and Human Services [USDHHS], n.d., b).

Progression from GDM to type 2 diabetes (T2DM) can be prevented or delayed (Kitzmiller, Dang-Kilduff, & Taslimi, 2007). Post-delivery glucose screenings are an essential standard of care for tracking persistent glucose elevations and DM risk among women with a GDM history. However, trends indicate low rates of screening despite knowledge of the need for postpartum glucose screening subsequent to a GDM diagnosis (Ferrara, Peng, & Kim, 2009; Hunt, Logan, Conway, & Korte, 2010). Regular health screenings are central to early disease diagnosis; yet few researchers have explored whether women with a history of GDM (hGDM) receive the recommended follow-up glucose screenings, over their lifespan, beyond the postpartum period. Additionally, systems for encouraging and tracking ongoing glucose screening information among this high risk population are inadequate.

For some women, diagnosis of GDM may in fact be pre-existent or previously undiagnosed T2DM. The lack of follow-up glucose screening tests among those with a history of GDM may be one factor contributing to the high proportion of undiagnosed cases of diabetes among women (CDC, 2007; 2008). Evidence-based screenings among women with hGDM should be continued during their reproductive lifespan as GDM often reoccurs in subsequent pregnancies (Getahun, Fassett, & Jacobsen, 2010). Reoccurrence further increases the potential for perinatal morbidity as well as the onset of T2DM and related vascular complications (Bottalico, 2007). Early detection of elevated serum glucose levels provides opportunities for proactive education and may stimulate personal commitment to lifestyle changes and health promotion.

Women with hGDM who receive recommended gynecological care, such as annual cervical cancer screening test, may be more likely to receive follow-up glucose screenings and cardiometabolic risk assessments in conjunction with ongoing gynecological screenings. Cardiometabolic risk assessments are needed especially among women at risk because undetected or uncontrolled diabetes can lead to subtle, irreversible microvascular and macrovascular complications (Ruhl, 2009). Studies exploring the association among

demographic characteristics, post-GDM glucose screenings, and other gynecologic health screenings are few. Therefore, this study investigated the relationships among gynecological health screenings and the demographic characteristics of race/ethnicity, age, education, body mass index (BMI), and insurance coverage.

Chapter one presents the background and significance of GDM and provides the rationale for the research problem and study's purpose related to health screening beyond hGDM. The framework guiding this study is described as well as essential assumptions of the study.

Background and Significance

DM, the most common endocrine disorder in the U.S., is characterized by chronic elevated glucose levels secondary to inadequate insulin production and/or increased insulin resistance (CDC, 2007). Three major types of DM are currently recognized internationally including (a) Type 1 diabetes [T1DM], called insulin-dependent DM, accounts for 5-10% of all chronic cases of the disease; (b) Type 2 diabetes [T2DM], called non-insulin dependent DM, accounts for over 90% of all chronic cases; and (c) GDM, a type of carbohydrate intolerance first diagnosed during pregnancy (CDC, 2007), which is estimated to affect approximately 7% to 14% of all pregnancies in the U.S. (ADA, 2007).

The lack of screening for T2DM subsequent to GDM is a significant problem because of the number of women affected, the long-term consequences, and the increased risk of life-threatening disease related complications for women. According to the ADA (2007), GDM affects approximately 7% of all pregnancies or about 200,000 pregnancies in the U.S. each year. The March of Dimes (2006) and the National Institutes of Health [NIH] (2006) report about 1 in 100 childbearing women have diabetes before pregnancy and up to 7% of childbearing women develop GDM. In 2008, 1 in 16 women giving birth were documented as having pre-existing diabetes or GDM (AHRQ, 2010). These findings emphasize the importance of research among women at high risk. Greater emphasis on and financial support for prevention and

screening are needed as T2DM is a major contributor to coronary artery disease (CAD) development and its complications (ADA, 2009).

T2DM, a highly plausible result of hGDM, causes serious cardiovascular complications including hypertension with diastolic dysfunction, stroke with disability, retinopathy resulting in blindness, nephropathy, peripheral vascular disease with limb amputation and peripheral neuropathy (AHRQ, 2005a; CDC, 2007; National Institute of Diabetes and Digestive and Kidney Diseases [NIDDK], 2008). These complications can have a serious impact on later health and quality of life. Glucose control, as well as blood pressure and lipid balance, are essential to the treatment of DM and prevention of end organ vascular sequelae (ADA, 2009; Diabetes Control and Complications Trial Research Group [DCCT], 1995; Towfigh, A., et al., 2008; United Kingdom Prospective Diabetes Study [UKPDS], 1998). Diabetes prevention and early detection following the diagnosis of GDM are crucial to halting the epidemiologic course and natural history of women's cardiometabolic disease progression (Ruhl, 2009). Cardiometabolic health risk refers to the assessment of a person's risk level for developing diabetes and related cardiovascular system complications (ADA, 2006).

Women with diabetes have greater cardiovascular disease disparities as compared to men with the disease (AHRQ, 2006; Gregg, Gu, Cheng, Narayan, & Cowie, 2007; Wilson et al., 2007). Women with diabetes have much greater risk of developing coronary artery disease, hypertension, dyslipidemia, and hyperglycemia symptoms than do men with diabetes (Legato, et al., 2006). The risk of hospitalizations from cardiovascular disease is two to four times higher for women with diabetes as compared to those without the disease (AHRQ, 2007; Gregg et al., 2007; Wilson et al., 2007). In a longitudinal study reviewing nearly thirty years of mortality related health outcomes among diabetics, Gregg et al. (2007) found health outcomes between 1971 and 2000 for diabetic men were better than health outcomes for diabetic women. Diabetic men had a 43% relative reduction in age-adjusted mortality rate while diabetic women had no reduction in total or cardiovascular mortality. Hu and colleagues (2002) assert cardiovascular

disease (CVD) risk is often elevated among pre-diabetics before clinical diagnosis (Hu et al., 2002). Prevention, early recognition, and more aggressive interventions are important for women with hGDM as diabetes doubles the risk of cardiovascular morbidity and mortality (Gregg et al., 2007). Earlier detection of DM is crucial because cardiovascular disease is the leading cause of mortality among women in America (CDC, 2007).

Women diagnosed with T2DM have less optimal vascular health outcomes as compared to men diagnosed with the disease and women's experiences in healthcare encounters often differ from men's experiences (Shalev, Chodick, Heyman, & Kokia, 2004; Wexler, Grant, Meigs, Nathan, & Cageliero, 2005). Limited gender specific research studies may contribute to clinical outcome disparities (Legato, et al., 2006). Gender specific DM care of women has only recently begun to be a major focus of public health concern (Szalat & Raz, 2007). Because gender disparities in DM outcomes exist, an investigation of ongoing glucose screening subsequent to hGDM could offer contributory antecedent information relevant to the life-long health course of women at high risk for T2DM.

National Mandates Related to Diabetes Mellitus in Women

The significance of screening subsequent to GDM is supported by the national mandates addressing DM among women. *Healthy People 2010* national health objectives included "increasing quality and years of healthy life and eliminating health disparities" (United States Department of Health and Human Services [USDHHS], n.d., a). This set of national health objectives has been a driving force for assessing and evaluating public health in the U.S. Gaps in chronic disease prevention remain, and goals were not met by 2010; thus, the *Healthy People 2020* objectives emphasize greater focus on health promotion and disease prevention among high risk groups. The major *Healthy People 2020* diabetes-related goal specifies reducing "the disease and economic burden of DM and improving the quality of life for all persons who have, or are at risk for DM" (USDHHS, n. d., b, para 1). By screening women at high risk for DM, this public health goal of early disease detection could be addressed.

Additional public health initiatives of the CDC addressed DM among women across the life stages (Beckles &Thompson-Reid, 2001). The *National Agenda for Public Health Action: National Public Health Initiative on Diabetes and Women's Health* (Department of Health and Human Services, 2003) documents a monumental interdisciplinary collaborative vision to prevent diabetes onset among women through research and public education. The CDC (2007) has further identified *Objectives for the National Public Health Initiative on Diabetes and Women's Health*. Researchers from CDC have identified an underuse of preventive care services among women diagnosed with DM (Owens et al., 2008). However, scant research has examined preventive care services among those at high risk for developing DM following hGDM. Recent collaboration between the CDC and AHRQ was initiated to examine the gap in information related to access and quality of health care for women at high risk for DM (AHRQ, 2011).

National health initiative, addressing the burgeoning need for prevention and early detection of DM, provided a logical impetus for this research study examining the relationship between scheduled gynecologic and glucose assessments following the hGDM. Despite increasing evidence of the need to improve quality health outcomes among women diagnosed with DM (Legato et al., 2006), less is known about disease prevention and compliance with ongoing glucose follow-up screening recommendations subsequent to the first designation of DM risk. Since women are often first identified to be at risk for diabetes during obstetrical/gynecological care, more comprehensive approaches to gynecological health screenings based on client risk may be a plausible approach to ongoing diabetes health promotion. Further knowledge regarding diabetes prevention and periodic glucose health screenings among this gender-specific group could contribute to improving evidence-based prevention interventions and health outcomes while simultaneously decreasing diabetes-related costs (Rubin & Peyrot, 1998; Whittemore, Melkus, & Grey, 2005). Because few randomize clinical trials or longitudinal studies have examined the ongoing glucose status of women

previously diagnosed with GDM, this study addressed specific gaps in knowledge by exploring whether women who report receiving an annual gynecological care visit are more likely to report post-GDM glucose screening and whether routine gynecological care and post-GDM glucose screening are influenced by demographic characteristics of the women. Because of the need in women's health for gender-specific, population-based health promotion, this research study was timely.

Cost of Diabetes Care

Treatment of diabetes and its complications is associated with escalating health care costs. The estimated annual cost of diabetes care increased from $132 billion (CDC, 2007) to $174 billion in only two years (ADA, 2008). Some researchers project diabetes costs will triple within 25 years as the projected rate of cases doubles (Huang, Basu, O'Grady, & Capretta, 2009). In 2000, CDC researchers declared DM a public health emergency because of the rapid increases in incidence, prevalence, and cost (Narayan, Gregg, Fagot-Campagna, Engelau, & Vinicor, 2000). In a health care cost and utilization project [HCUP] report, nearly one in five hospitalizations accounting for over 7.7 million admissions were reported to be related to diabetic client admissions (Fraze, Jiang, & Burgess, 2010). These authors reported the mean length of stay for diabetics about a day longer than non-diabetics (5.3 days compared to 4.4 days).

GDM care increased non-complicated pregnancy costs by $3,305 per pregnancy and inflated national medical cost by $636 million for the mothers diagnosed with GDM and $40 million for their babies based on an analysis of the National Hospital Discharge Survey for 2007 (Chen et al., 2009). Gestational diabetics are among those at highest risk for postpartum re-hospitalization and acute care visits adding to the cost dilemma (Hamilton, Brooten, & Youngblut, 2002). Hamilton and colleagues (2002) demonstrated re-hospitalization reduction with properly managed care and nursing follow-up. Albrecht and colleagues (2010) explored prevalence trends of all types of diabetes among delivery hospitalizations during the decade

between 1994 through 2004. These authors found GDM represented the greatest proportion of hospitalizations and re-admissions. The complexities and costs of DM and GDM care impose a significant escalating economic burden on women, their families, and the nation (Chen et al., 2009). By contrast, Kim, Herman, and Vijan (2007) completed a cost analysis study among hGDM women and found the cost of postpartum glucose screening was most cost effective when follow-up was completed on an every three follow-up cycle. In a systematic review by Raikou and McGuire (2003), the economics of DM screening was purported to be cost effective especially among populations at high risk as compared to the cost of diabetes related complication care. Given that the average cost of glucose screening test is inexpensive in comparison to the economic burden of disease complications; further potential cost savings should be examined.

Conceptual Framework

Investigators have employed multiple theories and conceptual models to guide, describe, and explain various research approaches to chronic disease prevention. Yet eradication of chronic diseases, including diabetes, continues to elude clinicians and investigators. Ruhl (2009) conceptualized the Cardiometabolic Risk Factor and Disease Progression Model to describe factors associated with cardiometabolic diseases, such as diabetes and the interrelated vascular complications affecting women. Ruhl's (2009) model depicts a natural history continuum or epidemiological life course of disease progression from intrauterine prenatal exposures to the end of life. The complexity and interrelated progression of cardiometabolic disease depicts inflammatory systemic vascular changes leading to microvascular complications, cardiovascular failure, and death. The model further conceptualizes a progressive continuum of disease influenced by socioeconomic, psychological stress, and environmental exposures across the lifespan.

Ruhl's Model (2009) was derived from the American Diabetes Association's promotion of cardiometabolic health through the "Cardiometabolic Risk Initiative" originated in 2006. Using

research findings, Ruhl (2009) identified non-modifiable risk factors such as age, race, gender, and family history as well as modifiable risk factors such as stress and obesity as contributing to the progression of cardiometabolic and vascular morbidities. Modifiable and non-modifiable risk factors interact with lifespan events or clinical diagnoses such as GDM, thereby increasing the likelihood of disease progression leading to T2DM and related vascular complications. In the model, socioeconomic factors influence a woman's access to adequate health care while negative environmental exposures and psychological stress are interrelated factors contributing to cardiometabolic disease expression over the lifespan continuum (Ruhl, 2009). GDM is depicted as one of the gender-specific, clinical lifespan events potentially leading to vascular disease, heart failure, and death. A model guiding GDM research was sought. As a result, selected concepts derived from Ruhl's model were chosen for the present study (Figure 1) following a literature review and discussion with Catherine Ruhl (personal communication, April 13, 2010). These concepts are consistent with risk factors as described by ADA (year) that lead to T2DM.

Ruhl's model (2009) provides a context for examining relationships among the diagnosis of pre-diabetic risk factors, pre-cardiovascular risk factors, and women's health conditions leading to morbidity and mortality. Although Ruhl's model does not address prevention or screening, the model provides an opportunity for further related research and analysis. The conceptual model for the present research study was derived from Ruhl's model (2009) and depicts four risk factor categories preceding the overt diagnosis of T2DM. These pre-diabetic risk factors include socioeconomic factors, modifiable risk factors, non-modifiable risk factors, and lifespan events, represented in this study exclusively by a past medical reproductive hGDM. Primarycare and secondary prevention screening tests should be routinely conducted in the presence of risk factors according to evidence based standard guidelines.

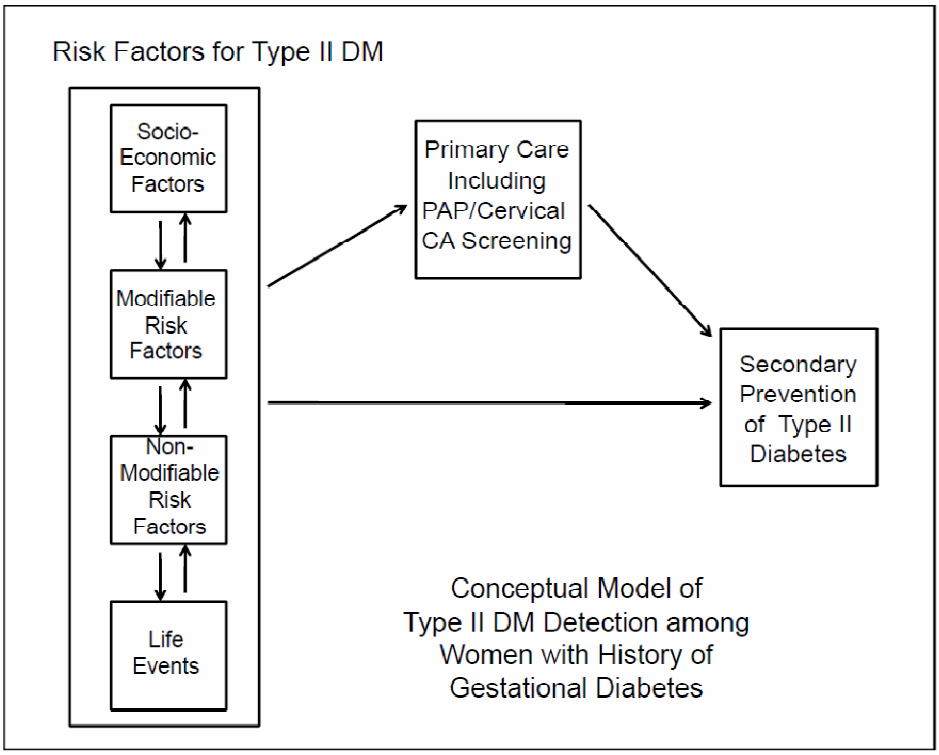

Figure 1. Kelly's Conceptual Model Based on Ruhl's Model

Table 1. Kelly's Conceptual Model Definitions

Conceptual Term	Definition
Socioeconomic Risk Factors	Factors influencing an individual's sociological and economic living potential including education level, income or earning capacity, and access to healthcare and other resources
Modifiable Risk Factors	Risk factors for disease which can be changed based on individual lifestyle choices such as body weight and body mass index by alterations in dietary/caloric intake and exercise changes (Gordis, 2004)
Non-modifiable risk Factors	Risk factors for disease which cannot be changed or modified by an individual such as race, ethnicity, and chronological age (Gordis, 2004)
Lifespan event	Physiologic health changes leading to an associated clinical condition (such as GDM) influencing the future risk of T2DM and related cardiometabolic comorbid complications (Ruhl, 2009)
Primary care including screening test	Evidence based population health primary care which includes screening for those at risk for disease such as cervical cancer screening test or Papanicolaou (Pap) smear. Primary prevention denotes an action taken to prevent disease development (Gordis, 2004).
Secondary prevention screening test	Evidence based population health test used to further diagnose diseases following initial screening and identification of risk such as in glucose test which test blood sugar and diagnose DM. Secondary prevention denotes action taken to identify and diagnose disease in an early stage of its' natural history (Gordis, 2004)

The conceptual model provided the broad concepts from which the research framework was derived. Based on the research framework, variables were selected for measurement. The operational definitions and data points for each variable are described in Chapter 3.

Table 2. Kelly's Research Framework Concept and Variables

Concept	Variable
Socioeconomic factors	Education level, health insurance
Obesity	An estimate of overall body fat measured by weight in kilograms/height in meters squared; Obesity equals a body mass index (BMI) level <30 kg/m²
Non-modifiable factors	Age, race, ethnicity
Lifespan event	A past medical/reproductive history of gestational diabetes
Primary health screening test	Annual cervical cancer screening or Pap test in the last 12 months
Secondary health screening test	Glucose test in the past three years (this variable is not specified by the type of glucose test)

To guide the study, a research framework (Figure 2) with the concepts to be studied was developed based on the conceptual framework. The research framework identified the concepts that were examined in this study. Socioeconomic risk factors were measured by examining the participant's education level and health insurance access. Modifiable risk factors were measured by BMI which influences obesity measurement; non-modifiable risk factors were measured by age, race, and ethnicity. A past hGDM represented the lifespan event risk factor of interest. The primary prevention screening test was measured by the participant's self-report of having had a Pap smear during the last year; while the secondary prevention health screening test was measured by the participant's self-report of having a glucose screening test within the past three years. The selected primary and secondary screening test timeframes represent the current standard of care measures recommended for evidence-based practice.

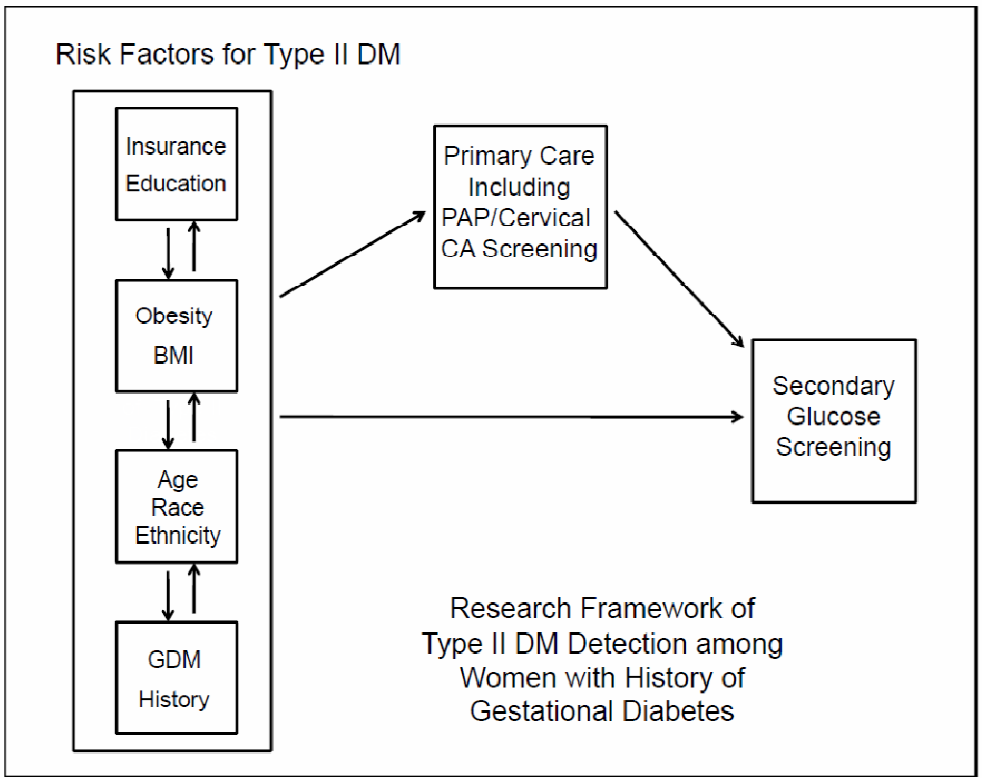

Figure 2. Research Framework
Kelly's Research framework derived from Ruhl's model

Purpose

The purpose of this retrospective cross-sectional study was to examine associations among demographic characteristics, gynecological care, and post-pregnancy glucose testing among a large representative sample of women who self-reported a past medical hGDM. A secondary analysis of CDC's Behavioral Risk Factor Surveillance System (BRFSS) 2008 data was used to investigate the relationship between a self-reported annual gynecological visit (which included a screening test for cervical cancer) and a glucose screening test (in the past three years). The time frames specified for tests represent current practice standards. Further analysis was done to see if demographic measures including race, ethnicity, education, age, BMI, or health insurance were associated with the dependent variable of interest, a glucose screening test for DM detection.

A wealth of evidence documents, women with a history of GDM are vulnerable to morbidity and at high risk for developing type 2 diabetes mellitus (T2DM) within a decade following the diagnosis of GDM. However, no published investigation to date has evaluated the concepts (embedded in BRFSS data) regarding the relationship of a self-reported glucose test based on recommended guidelines as compared to other well-established reproductive health screening test (cervical cancer screening). While the type of glucose screening test was unspecified in the BRFSS dataset, an investigation of the available data renders information regarding DM follow-up among a high-risk sample of women.

Research Questions

The following research questions were addressed in this study using a large, representative retrospective sample of women who self-reported a prior diagnosis of GDM.

1. What is the association between an annual gynecologic visit which includes a Pap/cervical cancer screening test and a glucose screening test among women who report hGDM?

2. Among women with hGDM and an annual gynecologic visit that includes a Pap/cervical cancer screening, what is the difference in the report of glucose testing by the demographic measures of race, ethnicity, education level, age, BMI, or health insurance?

Hypotheses

The null hypotheses for this study: There is no relationship between an annual gynecological visit which includes a Pap/cervical cancer health screening and a glucose screening test for DM detection among women who report hGDM. Additionally, there is no difference in the report of glucose screening test results regardless of demographic characteristics among hGDM women who had primary annual Pap/cervical cancer screening and secondary glucose screening test for diabetes and those who did not complete both screening test.

Assumptions

All assumptions are embedded in the conceptual framework and the study design.

1. Women diagnosed with hGDM are informed and knowledgeable of their pre-diabetic risk status and value health screening as a measure leading to optimal health outcomes.
2. Women with past medical histories of GDM who understand the risk associated with T2DM and also engage in annual cervical cancer screening would engage in post-delivery glucose testing as recommended.
3. Professional nurses and other health care professionals involved in the delivery of care to women diagnosed with GDM desire and value evidence based health screening as a primary/secondary prevention intervention with the potential to optimize quality health outcomes among women diagnosed with GDM. This valuing further stimulates provider currency with ongoing evidence based standards and translation of those standards to practice.

4. Glucose screening test and cervical cancer screening test among women diagnosed with GDM will lead to disease prevention, early disease detection, timelier interventions, reduced disease related complications and costs, decreased morbidity/mortality, improved quality of life, and improved healthcare quality among women diagnosed with a history of GDM.

Chapter Summary

This chapter provided a brief overview of the background and significance of GDM in the United States population of women. Women's health settings provide a context for more comprehensive health screenings especially as they affect reproductive and gender-specific health over the lifespan. With increasing disease prevalence and disease related costs, empirical exploration of self-reported health screenings among women with a history of GDM was proposed as an initial investigation with potential direction for population health outcome optimization. The study background, conceptual and research frameworks, purpose, research questions, and essential assumptions have been identified for this research study.

CHAPTER 2

REVIEW OF RELEVANT LITERATURE

GDM Context

GDM has been identified as a sentinel event occurring early in a woman's lifespan signaling the need for longitudinal glucose surveillance (Bottalico, 2007; Nelson, Hien Le, Musherraf, & VanBerckelaer, 2008). Published studies have demonstrated pre-diabetic women who have a history of GDM (hGDM) are seven times more likely to develop type 2 diabetes mellitus (T2DM) following pregnancy as compared to women without hGDM (Bellamy, Casas, Hingorani, & Williams, 2009). Robust evidence indicates 20% to 50% of the women diagnosed with GDM progress to overt T2DM within 5 to 10 years following their initial GDM diagnosis (Feig, Zinma, Wang, & Hux, 2008; Kim, Newton, & Knopp, 2002). Despite this evidence, diabetes prevention and translational integration of findings lag in clinical practice. Therefore, ongoing screening for early detection of DM onset has been re-emphasized (CDC, 2011).

Multiple studies document suboptimal levels of postpartum glucose screening follow-up among this population of women at risk of T2DM development (Almario, Ecker, Moroz, Bucovetsky, Berghella, & Baxter, 2008; Hunsberger, 2007; Ferrara et al., 2009; Kim, Tabaei, et al., 2006). Suboptimal postpartum glucose screening within 6 to 12 weeks following delivery becomes a serious problem because 200,000 women are diagnosed with GDM annually (ADA, 2007). Additionally, GDM recurrence has been reported to be high as 70% among women with hGDM (Feig, Zinma, Wang, & Hux, 2008). Recurrence increases the vulnerability to early pregnancy loss, congenital defects, perinatal morbidity, chronic DM, and other diabetes related cardiometabolic comorbidities (Bottalico, 2007; Ogonowski & Miazgowski, 2009). Some scientists have identified increased parity as a risk factor for recurrent GDM as well as future

DM (Bentley-Lewis, 2009); therefore follow-up glucose screening among these clients holds increased potential for optimizing inter-pregnancy care (Getahun, Fassett, & Jacobsen, 2010).

Pregnancy has been identified as a type of stress test unmasking subclinical manifestations of DM (Samuels-Kalow & Funai, 2007). Women with hGDM who continue to seek reproductive health care that includes gynecological health screening tests post-pregnancy may benefit from glucose screening follow up more often than women who do not seek annual gynecological care. Yet, a paucity of information exists regarding glucose screening trends beyond the postpartum period and longitudinal studies are lacking. Therefore, further research is needed to explore this gap in long-term glucose screening trends among women of this pre-diabetic group.

Information gained from landmark diabetes studies including the Hyperglycemia and adverse pregnancy outcomes [HAPO], the Diabetes Prevention Project [DPP], and the United Kingdom Prospective Diabetes study [UKPDS] support the benefits of strict glucose balance, ongoing glucose surveillance as well as behavioral changes leading to weight reduction among those with both GDM and DM (HAPO, 2008; UKPDS, 1998). Multiple systematic reviews confirm similar information regarding the need for ongoing glucose control and earlier interventions among hGDM women (Feig, Zinma, Wang, & Hux, 2008; Kim, Berger, & Chamany, 2007; Kim, Newton, & Knopp, 2002). Glucose balance and screening for early diabetes detection are especially important as women are reported “to suffer disproportionately from disability compared to men” (AHRQ, 2011, p. 3).

In a small study, investigating follow-up health screenings, Smirnakis, Chasan-Taber, Wolf, Ecker, and Thadhani (2005) found that 37% of a hGDM client sample (n=197) underwent a postpartum glucose screening test by 428 days (median time) post-delivery while 94% of the sample completed a Pap/cervical cancer screening test as part of gynecological screening by 49 days (median time) post delivery. These authors concluded that the lack of access to care was an unlikely explanation for glucose follow-up since 94% of the sample was screened for

cervical cancer while only 37% of their hGDM sample completed glucose screening according to American Diabetes Association (ADA) guidelines. While no statistical comparisons were made between the types of health screenings, the authors reported statistical findings documenting that women were more likely to have glucose screening when 1-hour glucose tolerance test glucose levels were ≥ 171 ml/dL, the geometric mean, than when glucose results were below the geometric mean (Multivariable HRs 2.1, 95% CIs 1.3-3.6, and 2.0, 95% CI 1.1-3.5). Clearly, these researchers demonstrated that, although gynecological screening has been pursued by women, providers may not use the gynecological screening opportunity to pursue glucose screening per ADA guidelines. This comparison between primary and secondary health screening test suggest the well-established cervical cancer screening test could serve as a proxy for co-conducting glucose screening follow-up among individuals with hGDM profiles.

Specifically, what is not known is whether a larger sample of women with hGDM who receive annual gynecological health screening for cervical cancer would be more likely to receive the secondary glucose screening assessments more than women who do not receive annual cervical cancer screenings. This study is designed to examine this gap within a larger representative sample of women who self-reported hGDM. Consistent assessment of glucose screening in conjunction with routine gynecologic care among women with hGDM could afford clinicians an opportunity to alter the natural trajectory toward T2DM.

In this chapter, a review of GDM pathophysiology including cardiometabolic disease, disease epidemiology, and evidence based standards of care will be discussed. Relevant literature will be presented related to independent characteristics including race/ethnicity, age, education level, body mass index (BMI), health insurance, and primary gynecological care as they are associated with the detection of T2DM and cardiometabolic risk progression among women at high risk for developing T2DM. Literature related to the dependent outcome concept of interest (glucose testing beyond the hGDM) will also be examined as the outcome related to primary and secondary prevention screenings in the same population.

Gestational Diabetes Mellitus (GDM) Pathophysiology

The three major types of diabetes mellitus, as previously discussed, include (a) type 1 diabetes (insulin dependent type which represents 10% of all types), (b) type 2 diabetes (non-insulin dependent which represents 90% of all types), and (c) gestational diabetes mellitus (GDM, initially identified during pregnancy, affecting 7% of all pregnancies annually. Individuals are considered pre-diabetic if they demonstrate impaired glucose tolerance (IGT;140-199 mg/dL) or impaired fasting glucose (IFG; 100-125 mg/dL or hemoglobin A1C values between 5.7%-6.4%), or with blood glucose levels higher than normal yet slightly below clinically diagnostic cut-off values (CDC, 2007). Approximately 57 million pre-diabetics reside in the nation; among these are many women with hGDM (CDC, 2007). Women with hGDM are considered pre-diabetic because they are at higher risk for developing type 2 diabetes and they often have IGT or IFG secondary to persistent insulin resistance (Callaghan, 2010). However, due to inadequate glucose follow-up screenings, most individual's glycemic status has not been recognized as life threatening. Chronic hyperglycemia leaves undiagnosed individuals at risk for vascular damage.

Pancreatic hormones (insulin, glucagon, somatostatin, and gastrin) are produced to support glucose, protein, and lipid metabolism (McCance, Huether, Brashers, & Rote, 2010). Insulin, produced by pancreatic beta cells in the islets of Langerhans, allows glucose to be absorbed and transported from the bloodstream to body tissues and cells for energy use (ADA, 2009; CDC, 2007). Hyperglycemia results from insulin resistance and/or inadequate insulin secretion secondary to beta cell deterioration or destruction. Classical clinical manifestations of diabetes include polyuria, polydipsia, and polyphagia. These symptoms may be initially unrecognized as they are somewhat subtle and may be dismissed among women as they are often associated with other gender-specific reproductive changes.

Although the first designation of GDM as a diagnosis was applied in the 1950's, the exact pathophysiology of GDM remains unclear (Buchanan & Xiang, 2005). Initially described

as “carbohydrate intolerance of varying degrees or severity with onset or first recognition occurring during pregnancy” (National Diabetes Data Group, (1979), p. 1039), GDM is now also understood to be a component of the metabolic syndrome leading to type 2 diabetes (Harlev & Wiznitzer, 2010). Scientists initially labeled the condition transient; however, the onset of GDM now appears to be a subtle, sub-clinical indicator of movement toward overt expression of T2DM among women with diabetic predisposition. This syndrome of clinical manifestations has also been labeled as syndrome X, Reaven’s syndrome, insulin resistant syndrome, metabolic syndrome, and cardiometabolic syndrome. The cluster clinical manifestations include: abdominal obesity, glucose intolerance, dyslipidemia, hypertension, and elevated coagulation factors (ADA, 2006). The American Diabetes Association (2006) now promotes the term “cardiometabolic syndrome” to further describe the cluster of multifactorial risks leading to an increased incidence of diabetes and other associated cardiovascular clinical manifestations.

An improved understanding of intra-abdominal adiposity or visceral fat has led to the identification of adipose cells as a major factor in pancreatic beta cell dysfunction and GDM onset. While an underlying causation of GDM continues to elude scientists, studies have demonstrated lower levels of adiponectin, higher levels of insulin receptor tyrosine phosphorylation and other metabolic influences of adipose tissue (Chen, et al., 2006; Cortelazzi et al., 2007; Friedman, J. E., et al., 1999). Harlev and Wiznitzer (2010) reported, “several investigators studied the genetics of GDM and the genetic relationship to T2DM” (p. 243). Research findings revealed 66 genes participate in placental “cell activation, immune response, organ development, and regulation of cell death” (p. 206e; Harlev & Wiznitzer, 2010, p.243). Other reports support genetic links (Enoquobaharie, Williams, Qiu, Meller, & Sorenson, 2009). Much of this new knowledge was revealed through the study of the post-birth placentas of women with GDM. Although the studies revealed information regarding pathological association with T2DM, causation underlying GDM onset remains unconfirmed (Harlev & Wiznitzer, 2010). What is known is women with underlying insulin resistance are prone to develop GDM

(Callaghan, 2010). Insulin resistance progresses to T2DM when pancreatic beta-cell deterioration occurs at a level in which glucose homeostasis cannot be accomplished thus, hyperglycemia results (Coulston, 2004). Insulin resistance worsens with progressive beta cell deterioration and further deterioration occurs as abdominal adiposity increases, age advances, and physical activity decreases (Chu, Kim & Bish, 2009; Kim, Newton, & Knopp, 2002).

In the normal physiology of pregnancy, hormonal changes and placental growth contribute to insulin resistance in the second trimester of pregnancy (Buchanan & Xiang, 2005). In normal pregnancies, physiological adaptations are made to adjust to placental hormones so that the woman's body remains euglycemic (within normal glucose balance). However, gestational diabetics remain hyperglycemic and unable to adjust to the changes thereby producing inadequate amounts of insulin secondary to pancreatic beta cell deterioration (Harlev & Wiznitzer, 2010). The latter becomes more complicated with increased maternal age, diminished activity, and co-morbidity development.

Insulin resistance has been reported in pregnancies with increased maternal adiposity and the greatest insulin resistance being among women exhibiting pre-pregnancy obesity (Buchanan & Xiang, 2005; Chu, Kim & Bish, 2009). Gestational hypertension and vascular inflammatory responses appear to be associated with increased GDM severity, especially when insulin administration is required to overcome insulin resistance (Kim, Newton & Knopp, 2002). In other studies, gestational diabetics have been reported to remain insulin resistant beyond pregnancy (Callaghan, 2010; Virjee, Robinson & Johnston, 2001). Callaghan (2010) asserts as many as one third of all gestational diabetics demonstrate some degree of abnormal glucose homeostasis after delivery. Only recently have scientists begun to look at the long term effects of GDM as a constellation of complications leading to T2DM and eventual cardiometabolic devastation as insulin resistance is seen as a common denominator in both T2DM and GDM (Coulston, 2004). Thus, it is plausible that hGDM followed by insulin resistance could be preclinical DM.

Diabetes in pregnancy can lead to increased maternal complications including infections, preterm labors, gestational hypertension, dystocia (difficult birth decent), and surgical deliveries. Diabetes can also lead to newborn complications including prematurity, low birth weight, macrosomia (large for gestational age), birth trauma, congenital anomalies, and stillbirth (March of Dimes, 2006). Gestational diabetes can lead to increased risk of developing T2DM for both the woman and her offspring (Fink, 2006; NIH, 2006). The cycle of diabetes will continue, as Pronsati (2007) reported, 1 of every 2 minority infants born in 2000 will develop diabetes, if current trends related to the increase in the incidence of diabetes continue. Some studies have hypothesized intrauterine fetal exposure and cellular programming as responsible for increasing prevalence of childhood obesity and earlier onset of T2DM onset among children (Yajnik & Deshmukh, 2009), thus presenting another reason to evaluate rates of ongoing diabetes prevention screening among women. Although the primary focus of screening pregnant women for GDM relates to positive perinatal outcomes, GDM designation has an embedded opportunity for long-term health promotion for both the maternal and the neonatal client.

Screening History and Treatment Challenges

The evolutionary history of glucose measurement, monitoring, and screening among diabetics has transitioned from urine “tasting” test in the first century BC to today’s gold standard serum glucose measure, the hemoglobin A1C (Owens, 2008). Serum glucose monitors and self-sampling or self-monitoring were first introduced in 1962 (Owens, 2008). Pregnant women were among the first clients to self-monitor blood glucose levels as a standard protocol for assessing problems and preventing hypoglycemia. Although glucose monitoring has a long history based on much scientific discovery, there remains no universal guideline directing clinical practice. However, there are multiple standards from several well-known and established sources.

Although GDM has been documented for over 50 years as a risk for the development of T2DM, health policy and standards for GDM screening criteria are inconsistent. Multiple

diagnostic criteria and a lack of universal screening standards continue to complicate clinical practice (Hunt & Schuller, 2007). A Cochrane review of treatments of gestational diabetes and impaired glucose tolerance in pregnancy revealed insufficient randomized controlled trials and insufficient data to make reliable conclusions or recommendations for standard effective treatment of the condition (Tuffnell, West, & Walkinshaw, 2007).

According to Langer (2006), screening for GDM originated in practice based upon the work of O'Sullivan and Mahan in 1964. Stricter screening criteria for GDM diagnosis were proposed in The National Diabetes Data Group (NDDG), a subsidiary group of the National Institute of Diabetes & Digestive & Kidney Disease (NIDDK), a division of the National Institutes of Health (NIH) which serves as collector and disseminator of data on diabetes. NDDG utilizes the less strict O'Sullivan and Mahan criteria for diagnosing GDM. The ADA and other groups have GDM screening criteria as well. The presence of multiple screening criteria disseminated by several organizations including the World Health Organization (WHO), NDDG, ADA and the American College of Obstetrics and Gynecology (ACOG) potentially contribute to inconsistencies in screening among providers. Table 3 displays major diagnostic screening criteria for GDM designation.

Table 3. Criteria for the Diagnosis of Gestational Diabetes Mellitus
(Standards and Blood Glucose Level)
(Adapted from Hunsburger, 2007)

Organizations with standards	Glucose Load and Time *1	Fasting *2	1 hour *2	2 hour *2	3 hour *2
National Diabetes Data Group	100-gram oral glucose tolerance	105	190	165	145
Carpenter and Coustan	100-gram oral glucose tolerance	95	180	155	140
American Diabetes Association and World Health Association	50-gram glucose challenge	NA*3	140	NA*3	NA*3

Table 3. continued

American Diabetes Association	75-gram oral glucose tolerance	95	180	155	NA*3
World Health Organization	Fasting/Casual	126/200	NA*3	NA*3	NA*3

*1 A ✝50g oral glucose challenge is a screening tool. A positive test is followed by an oral glucose challenge test. *2. All blood glucose level data are mg/dL, unless indicated otherwise. To convert mg/dL to mmol/L, multiply by 0.555. Two or more concentrations as high as or higher than those shown (National Diabetes Data Group and American Diabetes Association) and 1 or more concentrations as high or higher than those shown (World Health Organization) make the diagnosis of gestational diabetes. *3.NA indicates time points not performed. (*NDDG* 1979, Carpenter and Coustan 1982, WHO 1999 and 2002, ADA 2004, Jovanovic & Pettit, 2001).

Most pregnant clients are first screened for diabetes by random serum glucose obtained between the 24th and 28th gestational weeks of pregnancy. If the one-hour test is elevated or meets the screening cutoff of 140 mg/dl, the woman is subsequently further tested by assessing a three hour glucose tolerance test. Values above the cutoff are diagnostic of GDM. It is not known if those identified with GDM are early type 2 diabetics or true gestational diabetics until at least six weeks postpartum, due to the presence of pregnancy hormones. T2DM can only be determined if clients are re-screened by a three hour glucose tolerance test. ADA recommends retesting GDM clients six weeks postpartum. Subsequent glucose screening testing is advised at least every three years following delivery if postpartum screening results are negative (ADA, 2010).

Inconsistencies in screening practices, application of guidelines, and differences in sensitivity and specificity values were evident in multiple studies contributing to contrasting results regarding GDM care (Esakoff, Cheng, & Caughey, 2005; Friedman, Khoury-Collado, Dalloul, Sherer & Abulafia, 2006; Pennison and Egerman, 2001). Inconsistent GDM screening and treatment practices were reported in a systematic evidence review by the U.S. Preventive Services Task Force (USPSTF) (2003). This group reported there was no well-conducted randomized controlled trial (RCT) providing direct evidence for the health benefit of screening for GDM. Therefore, the Task Force found insufficient evidence to make recommendations for screening asymptomatic pregnant women (USPSTF, 2003). Nevertheless, most obstetrical care

providers screen pregnant clients for GDM during the third trimester of pregnancy (between the 24th and 28th weeks of gestation) based upon the expert opinions of the ADA and the ACOG. Both groups recommend screening based on individual risk factors.

Although inconsistent GDM screening practices were identified, one theme emerged; screening impacts perinatal outcomes as well as long-term health. More research is needed to determine the appropriate universal standard of care for women with GDM during pregnancy and beyond. This gap highlights an area in need of further research beyond the scope of the present study.

Risk Factors for GDM and Progression to Type 2 Diabetes

Scientists agree that interactions exist among demographic characteristics, recurrence of GDM in subsequent pregnancies, and progression to cardiometabolic syndrome and T2DM. Some of these risk factors are non-modifiable including race/ethnicity, age, and gender. Other risk factors are modifiable such as obesity, socioeconomic status, and health insurance access although the success in making long-term modifications remains complex and challenging. The next section examines how non-modifiable and modifiable factors are interrelated with GDM and DM disease progression.

Socioeconomic Status Factors

Socioeconomic position (SEP), as quantified by education level, employment status, and income, is known to be associated with reduced health care access and adverse health outcomes (Zhang, Geiss, Cheng, Beckles, Gregg, & Kahn, 2008). Strong associations exist between the prevalence and incidence of diabetes and SEP (AHRQ, 2011). CDC estimated SEP among women with diabetes as "markedly lower" than that of women without diabetes. Women with diabetes as compared to women without diabetes were described as being more likely to be minority, single, living alone, low-income, and retired or unable to work (CDC, 2000; Hannan, 2009). The socioeconomic profiles of women at risk for diabetes indicate low-levels of health promotional activity or evidence-based preventive health care services (AHRQ, 2011) thus; health screenings based on the SEP risk factor for diabetes are often compromised.

Lower SEP and economic insecurity threaten the health of women at different points across the life course (Beckles & Thompson-Reid, 2001). Gender SEP disparities and the risk of poor outcomes among female populations with DM have been documented in several reports (AHRQ, 2007; AHRQ, 2011; Black, 2002; Gregg et al., 2007; Szalat & Raz, 2007). For example, a study by Bird and colleagues (2007) revealed women with diabetes and heart disease were less likely to receive routine outpatient care as compared to men who had similar health conditions, although women saw health care providers more frequently than men. These authors assert gender difference remained even after researchers accounted for the influence of SEP factors (Bird, et al., 2007). SEP is linked to health care access and primary preventive services (AHRQ, 2011; Owens, Beckles, Kar-Yee Ho, Gorrell, Brady, & Kaftarian, 2008). Further discussion of this link among women at risk is discussed in the literature reviewing health insurance.

Education level

Educational attainment is a strong determinant of socioeconomic position and health outcomes. CDC scientists reported (2000) “at least one in four women aged 45-64 with diabetes had a low level of formal education and one in three had low SES regardless of race, ethnicity or living arrangement (marital status, size of household, and employment status)” (p.6). Educational attainment is reported by Beckles & Thompson-Reid (2001) to have a “stronger association with cardiovascular health-related behaviors than either occupation or income” (p.14). These authors assert lifestyle behaviors and values are less likely to change after the early adulthood period. Poverty status is highest among women with educational attainment below the 12th grade. In an analysis of access and quality of health care, 2003-2006, AHRQ documented, “women at risk for diabetes were significantly more likely than women not at high risk for diabetes to report fair or poor health in the past year if they had more than a high school education” (p. 14). Studies confirm interrelationships among educational attainment, literacy, health literacy, and DM outcomes (McLaughlin, 2009; Schillinger, et al., 2002). The extent to which the same interrelationships impact health screenings is not known.

Some scientists have identified gender-specific outcome differences among women at risk for DM based upon educational attainment. Loucks, Rehkopf, Thurston, and Kawachi (2007) analyzed cross sectional data from the National Health and Nutrition Examination Survey (NHANES) III to assess the likelihood of socioeconomic position being associated with the presence of metabolic syndrome. They found low education (<12 years) to be associated with the syndrome more strongly in women (odds ratio [OR], 1.77; 95%confidence interval [CI] 1.39-2.24) than in men (OR1.27 CI, 0.97-1.66). Similarly, their findings confirmed SEP associations with metabolic syndrome among multiethnic women (White, Black, and Mexican American) while SEP was less strongly associated with metabolic syndrome in men. Education was associated with five clinical features of the condition including abdominal obesity, hyperglycemia, and hypertension (Loucks, Rehkopf, Thurston, & Kawachi, 2007).

In her global report of women, gender equality, and diabetes, Hannan (2009) concluded "the serious consequences of gestational diabetes for women and their babies should be a concern for men as well as women… it is critical to ensure more effective prevention action through education and screening as well as appropriate treatment, care and follow-up" (p. S6). Therefore, gender and education level matter when it comes to DM. Increased focus on the GDM population could directly benefit shorter and longer-term risk of diabetes development for both women and their male and female babies (Hannan, 2009). Few studies have addressed the cycle of diabetes initiated in the next generation of individuals at risk subsequent to maternal hGDM.

Health Insurance

AHRQ news indicated "women accounted for nearly 60 percent of 39.4 million admissions to U. S. hospitals in 2007" (para 1) the leading reason for admissions among women was related to intrauterine pregnancy while the second leading reason for admission involved cardiovascular disease (AHRQ, 2010b). Women go to health care providers more often than do men and are more likely to have a usual source of care (Shalev, Chodick, Heyman, & Kokia, 2005). In spite of health care services and access, disparities exist for many women at risk for diabetes (AHRQ, 2006a; AHRQ, 2007). Several researchers have described gender differences in health care utilization and outcomes among women (Shalev, Chodick, Heyman, & Kokia, 2005; Wexler, Grant, Meigs, Nathan, & Cageliero, 2005).

Health care access is closely connected to health insurance and insurance type. Women have been faced with unique challenges related to having individual health insurance as it has often been harder for women to obtain insurance coverage if they had pre-existing conditions or even had a prior cesarean section (Wade & Ruhl, 2008). Women have often been quoted higher rates than men or have had longer waiting periods to obtain insurance with higher premiums due to reproductive services (National Women's Law Center, 2004; Wade, K. & Ruhl, 2008). These disparities prevail even when women are eligible for Medicaid governmental

health insurance services. Generally, pregnant women who are treated by obstetrician/gynecologists during pregnancy and postpartum, return to primary care providers for health care following postpartum. Medicaid insured women often lose insurance eligibility following the postpartum period thereby limiting access to preventive care services. Many women are ineligible for Medicaid and access to health care is linked to diabetes detection and screening (Zhang et al., 2008). This may change in the present health care reform environment, yet no studies of magnitude are available. Zhang and colleagues (2008) purported "undetected diabetes was related to insurance coverage, routine patterns of health care utilization and continuity of coverage" (p. 1749). Therefore, screening could be delayed or omitted.

The characteristic of race/ethnicity interacts with access to care services. Kim, Sinco, and Kieffer (2007) studied variations in racial/ethnic access to health care among women with hGDM. Using a cross sectional design the researchers conducted a telephone survey of a random sample of women (*N*=4718) from the national population based Behavioral Risk Surveillance System 2001-2003. The researchers found racial/ethnic variations among hGDM women in regards to use of health care services and access to care as well as family planning and perceptions of health. Hispanic/Latino women were reported to have the greatest health care access barriers as 40% of participants self-reported the lack of health insurance. African American women reported the highest use of emergency room services or urgent care clinic services as their primary care access facility. Interestingly, African American women have been reported to be significantly more likely than non-Hispanic white women to be covered by only public health insurance coverage (AHRQ, 2011).

Follow-up of women with hGDM has been studied by several researchers across the U.S. In a retrospective study at the University of Michigan, Kim, Tabaei, et al. (2006) reviewed records of women with a history of GDM (*N*= 570). The study was done to analyze glucose screening follow up postpartum. Results revealed low percentages of testing following

deliveries. Among women with at least one follow up visit postpartum (*N* =447), 42% received at least one glucose test and only 35% were tested at least once as recommended.

Similarly, Hunsberger (2007) explored risk factors for GDM and further examined the extent of postpartum follow up by physicians (*n* =238). Although this author found that 95% of the physicians tested for GDM during pregnancy, only 19% of the same providers tested for DM postpartum (Hunsberger, 2007). Several researchers have found similar evidence of missed glucose screenings following hGDM (Almario, Ecker, Moroz, Bucovetsky, Berhella & Baxter, 2008; Smirnakis, Chasan-Taber, Wolf, Ecker & Thandhani, 2005). While it is not known whether the omission of screenings are related to health insurance status, as in the study by Zhang, and colleagues (2008) evidence indicates access to care and health insurance influences health care outcomes. Lack of access, race, ethnicity, SEP, and age are all associated with lack of ongoing care among women (AHRQ, 2011; Beckles & Thompson-Reid, 2001).

Modifiable Risk Factors

Obesity and Body Mass Index

Obesity, a leading contributor for T2DM and cardiovascular disease (CVS), is more prevalent among females as compared to males of the same age. The obesity risk factor is most prevalent among minority women (CDC, 2011). Obesity is also associated with a number of other health-related consequences including dyslipidemia and hypertension. In addition, links between obesity, education level, and SEP have been documented among women at high risk for DM (AHRQ, 2011).

Body Mass Index (BMI), the most widely reported anthropometric measure, represents an estimate of overall body fat measured by weight in kilograms divided by height in meters squared. Individuals are considered to be obese when BMI is > 30 kilograms/meter^2. Evidence abounds to demonstrate the link between increased abdominal obesity and T2DM (Chen, et al., 2009; Cortelazzi et al., 2007; Friedman, J. E., et al., 1999). Abdominal girth is purported to be a

better measure of the metabolic syndrome risk than BMI (Appel & Bannon, 2007), yet few clinicians consistently measure and record abdominal girth (Appel & Bannon, 2007).

Elevated BMI and obesity have been linked to GDM. Heddersan, Williams, Holt, Weiss, and Ferrara (2008) found weight gain of "2.3 to 10.0kg/year" in the five years prior to conception increased the likelihood of developing GDM 2.5-fold (OR 2.61 [95%CI, 1.50 to 4.57]) among a multiethnic cohort of women (n=14,235). This finding is important as most women do not seek pre-conception counseling including those with hGDM who are at highest risk for morbidity. Paramsothy, Lin, Kernic, and Foster-Schubert (2009) found an association between interpregnancy weight gain and the likelihood of a subsequent cesarean delivery (OR 1.70 [95% CI 1.16-2.49]) among women with hGDM (n= 2,753) who gained <10 pounds between pregnancies. This retrospective cohort study was completed using linked birth certificate data of hGDM women with at least two births with the first being a vaginal delivery. Although limitations existed in this retrospective study, interpregnancy weight associations are linked to perinatal and long-term complications among this population.

In a prospective cohort study, Saldana, Siega-Riz, Adair, and Suchindran (2006), examined the relationship of pre-pregnancy BMI, pregnancy weight increases, and the relationship to glucose intolerance among pregnant participants (*n*=2254). Increased pre-pregnancy obesity BMI's were more closely associated with the development of glucose intolerance and GDM (OR 3.7, 95% CI 2.2-6.3) overweight (OR 2.2, 95% CI 1.1-4.3) as compared with normal weight women. The authors concluded that increased pre-pregnancy weight was strongly associated with GDM; therefore, pre-pregnancy BMI should be addressed prior to pregnancy to prevent complications. This finding was consistent with the report of Buchanan and Xiang (2005) who also report an association with increased adiposity and GDM occurrence among women with elevated BMI's prior to pregnancy.

Chu et al. (2009) studied pre-pregnancy obesity using 2004-2005 Pregnancy Risk Assessment Monitoring System (PRAMS) data. In this study (*n*=75,403), obesity was found to

be associated with pregnancies complicated by GDM. In addition, obesity was reported to be 50% higher among Medicaid recipients as compared to private payors. These findings regarding associations between obesity and diabetes parallel what was seen in the general population of Americans during the same years.

"Obesity, often accompanied by insulin resistance, is a strong risk factor for GDM and likely contributes to the increasing prevalence of GDM" (Hunt & Schuller, 2007, p.193). Although obesity is strongly linked to the risk of GDM and T2DM, no longitudinal studies were identified in which glucose screening was examined among obese clients with hGDM.

Non-Modifiable Risk Factors

Age

Age and gender disparities in preventive services have been reported among young women with diabetes (Owens, M. D., et al., 2008). CDC and other organizations recommend prevention services across developmental life stages as a public health promotion approach related to preventing diabetes across age groups (Beckles & Thompson-Reid, 2001; CDC, 2011). Nevertheless, the burden of the disease remains greatest among older, minority populations as compared to non-Hispanic white Americans (AHRQ, 2005b; CDC, 2007; NIDDK, 2008). Older females, minorities, and socioeconomically deprived groups are reported to be "least likely to receive timely and adequate health care" (Black, 2002, p.543). One in four older adults is now diabetic (CDC, 2007) yet no studies were identified to demonstrate greater glucose screening among this group. Although the incidence and prevalence rates of DM have increased among both men and women, women are more likely to live longer with disease related burdens and have poorer quality of life (CDC, 2010). Because older women are living longer with diabetes, there is a critical need to address diabetes prevention, early detection, and treatment earlier in the lifespan.

Race/ethnicity

Significant evidence has been accumulated to demonstrate that race/ethnicity is related to development of cardiometabolic syndrome and DM. Lifetime risk of DM is greater for minority women (Misra & Lager, 2009; CDC, 2007) and is the fourth leading cause of death among this group (CDC, 2008). Minority women over age 30 are at greatest risk of GDM and T2DM. Vulnerability to diabetes is highest among American Indian women. Some studies have identified rates of diabetes as high as 70% among Pima Indian women (Beckles, Thompson-Reid, 2001). One study of the Pima Indians between 1987 and 1996 concluded 40% of the T2DM among youth resulted from intrauterine exposure (Metzger, 2007).

Getahun, Nath, Ananth, Chavez, and Smulian (2008) evaluated national GDM temporal trends between 1989 and 2004 among a large sample by using the GDM diagnosis code (648.8) to derive characteristic findings (weighted *n*= 58,922,266). Regression analysis showed prevalence rates of GDM increased from 1.9% in 1989 to 4.2% in 2003-2004, a relative increase of 122% (95%CI 120%-124%) with the greatest increases among racial/ethnic minorities. The widening black-white disparity was recommended for further investigation, although demographics of age and region were highlighted.

Race specific risk for diabetes and cardiometabolic trends have been confirmed in multiple studies. Appel (2007) identified differences in the metabolic syndrome presentation among African American women. This group of women has been demonstrated to have both lower insulin sensitivity and higher circulating levels of insulin compared with white and Hispanic women. Appel (2007) concluded the ATP III definition of abnormal lipid profile may be inappropriate for black women.

Researchers have also documented racial/ethnic differences in GDM, maternal and fetal outcomes, and access to care. Rosenberg, Garbers, Lipkind, and Caissons (2005) conducted a large population based study (N= 329,988) among four racial/ethnic groups in New York City. The researchers used vital statistics data to examine associations between obesity,

diabetes and three adverse pregnancy outcomes. Their findings identified that women with chronic and gestational diabetes were at significant risk for primary cesarean sections, preterm labor, and low birth weight. These findings were consistent with the findings of Thorpe, et al. (2005) and Nicholson, et al. (2006) who also documented increases in adverse perinatal outcomes for minorities. Adverse outcomes are also linked to increased cost of care (Chen et al., 2009; Fraze, Jiang, Burgess, 2010).

Trends for gestational diabetes among pregnant women in New York City were analyzed from birth statistics from 1990-2001 by Thorpe, et al. (2005). The review of birth records revealed more than 1.5 million births occurred during the time period. Researchers found a trend toward an increase in the prevalence of GDM among most racial/ethnic groups. In this region, the highest prevalence of gestational diabetes was observed in South and Central Asian, Mexican, and non-Hispanic Black pregnant women.

Nicholson et al. (2006) examined the relationship between race and cesarean delivery, episiotomy, low birth weight infants in pregnancies with type 2 and gestational diabetes to identify factors that might explain racial differences. In this population based, cross sectional study sample (N=6,310), Black race was associated with higher incidence of cesarean delivery and low birth weight but lower odds of episiotomies. The data source was the 1999-2004 Maryland Health Care Commission Database. The authors concluded “in pregnancies with diabetes, adjustment for sociodemographic, hospital and clinical factors only partially explain racial differences in procedure use and infant low birth weight” (p. 626). Additionally, the authors indicate that the findings of the study have implications for further exploration of explaining racial differences and implications for educational interventions with clients related to long term risk reduction for diabetes.

In a systematic review examining recurrence of gestational diabetes, Kim, Berger and Chamany (2007) reviewed 13 studies from 1965-2006 and found GDM recurrence rates ranging from 30 to 84% following GDM in prior pregnancies with the highest rates among minority races.

Similarly, Getahun et al. (2010) identified higher recurrences of GDM among Hispanic and Asian/Pacific Islanders in their investigation of women delivered in a Southern California health care system (*n*=540,956). They concluded, “A pregnancy complicated by GDM is at increased risk for subsequent GDM” (p.1.e1). Recurrence of GDM offers multiple perinatal opportunities to address client and family health promotion to decrease the risk for ameliorating subsequent type 2 diabetes and its complications.

Lee, Hiscock, Wein, Walker, and Permezel (2007) assessed GDM risk in a retrospective cohort study using survival analysis of 5,470 GDM patients in Australia. Conclusions of this study document women with GDM as predictive for T2DM and worthy of long term follow up to address amelioration of their increased cardiovascular risk.

Women of Hispanic origin demonstrate higher risk of GDM as compared to all other high risk perinatal conditions. Brown, Chireau, Jallah, and Howard (2007) examined racial disparities in perinatal outcomes in the southeastern region of the U.S. at a tertiary center, using a cross-sectional study design. In the sample of 10,755 women seen from 1994-2004, Hispanic women had lower risk for all perinatal morbidities than expected with the exception of a higher risk for GDM. This unexpected finding was labeled the “Hispanic paradox.”

These studies along with national governmental statistics provide evidence of growing trends of racial and ethnic differences and health disparities for minorities related to diabetes in perinatal health. Because diabetes is increasing in prevalence and negatively impacts perinatal health outcomes and long-term health costs, it is imperative that health professionals re-evaluate strategies to address the growing problem and seek to prevent complications by implementing screening interventions earlier for among minorities.

Missed opportunities during and after obstetrical care may be especially critical for women of color who are at greatest risk for poorer pregnancy outcomes in general and are also at greatest risk for developing a diagnosis of gestational diabetes and subsequent T2DM (AHRQ, 2006; Black, 2002; Kim, Tabaei, et al., 2006; Office of Minority Health, 2007). Diabetes

places women of color at increased risk for continuing the alarming trend of health disparities in maternal outcomes in spite of early prenatal care (Black, 2002; Fink, 2006; March of Dimes, 2006). Identifying opportunities for primary and secondary care interventions related to hGDM could optimize perinatal outcomes, reduce the burden of health care cost, and reduce long term morbidity risk for both clients and their families.

All of these studies have documented inconsistencies in screening criteria, treatment and follow up practices. These findings suggest there are gaps in research, practice and policy for GDM health care guidance. The findings from these studies suggest a need for further research to address quality of care measures that have the potential to positively impact outcomes for women with hGDM.

Gynecological Health Screening

Women who routinely receive gynecological screening for cervical cancer are being seen by primary women's health care providers. Being seen by a health care provider for prevention would be a likely time for secondary prevention screening related to a history of GDM. Background on screening for cervical cancer will be discussed in comparison to diabetes and cardiometabolic disease screening.

Pap/Cervical Cancer Screening Test

Cervical cancer screening has been well-established since World War II following the publication of George Papanicolaou's 1941 report entitled, The Diagnostic Value of Vaginal Smears in Carcinoma of the Uterus (Ruhl, 2008). As a result, Ruhl(2008), citing the American Cancer Society, reported cervical cancer death rates decreased by 74% over a four decade time period between 1955 thru 1992 (Ruhl, 2008). Although this primary prevention screening test was not without initial criticism or ambiguous diagnostic guidelines issues, its efficacy in decreasing morbidity and mortality could be a blueprint to formulating similar universal secondary glucose screening guidelines among hGDM clients and those at highest risk of T2DM and cardiometabolic disease.

Though cervical neoplasia advances slowly, women who are not screened demonstrate increased risk of advanced stage cervical cancer at higher rates than those who are screened (Ruhl, 2008). The efficacy of the screening in the area of cervical cancer has led to new discoveries and a vaccine to ameliorate HPV initiated cervical cancer. Gains affected by the well-established, population based screening program among women could be a model or blueprint on which other more critically needed health screenings programs could be patterned. With the known risk of cardiometabolic disease and epidemic levels of T2DM among women, glucose screening programs could provide parallel benefits. Despite differences in glucose screening standards, researchers agree that women with hGDM need to be screened to decrease cardiometabolic risk and prevent/delay progression to T2DM. Smirnakis and colleagues (2005) demonstrate evidence of opportunities to use cervical cancer screening test as a proxy for follow-up glucose screening among women with hGDM. This study further explored the Pap as a proxy for glucose screening.

Importance of Screening Evidence for Nursing

Multiple researchers have compiled evidence supporting the significant impact professional nurses have on improving the quality of patient outcomes (Aikens, Clark, Cheung, Slone, & Silber, 2003; Brooten et al., 2001; Garcia-Patterson et al., 2003). Aikens and colleagues (2003) confirmed an association between lower risk-adjusted inpatient mortality and the level of professional nurse education. In this cross-sectional study of patient outcomes (n=232,342), the authors concluded lower patient mortality and better outcomes were associated with more highly educated nursing care. In a retrospective analysis, Garcia-Patterson, et al. (2003) compared differences in perinatal outcomes for women with GDM who were managed by endocrinologist as compared to nurse managed clients. No differences in perinatal outcomes were found between the groups. The researchers concluded that GDM clients need nurses to play an active role in GDM care.

In 2006, the NIH launched a diabetes prevention campaign with the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) called “Small Steps. Big Rewards. Prevent type 2 Diabetes.” This campaign represented the nation’s first multicultural type 2 diabetes prevention campaign among women at risk. Another addition to the NDEP campaign is the program for public awareness called “It’s Never too Early to Prevent Diabetes.” This program is focused on raising public awareness of the lifelong risk of developing T2DM for women who have had gestational diabetes and their children (NIH News, 2006).

In the only study located describing gestational diabetes education and prevention programs, Evert and Hei (2006) implemented a two part GDM program in which women with GDM were referred. The program was offered by professionals at the Joslin Diabetes Center in Seattle, Washington. This program utilized a curriculum that was research based, culturally appropriate, and incorporated materials from the National Institutes of Health (NIH). Clients were seen in paired visits by a registered nurse and a dietician, both certified diabetic educators. Although no outcomes were reported, the program demonstrated the efficacy of professional nurse involvement in interdisciplinary teams to optimize long term outcomes.

Other researchers have concluded that nurses need to take a more active role in the primary prevention of GDM and secondary prevention of T2DM. Nurse researchers Case, Willoughby, Haley-Zitlin and Maybee (2006) described similar conclusions when they reviewed GDM epidemiology in relation to type 2 diabetes in the research literature from 1995 to 2005. The authors recommended that diabetes educators, often nurses, must play a role in increasing awareness of the need for postpartum screening for women with GDM. These studies support the need for greater involvement of highly educated nurses in diabetic care and enhanced involvement of nurses on research teams.

A cross-sectional, descriptive study by Vonderheid, Montgomery, and Norr (2003) evaluated Mexican American and African American study participants regarding health promotional offerings during prenatal care (N=159). The authors found that the minority

participants wanted more health promotional content during pregnancy than they received from their care providers. Although the authors did not indicate the type of educational information clients wanted to have included in their health care visits, this study supports the need for nurses to involve clients in setting goals related to their educational needs. Evidence documents many intervention opportunities are being missed related to educating prenatal clients of the lifetime risk of developing diabetes.

Knowledgeable, culturally sensitive professionals are vital to improving the care of all clients. Prenatal care and postpartum follow-up offer unique opportunities for nurses to implement evidence based strategies related to reducing morbidities (Case et al., 2006). As a result, clinicians should seize every occasion to partner with clients, communities, and interdisciplinary healthcare professionals to improve health outcomes for women at risk for diabetes.

Intervention opportunities

The perinatal period is an optimal time for primary health care delivery (Fink, 2006). Pregnancy is a time when many clients are receptive to health promotion, educational interventions (Lowdermilk & Perry, 2007) and becoming empowered for self care (Vonderheid, Montgomery, & Norr, 2003). Pregnant clients frequently demonstrate the motivation and readiness to partner with health professionals to learn about their health care needs. Pregnant clients may be enrolled in obstetrical care for nearly one year early in their lifespan and many return to the same care provider for subsequent obstetrical and gynecological care.

While women with hGDM should be advantaged by the early recognition of their future risk of cardiometabolic morbidity, the literature reveals women are more often vulnerable to missed diagnosis and poor diabetes outcomes (Ferrara et al., 2009; Kim, Tabaei, et al., 2006; Legato et al., 2006; Misra & Lager, 2009). Many women who enter reproductive health care settings demonstrate readiness for health education and self-care empowerment. Fragmentation of health care services, inconsistent screening guidelines and slow

dissemination of translation of research may hinder quality evidence based care for women with hGDM. Roglic (2009) suggests “while waiting for research to illuminate specific aspects of diabetes in women, women should benefit more from the already existing knowledge on diabetes prevention and management” (p. S12).

Chapter Summary

Through this critical review of the literature, evidence has emerged that disparities in outcomes are associated with the demographic characteristics of women with GDM. Multiple reports documented racial and ethnic disparities in regard to maternal/fetal outcomes among clients diagnosed with GDM. In addition, national statistics document hGDM as a major risk factor for T2DM development among women within 5-10 years following GDM (CDC, 2011). Mixed findings were reported for ethnic differences in screening thresholds regarding sensitivity, thus there is a need for additional studies in this area (Esakoff, et al., 2005; Pennison & Egerman, 2001).

Postpartum follow-up for clients with GDM is less than adequate and few studies have evaluated glucose follow-up beyond the postpartum period among this population of women. Although the review addressed associations between identified risk factors and T2DM, no studies connected risk factors to glucose screening models. There is a burgeoning need for greater emphasis on ongoing secondary prevention screening and health promotion to delay and detect T2DM earlier among this at-risk population. Because no universal evidence-based screening guideline for GDM exist due to the lack of randomized clinical trials, other data sources such as databases of national surveys need to be used to provide guidance in this area. This literature review supported a need for the present study using secondary analysis of BRFSS to examine associations between well-established gynecologic care and follow-up glucose screenings.

CHAPTER 3

METHODS AND PROCEDURES

This chapter presents the methods and procedures used in this research study. A secondary analysis was conducted of cross-sectional data contained in the Behavioral Risk Factor Surveillance Survey (BRFSS) 2008 dataset compiled by the Centers for Disease Control and Prevention (CDC). The study examined selected health screenings among a representative sample of adult women self-reporting a history of gestational diabetes mellitus (hGDM). Specifically, this study was designed to 1) determine associations between an annual gynecologic visit for a Pap/cervical cancer screening and a glucose screening test and 2) examine differences among women with a history of GDM and an annual gynecologic visit which included a Pap/cervical cancer screening test by demographic measures including race, ethnicity, education level, age, BMI, and health insurance. This chapter highlights the methods and procedures that were used to examine the variables of race, ethnicity, education level, age, BMI, health insurance, Pap/cervical cancer screening, and a glucose screening test. This epidemiologic investigation was proposed to extend the discourse regarding GDM, health screenings, and demographic associations among women at high risk for T2DM. Sampling for this study is discussed as well as data analyses, ethical considerations, and delimitations.

Research Design

The research design was a quantitative secondary analysis using retrospective, cross-sectional data to analyze responses from hGDM participants collected using a large database that is publicly accessible. Advantages of the cross-sectional design included the reduction of time and cost related to data collection and analyses (Polit & Beck, 2004). Secondary data are also useful in evaluating utilization patterns, efficacy, and effectiveness of health outcomes

(Hulley, Cummins, Browner, Grady, & Newman, 2007). Hulley and colleagues (2007) purport information obtained from secondary analyses can have major public health implications.

Description of BRFSS Setting

Initiated in 1984, the BRFSS survey is one of the largest continuously conducted health surveys (CDC, 2008). The survey is conducted in all U.S. states and territories and is a collaborative project of CDC and state health departments. The purpose of the survey is to collect uniform data from each state regarding preventive health practices and risk behaviors associated with chronic diseases affecting adults in the nation (CDC, 2008). Public health information obtained from the data is used to measure progress toward meeting national health objectives such as the *Healthy People* 2010 and 2020 objectives. Additionally, survey information is used by states to identify emerging health trends, identify health goals, and formulate health related initiatives, policies, and legislation. The BRFSS 2008 data were collected by a cross-sectional telephone survey. Data collection is conducted throughout the year, thereby, reducing seasonal bias. Further information regarding the dataset is available for public use on the CDC website (http://www.cdc.gov/brfss/).

Sample

The 2008 BRFSS population was based on probability sampling of all households in the U.S. with landline telephones. Probability sampling was conducted in the original dataset by using disproportionate stratified sample (DSS) design (BRFSS, 2008). DSS design ensures a more adequate population representation, and is a type of probability sampling design used "when comparisons are sought between strata of greatly unequal size" (Polit & Beck, 2004, p. 298). BRFSS stratified the sample by units of large groups or clusters (consisting of a 100-number blocks of residential telephone numbers). The BRFSS data are weighted to more adequately adjust for the probability of selection by phone number, number of adults residing in household, and the number of landline phones per home (CDC, 2008). Poststratification adjustments are made by CDC to derive final weight (CDC, 2008).

For this study, a sample was drawn from the randomized population of BRFSS 2008 participants (N=414,507). The BRFSS population consists of civilian, non-institutionalized, adults, age 18 and older who live in the U. S. and its territories (CDC, 2008). The study sample consisted of female adults self-identified as having a past medical history of gestational diabetes (n= 3,700). Two steps were taken to select the study sample of women with hGDM.

The first step was selecting female respondents answering diabetes core questionnaire item 6.1, “Have you ever been told by a doctor that you have diabetes?” with an affirmative response selecting item 2- “yes, but female told only during pregnancy” (variable 87). This resulted in 3700 participants self-reporting hGDM. From the group of 3700, participants were selected based on the availability of data regarding Pap/cervical cancer screening test. The participants were selected who had data available for core question 18.6 “How long has it been since you had your last Pap test?” From that group of 2210, participants were selected based on the availability of data available for optional module question 1.1 “Have you had a test for high blood sugar or diabetes in the past three years?” Based upon these criteria, the final study sample consisted of 1772 women.

The CDC BRFSS dataset provided a large representative sample adequate for hypothesis testing and generalizability. A power analysis using G power (Faul, Erdfelder, Lang, & Buchner, 2007) identified the sample size required to detect a small effect. Because of multiple analyses, the more stringent significance level of 0.01 was selected. The power analysis revealed a minimum sample of 463 participants was needed, based on a beta of .20, alpha of .01, and odds ratio of 1.2. The sample of 1772 women exceeded the minimum size required for analyses.

Measurement Methods

The 2008 BRFSS questionnaire contained three components: (a) the standard core questionnaire which was administered to all BRFSS participants; (b) 17 optional modules, administered at the states’ discretion based on their population needs; and (c) state added

questions (CDC, 2008 overview). The 2008 questionnaire contained fixed-alternative questions containing both dichotomous, multiple-choice, and questions to which participants could select all responses that applied. The questionnaire was available in both English and Spanish. The full questionnaire is available at http://www.cdc.gov/brfss/questionnaires/questionnaires.htm. Interviewers were trained by CDC scientific staff to collect data to reduce response bias and minimize missing data (CDC, 2008).

The original BRFSS data collection was completed by specially trained CDC interviewers via telephone survey. Interviews were accomplished using BRFSS core questionnaire and optional module 1, specified for pre-diabetes awareness. The pre-diabetes optional module was selected for data collection in 28 states (of note: few southern states with high diabetes prevalence rates selected this optional module; southern states using this optional included TX, TN, AL, AZ, NC) (see Appendix A for the questionnaire items used for this research study).

Questions selected for this study were drawn from the original BRFSS 2008 questionnaire. Database variables were recoded into new variables in order to analyze the research questions. Selected questions with recoded variables can be found in Appendix A. Further information regarding the operational definition of variables is presented in Table 4. Participants' self-reported data were primarily represented by nominal and categorical measurement in the original BRFSS dataset. Therefore, the Rao-Scott chi-square test was used to analyze categorical data, design-adjusting for the complex survey sampling method (Rao & Scott, 1981). For analyses using interval level data (i.e. age), independent sample t-tests were computed, adjusting for the sampling method. Data were weighted to adjust for DSS design. Pairwise deletion was applied to deal with missing data for specific variables.

Conceptual and Operational Definitions

Table 4. Conceptual and Operational Definitions of Study Variables

Study Variable	Conceptual Definition	Operational Definition
Education level	Years of formal education, a socioeconomic factor which impacts access to health care and health literacy	Subscale score on BRFSS: Education level (BRFSS core item 12.8, variable 115)
Health insurance	Type of health care payment, a socioeconomic factor which impacts access to health care	Insurance type (BRFSS core item 3.1, variable 80)
Body Mass Index (Obesity)	Body mass index (BMI) level <30 obese and <25 overweight, modifiable factor associated with the onset of diabetes	BMI4CAT (BRFSS core item calculated variables 12.18, column 1263)
Age	Chronological years of life, a non-modifiable factor	Age (BRFSS core item 12.1, variable 101),
Race	Racial heritage, a non-modifiable factor	Race (BRFSS core item 12.4, v 110)
Ethnicity	Hispanic or Non-Hispanic ethnic heritage, a non-modifiable factor	Hispanic ethnicity (BRFSS core item 12.2, variable 103)
Gestational diabetes mellitus life event	Diabetes diagnosed for first time during pregnancy	A past medical/reproductive history of gestational diabetes (core item 6.1, variable 87 code 2)
Primary health screening test	Cervical cancer screening test in the last year	Score on BRFSS (item 18.6 variable 182 code 1)
Secondary health screening test	Glucose screening test in the past three years	(pre-diabetes optional module1, item 1, variable 227)

The reliability of this study was contingent upon the reliability of the original BRFSS data collection process. The evidence supporting the reliability of the original BRFSS data included the use of stringent data collection protocols including a standardized questionnaire, CDC trained telephone interviewers, CDC interviewer performance monitoring, and the employment of the computer-assisted telephone interviewing (CATI) system to collect participant response data. The CATI system decreases measurement error in survey data collection. Data were submitted by states to CDC on a monthly basis for data processing and

quality tracking. The reliability and validity of the BRFSS data quality has been reported in approximately 20 studies according to the CDC (CDC, 2010). Nelson, Holtzman, Bolen, Stanwyck, and Mack (2001) reviewed over 200 studies using BRFSS measures and found high or moderate reliability and validity for the majority of BRFSS core questionnaire measures. More information regarding BRFSS data quality, validity, and reliability is available on the BRFSS website at http://www.cdc.gov/brfss/pubs/quality.htm.

Procedures

The BRFSS dataset was chosen based on the concept/variable selection and data availability. In addition, personal communication with CDC scientists regarding the research questions, GDM unit of analysis, and available population based health surveys contributed to dataset selection and research design (personal communication April 20, 2009 with Patricia Thompson-Reid). Figure 3 displays the process of data selection and preparation. Because the BRFSS data collection included oversampling underrepresented groups, the data for this study had to be weighted to allow for the complex sampling method (Aday, 1996; CDC, 2008).

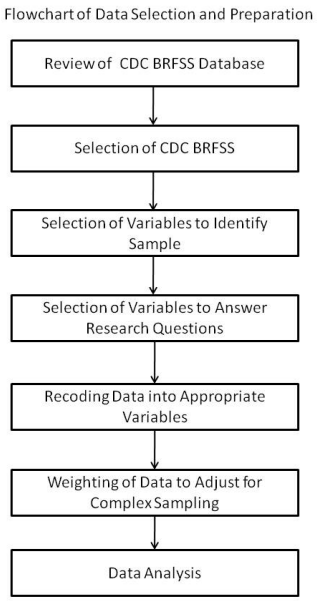

Figure 3. Flowchart of Data Selection and Preparation

Ethical Considerations

Written permission to conduct this study was obtained from the University of Texas at Arlington Institutional Review Board (IRB) (Appendix B). The IRB approved this study as exempt from coverage under the federal guidelines for the protection of human subjects referenced at Title 45 Part 46.101 (b)(4) as the investigation contained neither individual-identifying data nor individual data analyses. Informed consent was obtained from the subjects during the data collection process for the BRFSS.

Plan for Data Analyses

Statistical analyses incorporated estimating procedures due to the complex sampling design that used weighted procedures as described by the National Center for Health Statistics and CDC. Statistical analysis was completed using SAS statistical software, version 9.2 (SAS Institute Inc., 2008). The use of sample survey data allows scientists to gain information regarding a sample drawn from a larger aggregate thereby; more statistically valid population inferences can subsequently be made from data analyses incorporating the complex sampling design (SAS, 2011).

Rao-Scott chi-square test of independence was calculated to determine if there was a significant association between gynecological visits for cervical cancer screening test and glucose test in the past three years. If there was significant association, chi-square tests of independence were employed to examine associations between categorical demographic variables (Tables 5 and 6). To compare the means of the two groups on the continuous variable of age, an independent samples t-test was computed to evaluate evidence of a statistically significant difference. Data preparation, which included checking for outliers and missing data, was completed prior to the analysis as guided by assumptions for chi-square and t-test analysis. Key assumptions for Rao-Scott chi-square test for independence are (a) each observation is independent, (b) the minimum expected frequency for any cell should be 10 or greater, and (c) sample randomization (Pallant, 2007). Homogeneity of variance was assumed for independent

samples t-test (Pallant, 2007). The final sample size used for the investigation of hGDM glucose screening follow-up was (*n*=1,772).

To answer research question #1 regarding the association between gynecologic visits and glucose screening, the procedures described in Table 5 were used. Table 5 includes the identified variables drawn from the BRFSS 2008 questionnaire and codebook.

Table 5. Operational Definitions to Answer Research Question #1

Influencing factor	Specific Variables	Data analysis	Interpretation
Life event history of GDM	Answer of "Yes", to BRFSS Core item 6.1, variable 87 response 2; told "only during pregnancy" "Have you ever been told by a doctor that you have diabetes?" Yes=1; Missing=0	Used to select sample adjusting for the sampling method	
Gynecologic visit for annual Pap/cervical cancer screening test	Answer of "within past year" to BRFSS Core item 18.6 variable 182 " response 1 How long has it been since you had your last Pap test?" response 1 "within the past year" Within past year=1; Other=0	Rao-Scott chi-square Gynecologic visit by Glucose test	If $p < .01$, then a statistically significant difference exists
Glucose screening test in last three years	Answer of "Yes" to BRFSS Optional module 1(pre-diabetes) item 1 variable 227 "Have you had a test for high blood sugar or diabetes within the past three years?" Yes=1, No=0; other responses= missing		

To answer research question #2 regarding differences by demographic characteristics, variables were identified and recoded from the BRFSS 2008 questionnaire and codebook (Table 6).

Table 6. Operational Definitions to Answer Research Question # 2

Influencing factor	Specific Variables	Data analysis	Interpretation
Health Insurance	BRFSS Core item 3.1, variable 80 "Do you have any kind of health care coverage, including health insurance prepaid plans such as HMOs, government plans such as Medicare?" yes,1=1, no, 2=0, ELSE=missing	Rao-Scott chi-square of Glucose testing by Health Insurance as coded	If $p < .01$, then a statistically significant difference exists
Education level	BRFSS Core item 12.8 Variable115 recoded as "What is the highest grade or year of school you completed?" Coded as 1=8th grade or less (elementary) 2=Some high school 3=High school graduate 4= College of any amount	Rao-Scott chi-square of Glucose testing by Education level, adjusting for the sampling method	If $p < .01$, then a statistically significant difference exists

Table 6. continued

Obesity BMI	BMI calculated variable using item 12.18 calculated variable 1263 for each category Category 1-If BMI below 25 Category 2-If BMI 25-30 (overweight) Category 3-If BMI greater than 30 (obese) 1=yes 2=no	Rao-Scott chi-square glucose testing by BMI	If $p < .01$, then a statistically significant difference exists
Age	Item 12.1 AGE variable101 "What is your age?" ___ (age in chronological years)	Independent samples t-test with AGE as the dependent variable and glucose testing as the independent variable	If $p < .01$, then a statistically significant difference exists
Race	Item 12.4 Race Choice Variable 110 "Which one of these groups would you say best represents your race?" White=1; Black =2; Asian=3; Other =4; ELSE=missing	Rao-Scott chi-square of glucose testing by Race, adjusting for the sampling method	If $p < .01$, then a statistically significant difference exists
Ethnicity	Item 12.2 Variable 103 "Are you Hispanic or Latino?" Yes =1; No=0, Any other= missing	Rao-Scott chi square of glucose testing by ethnicity, adjusting for sampling method	If $p < .01$, then a statistically significant difference exists
hGDM and gynecological visit for Pap/cervical cancer screening test in the last year	If DIABETE2=1 and PAPINLASTYEAR=1	This group represents the group compared to others for demographic differences	If $p < .01$, then a statistically significant difference exists

Delimitations

The original BRFSS population included US civilian, non-institutionalized adults aged 18 or older who had land line telephones and agreed to participate in a telephone survey. For this study, the sample included only women with a history of GDM and data for annual Pap/cervical cancer and glucose screening tests. Because the BRFSS questionnaire was developed in English and Spanish, the participants spoke one of these languages and did not include persons who could not speak either of these languages.

Chapter Summary

This chapter provided a summary of the methods and procedures utilized in this study. Characteristics of the BRFSS 2008 setting, sampling plan, instrument, and data management are described. In addition, ethical considerations for the protection of human subjects were presented.

CHAPTER 4

FINDINGS

The results of this secondary analysis derived from the BRFSS 2008 dataset are presented in this chapter. These results provided information regarding whether women self-reporting hGDM and an annual cervical cancer screening test were more likely to have had a glucose screening test in the past three years than other women reporting hGDM. In addition, findings regarding associations among specified demographic characteristics and glucose screening test are presented.

Study Results

Sample Description

Study participants were selected from the BRFSS 2008 dataset. The sample consisted of 1772 women with hGDM and data for Pap/cervical cancer and glucose screening tests. The mean age of the hGDM sample was 38.6 years of age ($Sx = 0.77$). Of the 1772 participants included in this study, only 20 had reported their race. Therefore, it was not possible to analyze or describe the race variable because of the large amount of missing data. Further description of the sample is presented in Table 7.

Table 7. Description of Women with hGDM from the BRFSS 2008 Dataset (*n*=1772)

Variable	Unweighted Frequency	Weighted Frequency	Weighted Percentage
Ethnicity (*n* = 1765)			
Hispanic	148	127922	14.51
Non-Hispanic	1617	753431	85.49
Missing	7		
Education Level (*n* = 1769)			
Elementary	47	24476	2.77
Some high school	93	79428	8.99
High school or GED	451	234220	26.52
Any college	1178	544937	61.71
Missing	3		
Health Insurance (*n* = 1771)			
Yes	1521	745995	84.47
No	250	137204	15.53
Missing	1		
Obesity- BMI (*n* = 1643)			
1	584	294527	35.40%
2	512	268594	32.28%
3	547	268965	32.32%
Missing	74		
Pap Screen (n = 1772)			
Yes	1107	628609	71.15%
No	665	254860	28.85%
Glucose Screening (n = 1772)			
Yes	1173	597375	67.62%
No	599	286095	32.38%

Research Question #1

Among women who a history of gestational diabetes mellitus, what is the association between an annual gynecologic visit which includes a Pap/cervical cancer screening test and receiving a glucose screening test?

H□: There is no relationship between an annual gynecological visit which includes an annual Pap/cervical cancer health screening test and a glucose screening test for DM detection among women who report hGDM.

Rao-Scott chi-square test of independence was computed using SAS statistical software. The assumptions of independent observations and at least 10 per cell were met. The results indicate a statistically significant association between hGDM women who had an annual Pap in the last 12 months and a glucose screening test during the past three years (χ^2 = 11.290, *df*= 1, *p*= 0.0008; Table 8). The odds ratio was 1.997 (95% confidence interval [CI] 1.632 to 2.444) indicating that the odds of having a glucose test (in the past three years) was nearly two times greater if hGDM women had completed an annual Pap/cervical cancer screening test than if they had not completed an annual Pap/cervical cancer screening test.

Table 8. Association of Gynecological Screening and Glucose Testing among Women with a History of Gestational Diabetes Mellitus (*n*=1772)

	Pap Screening*	No Pap Screening*
Glucose Screening	51.51%	16.10%
No Glucose Screening	19.64%	12.74%
Total	71.15%	28.85%

*Percentages are weighted.

Research Question #2

Among women with hGDM and an annual gynecologic visit that includes a Pap/cervical cancer screening, what are the differences in the report of glucose testing by the demographic measures of race, ethnicity, education level, age, BMI, or health insurance?

H□: There are no relationships between the self-report of a glucose screening test and any specified demographic variable including race, ethnicity, education level, age, BMI, and health insurance among the sample of women with hGDM who also completed an annual Pap.

Rao-Scott chi-square test of independence was computed using SAS software for the analysis of each categorical demographic variable while the independent samples t-test was completed for the analysis of age. Assumptions were met for both types of analyses. Only 20 of the 1772 participants responded to the question on race. Therefore, no analyses were conducted for this variable.

There was no significant difference between women who had completed a glucose screening test and those who had not completed a glucose screening test ($\overline{X}$ = 42.70, $\sigma_{x\square}$ = 0.45

versus $\overline{X}$ = 41.81, $\sigma_{x\square}$ = 0.67 respectively). However, the difference was greater than 0.01 or not significant (*t* =-1.07, *p* =0.29).

The Rao-Scott chi-square analysis of differences in glucose screening test related to Hispanic ethnicity revealed no statistically significant difference (χ^2 = 0.1322, *df* = 1, *p*= 0.7162 Table 9).

Table 9. Differences By Hispanic Ethnicity in Glucose Testing among hGDM Women who have had Pap Screening Test (n=1103)

	Hispanic*	Not Hispanic*
Glucose Screening	10.86%	61.48%
No Glucose Screening	3.55%	24.11%
Total	14.40%	85.59%

*Percentages are weighted

The Rao-Scott chi-square analysis of differences in glucose screening test related to educational level revealed no significant differences (χ^2 = 1.52213, *df*= 3, *p*= 0.6774 Table 10).

Table 10. Differences By Education Level in Glucose Testing
among hGDM Women who have had Pap Screening Test (n=1103)

	Elementary*	Some High school*	HS grad or GED*	Some college*
Glucose Screening	1.21%	6.05%	16.38%	48.75%
No Glucose Screening	0.94%	1.80%	8.16%	16.70%
Total	2.15%	7.85%	24.54%	65.45%

*Percentages are weighted

The Rao-Scott chi square analysis of differences in glucose screening test related to BMI revealed no significant differences (χ^2 = 0.6047, *df*= 2, *p*= 0.7391 Table 11).

Table 11: Differences By BMI in Glucose Testing
among hGDM Women who have had Pap Screening Test (n=1033)

	1* BMI<25 Neither overweight or obese	2* BMI 25-30 Overweight	3* BMI > 30 Obese
Glucose Screening	22.90%	23.17%	26.55%
No Glucose Screening	12.07%	9.22%	6.08%
Total	34.97%	32.39%	33.64%

*Percentages are weighted

The Rao-Scott chi square analysis of differences in glucose screening test related to health insurance plan revealed no significant differences (χ^2 = 2.0464, *df*= 1, *p*= 0.1526 Table 12).

Table 12. Differences By Health Insurance in Glucose Testing among hGDM Women who have had Pap Screening Test (*n*=1107)

	Insurance*	No Insurance*
Glucose Screening	65.03%	7.37%
No Glucose Screening	22.93%	4.67%
Total	87.96%	12.04%

*Percentages are weighted

No statistically significant differences in glucose screening tests were found related to any of the demographic variables. The null hypothesis was retained for research question #2.

Chapter Summary

This chapter described the data analyses of associations among 1772 women with hGDM, gynecological care which included cervical cancer screening test, and glucose screening test. There was a statistically significant association between an annual cervical cancer screening test and glucose screening test in the previous three years. There were no significant differences in glucose screening based on any of the specified demographic characteristics including race (for which there was too much missing data), ethnicity, education level, age, BMI, or health insurance.

CHAPTER 5

DISCUSSION

The study results of statistical analyses and the sample descriptive are discussed in this chapter. All major findings are interpreted in conjunction with current literature. Additionally, study limitation, implications, research recommendations and conclusions are presented.

Interpretation of Major Findings

Representativeness of Sample

The sample from the BRFSS dataset rendered a large representative sample of women with hGDM. The few published studies of women with hGDM have focused primarily on glucose screening follow-up at 6 weeks post-delivery as compared to later timeframes. Many of those studies have examined glucose screening among smaller, more homogenous samples. This investigation of glucose screening follow-up included a more diverse, randomized sample of hGDM participants.

The mean age of the women in the study sample was near the fourth decade of life, near the end of the reproductive cycle. Individuals have been reported to be at higher risk for T2DM related to age during the middle years of the lifespan and beyond (Beckles, Thompson-Reid, 2001; CDC, 2007). Thus an analysis of health screenings among this hGDM sample of women at risk related to age was an important group to examine.

The proportion of Hispanic women in this sample was similar to the proportion of Hispanics in the U. S. from 2000 to 2010, which was 12.5 to 15.5% (U. S. Census, 2010). The study sample for which data were available indicated 14.4% of those were of Hispanic/Latino ethnicity. This information was vital as Hispanics, who are at increased risk of developing DM, have increased in number to become the largest minority group in the U.S. population (CDC, 2007; U. S. Census, 2010). In view of the “Hispanic paradox” described by Brown and

colleagues (2007), it would be important to assess glucose screening follow-up and information related to participants' country of origin as well as whether the participants were first, second or third generation immigrants would have been useful to the discussion.

Only 20 of the 1772 participants for which data were available self-reported their race. Unfortunately, the variable for race was unusable due to the large amount of missing data; therefore, it was not possible to compare glucose screening differences of the sample to the population. With the increasing diversity of the U.S. population, reasons for the large amount of missing data in this sample should be explored and discussed with staff at the CDC.

The sample revealed a large proportion (weighted percentage of 61.7%) of college educated participants. Also, a large proportion (87%) of the women reported having health insurance plans although the type of health insurance plan was not examined. This could reflect a relationship between the level of educational attainment and employment with health insurance benefits. Of interest is that, although more than half of the study sample had health insurance, which most likely covered payment for cervical cancer screening tests, 22.93% reported not completing a glucose screening test in the three years preceding their participation in the BRFSS survey. More information is needed related to the phenomenon of missed glucose screening.

The sample characteristic for the BMI variable revealed a little over one-third of the sample were neither overweight nor obese (35.4%), nearly one-third were categorized as overweight (32.28%), and nearly one-third were categorized as obese (32.32%). This finding that over 65% of the women were overweight or obese is cause for concern when there was no statistically significant difference in the rate of glucose screening tests. Overweight and obese women with hGDM are at an increased risk of DM based on their hGDM status as well as their BMI status (CDC, 2010). These findings meant that two-thirds of the participants in the study sample were eligible for screening based on BMI and also eligible for health promotional weight reduction interventions which have been demonstrated to decrease DM onset (HAPO, 2008;

UKPDS, 1998). Further information regarding the sample descriptive is presented in Table 7. A discussion of findings related to the research questions is presented in the next section.

Research Question #1 Findings

Findings from research question #1- *What is the association between an annual gynecologic visit which includes a Pap/cervical cancer screening test and a glucose screening test among women who report hGDM?*

A statistically significant association was identified and the null hypothesis was rejected. The study findings showed that hGDM women in this sample were twice as likely to complete follow-up glucose screening test when an annual Pap/cervical test was completed. One explanation for this finding would be that the gynecological clinical environment was the setting in which the women were originally diagnosed with GDM. It is plausible that an annual Pap/cervical cancer screening test prompts health care providers to review the obstetrical history, identify the history of GDM, and initiate the glucose screening test. Although several reviewed studies revealed suboptimal postpartum glucose testing at six weeks following a hGDM pregnancy experience (Almario, Ecker, Moroz, Bucovetsky, Berghella, & Baxter, 2008; Hunsberger, 2007; Ferrara et al., 2009; Kim, Tabaei, et al., 2006) an annual gynecological visit for the primary screening test for Pap/cervical cancer offers the provider, as well as the client, another opportunity to address the need for secondary glucose screening tests. These findings are consistent with Kelly's conceptual model and research framework (Figure 1 and Figure 2). The ACOG recommendation (2009) that health providers perform a Pap/cervical cancer screening test prior to prescribing hormonal contraceptive could be one motivator for many women to have an annual Pap/cervical cancer screening test. It is also plausible that this could also stimulate more follow-up glucose screening tests among women with hGDM.

Although few studies have examined associations between the two health screening tests, Smirnakis and colleagues (2005) demonstrated a contrast between the number of cervical cancer screening test and the number of glucose screening follow-up tests at six weeks

postpartum among women with hGDM. These authors found an increased number of cervical screening tests were ordered and completed as compared to the number of glucose screening tests. More information is desired regarding this contrast in screening tests as DM imposes an imminent risk of cardiometabolic morbidity and mortality among pre-diabetic and diabetic women even prior to their clinical diagnosis (Gregg, et al., 2007; Hu et al., 2002; Legato, et al., 2006). The finding of an increased likelihood of glucose screening among those hGDM women who complete an annual Pap/cervical cancer screening test in the present study documents an important discovery worthy of further research.

One of the most disturbing findings was that not all women who had been seen in a health care setting for annual gynecological visit had also received a glucose screening test. Of the 1772 women with hGDM for whom data were available, only 67% had received a glucose screening test in the past three years. Despite having access to care, one-third of the women who were not screened represent missed opportunities for implementation of appropriate evidence-based glucose screening tests. Zhang and colleagues (2008) reported missing diagnoses among those with access to health care while Kim, Tabaei, et al., (2006) and other scientists also reported similar missed screening opportunities among women with hGDM.

Although no similar studies were identified in the literature that examined health screenings follow-up among women with hGDM beyond the six-week postpartum period, the finding of a larger proportion of Pap smears as compared to glucose screening tests was consistent with Smirnakis and colleagues (2005) findings. In the present study sample of 1772 participants for which data were available, 71.1% of the sample completed an annual Pap/cervical cancer screening tests while 67.6% completed a glucose screening test in the previous three year period. The next section addresses the findings of research question 2.

Research Question #2 Findings

Findings from research question #2- *Among women with hGDM and an annual gynecologic visit which includes a Pap/cervical cancer screening, what is the difference in the*

report of glucose testing by the demographic measures of race, ethnicity, education level, age, BMI, or health insurance?

No statistically significant differences in the report of glucose screening tests related to the specified demographic characteristics; therefore, the null hypothesis was accepted. This finding was consistent with the literature in that no studies were located in which the rate of glucose screening among hGDM women was influenced by any specified demographic risk characteristic. GDM is a major risk factor for T2DM without any other risk factor. In addition, risk factors such as obesity, which is often associated with insulin resistance beyond pregnancy (Callaghan, 2010; Virjee, Robinson & Johnston, 2001) have not increased the likelihood that the women were screened for glucose. Over one-half of the study participants in the present study were categorized as having a BMI which was overweight or obese; however, this demographic risk did not make a difference in their report of a glucose screening test.

Although a preponderance of literature has documented ethnic minorities, individuals of older chronological age, and those with increased (obese) BMIs are at increased risk of GDM recurrence and T2DM onset, no studies demonstrated the use of two or more risk categories were related to increased glucose screening. This finding was consistent throughout the literature as few studies were identified in which demographic risk factors were utilized to examine glucose screening among hGDM women although, the link between diabetes and race, age, and obesity are evidenced (Buchanan & Xiang, 2005; Chu, Kim, & Bish, 2009).

This study sample represented a high risk group of women that are reported to be seven times more likely to develop T2DM as compared to women who have not had GDM (Bellamy, Casas, Hingorani, & Williams, 2009). Based upon the mean age of this sample, many participants were likely to be within the 5-10 year period following their initial GDM diagnosis. Given that several scientists reported 20%-50% of women with hGDM progress to T2DM within 5-10 years after their initial hGDM diagnosis (Feig, Zinma, Wang, & Hux, 2008; Kim, Newton, & Knopp, 2002), failure to complete glucose screening per evidence-based guidelines is indeed to

be considered a sentinel event as purported by Bottalico, (2007) as well as Nelson, et al., (2008). Further root cause analyses for the lack of screening among hGDM women are needed to examine the sentinel event. Failure to screen this group of women at high risk may represent a lack of understanding of risk severity among health care professionals and hGDM clients. Further research is needed to explore screening barriers experienced by hGDM clients.

Study Limitations

The BRFSS data are useful in minimizing research related time and cost, although self-reported data collected via landline telephones may have posed a study limitation due to recall bias and other biases inherent with self-reported data. The questions used for this study were not of an intimate or confidential nature, thus attenuating the need to give false or socially acceptable answers. The CDC identified limitations inherent in the use of landline telephone surveying because the increasing number of households utilizing only wireless telecommunication services. Lack of landline telephone coverage may be a potential limitation especially among certain racial/ethnic groups at higher risk for diabetes. CDC (2008) reported that they continue to monitor the impact of the changes in telecommunication usage on the validity of using only landline phones.

Only 28 states selected the optional module related to pre-diabetes, thus, limiting generalizability of the findings. Of additional concern was that, of these 28 states, very few were southern states where diabetes is more prevalent (CDC, 2011). Despite these limitations, the sample was large enough to reject the null hypothesis and afforded the researcher an opportunity to explore participant and provider screening behaviors subsequent to GDM.

Additional limitations of the secondary analysis were the wording of the questionnaire; the lack of control over the study population, design, or measurement; and missing data. One example of questionnaire wording that limited the findings was that the question about glucose screening which did not specify the type of glucose screening tests reported by the participants (i.e. fasting, random, oral glucose tolerance test, or HgbA1C). Furthermore, information

regarding the year of pregnancy and delivery were not known thus rendering it difficult to determine whether timing for a secondary glucose screening test was appropriate at the point of data collection. Another example of a questionnaire wording limitation related to the ethnicity demographic questions. For example, the question regarding ethnicity did not differentiate the specific Hispanic country of origin. Knowing the country of origin could be crucial since Mexican Americans are documented as being at greater risk for T2DM as compared to Hispanics of European descent. Additionally, identifying participants' level of acculturation could have illuminated another dimension of information as second and third generation immigrants have often acculturated to an American lifestyle more than first generation immigrants. Due to missing data, only 1772 of the available 3700 hGDM women could be included in the analyses.

Despite these potential limitations, variables for which data were available in the BRFSS 2008 were selected based on the research framework to test associations among this high risk group. The selection of all concepts in the framework was based on a critical review of the literature. Although study limitations were inherent in the use of secondary data, the study findings make an initial contribution to knowledge in the area of gender-specific diabetes screening within gynecological clinical practice settings.

Conclusion

This cross-sectional study was designed to examine the health screening practices of hGDM women beyond the perinatal period. In the large sample of hGDM participants, women were twice as likely to complete follow-up glucose screening test if they had been screened within the past year for cervical cancer thus supporting the research framework. Although limitations precluded some analyses in this study, the women with hGDM who received both health screening tests according to evidence-based standards had more information to guide health promotion decisions. All women with a history of GDM should be afforded similar opportunities for glucose screening as a great deal of evidence documents the natural course of diabetes morbidity (Ruhl, 2009). The need for longitudinal glucose screening is supported by

the literature as well as Ruhl's cardiometabolic model which links increased risk of morbidity over time.

Chronic DM and cardiometabolic disease prevention are a women's health priority among those with hGDM. The risk of cardiometabolic disease is increased among undiagnosed and untreated diabetics (Hu, et al., 2002). Findings from this study revealed the likelihood of glucose screening doubled when an annual primary care cervical cancer screening test was completed. GDM has been identified as a sentinel lifespan event which should afford high risk, pre-diabetic women more comprehensive, evidence-based primary prevention care (Bottalico, 2007; Nelson, Hien Le, Musherraf, & VanBerckelaer, 2008). Many of the 200,000 women diagnosed annually with gestational diabetes receive continue care in the same settings as they received their initial GDM diagnosis (Hunsberger, 2007; Smirnakis, Chasan-Taber, Wolf, Ecker, & Thadhani, 2005). Their reproductive health histories should offer them a foundation for more comprehensive health screenings.

Implications for Nursing

Nursing Practice

Findings from this study identify associations between health screenings in the gynecological health settings. Women's health nurses should be aware of these findings and evidence-based practice guidelines as they encounter hGDM clients. Nurses and nurse practitioners in all settings accessed by hGDM women should be astute to assess opportunities for health promotional interventions, education, and discharge planning related to holistic health screenings. Women often enter reproductive health settings ready to learn, seeking health information to enhance self-care. Postpartum nurses should include follow-up glucose screening reminders for hGDM clients into discharge teaching checklist and materials. Women's health offices should integrate materials from the NIDDK "Small Steps, Big Rewards, Prevent Type 2 Diabetes" and "It's Never too Early to Prevent Diabetes" programs in waiting room areas

to promote GDM client awareness of the need for follow-up glucose screening beyond pregnancy.

Multiple researchers have demonstrated evidence supporting the significant impact professional nurses have on improving the quality of patient outcomes (Aikens, Clark, Cheung, Slone, & Silber, 2003; Brooten et al., 2001; Garcia-Patterson et al., 2003). The likelihood of meeting the Healthy People 2020 goals related to DM could be impacted by screening women with hGDM. Nurses and other health care professionals should assess, educate, and emphasize the importance of ongoing glucose screenings based on evidence based standards among women with hGDM. Glucose screening should be offered to hGDM women along with other gynecological care because of client mobility and fragmented health care services. Some studies have shown efficacy of the use of reminder methods including postal reminders and chart coding to increase postpartum glucose screening rates (Stern, Logan, & Palmer, 2011). Implementation of electronic medical records could also prompt providers to complete evidence-based screenings among hGDM clients.

The increasing incidence, prevalence, and cost of GDM and DM among women with hGDM increase the need for longitudinal glucose screening for early diabetes detection and treatment to prevent further complications. While eradication of diabetes may be unrealistic, early identification and earlier treatment are possible and plausible for reducing the economic burden related to disease treatment for complications among diabetic women. Nurses are central to health care delivery and health promotional interventions among all clients including those with hGDM (Brooten, et al., 2001; Case, et al., 2006; Vonderheid et al., 2003).

Motivated by these findings, appropriate glucose screening follow-up among hGDM women can be increased by application of evidence based clinical guidelines by all primary care health care providers. These clinical guidelines specify a glucose screening test at least every three years subsequent to the history of GDM (ADA, 2010). Clients with more than one risk factor for DM should also be advised to become more actively engaged in health promotional

activities which could also improve glucose balance. The second method to increase the likelihood of ongoing glucose screening would be to increase the number of women returning for an annual gynecological visit which includes Pap/cervical cancer screening test.

Nursing Education

From the study findings and the literature review, it is clear that nurse educators should emphasize continuing education, evidence-based practice currency, and translation of research to practice related to screening among hGDM client. The emphasis on health promotion and prevention should be enhanced in wellness related clinical areas such as in women's health. Undergraduate and graduate nursing students should be taught to use every opportunity to integrate prevention and health promotional interventions into practice. Vonderheid and colleagues (2003) documented clients wanted more health promotional content included in prenatal care. Information related to lactation, good nutrition, postpartum weight reduction, and health screening schedules could be included to address all clients' needs while potentially impacting hGDM client care.

Holistic wellness orientation should include the use of the reproductive health history as a risk assessment tool useful for assessment as well as teaching. Nursing students should be apprised of risk assessments which minimize poor health outcomes within fragmented health care systems while simultaneously integrating health promotional teaching into client care delivery.

Nursing Research

It is conceivable that the information obtained from this analysis could be foundational for replication in subsequent years of BRFSS data. Nurses should increase the number of replication studies to enhance the credibility of these findings while generating further external validity (Burns & Grove, 2011). Further studies of health screenings among hGDM clients are needed beyond the immediate postpartum period.

In addition, qualitative or mixed method research studies among a similar representative sample of women with hGDM could give voice to clients' experiences regarding barriers to glucose screening follow-up. Also, the limitation inherent in secondary analysis and survey questionnaire wording could be overcome through qualitative research studies.

Another area in need of further research is an assessment of provider knowledge regarding current evidence based glucose screening guidelines for hGDM client care beyond delivery. Several scientists reported a need for further provider continuing education (Almario, et al., 2008; Hunsberger, 2007; Hunt, Logan, et al., 2010). Nurses as well as other health care professionals should be updated regarding the latest DM evidence. In addition, there is a need for more involvement of highly educated nurses on research teams (Case et al., 2006).

It is reasonable that an annual Pap/cervical cancer screening test could prompt providers to review the obstetrical history, identify the hGDM status, and initiate the glucose screening test. The ACOG recommendation that health providers perform a Pap/cervical cancer screening test prior to prescribing hormonal contraceptive is a motivator for many women to have an annual Pap/cervical cancer screening test (ACOG, 2009).

Although this study focused on long-term maternal outcomes, future research could also focus on screening needs of the children born to women with hGDM who are also documented as being at risk for childhood obesity and early DM development (Metzger, 2007; NIH News, 2006). It is important to break the cycle of diabetes among all affected by hGDM. However, no evidence based guidelines regarding glucose screening have been developed currently for this group of individuals at diabetic risk.

Chapter Summary

Findings from this study of health screenings beyond the history of hGDM demonstrate an associative relationship between an annual Pap/cervical cancer screening tests and follow-up glucose screening tests among this vulnerable population of women at DM risk. Although there were no associative relationships found in health screenings based on any specified

demographic characteristics, literature documents the increased risk of T2DM onset, thus clinicians should screen all hGDM clients especially when there is more than one risk factor for DM. Screening cost has been documented as being more cost effective than the cost of DM related complication care (Kim, Herman, & Vijan, 2007; Raikou & McGuire, 2003). Findings from this study revealed missed opportunities to screen hGDM clients over the life course. Since women are often diagnosed with diabetes risk earlier in the lifespan than men are diagnosed and their health outcomes are often worse, hGDM women should be afforded opportunities for earlier glucose health screenings and more aggressive interventions to ameliorate their risk of cardiometabolic morbidity while thereby also reducing reported gender disparities (AHRQ, 2006; Gregg, Gu, Cheng, Narayan, & Cowie, 2007; Legato et al., 2006; Wilson et al., 2007). Further research is needed to explore gender-specific DM health screening differences. Yet, findings from this study indicate glucose health screening follow-up among hGDM women is increased when examined in the context of annual gynecological well-woman care. This finding holds potential for earlier diagnosis and improve health outcomes among women at increased risk for DM morbidity and mortality.

APPENDIX A

STUDY QUESTIONNAIRE

Revised BRFSS 2008 Questionnaire

BRFSS 20008 Items Measuring Independent Variables

Socioeconomic status factors

Item 12.8 Education level
What is the highest grade or year of school you completed?
1-Grade 1 through 8 (elementary)
2-Grades 9-11 (some high school)
3-Grade 12 or GED (high school graduate)
4-College 1 year to 4 years (recoded to include any college)

Item 3.1 Insurance
Do you have any kind of health care coverage, including health insurance prepaid plans such as HMOs, or government plans such as Medicare?
1-yes
2-no
ELSE= missing

Modifiable risk factors

Item12.18 Three categories of BMI (calculated variables)
Category1- if BM neither overweight or obese< 25
Category2- if BMI overweight 25-30
Category3- if BMI obese < 30
1=yes
2=no

Non-modifiable risk factors

Item 12.1 Age
What is your age?
____ ____

Item12.4 Race
Which one of these groups would you say best represents your race?
White
Black or African American
Asian
Other (Native Hawaiian or other Pacific Islander, American Indian, Alaska Native, Other)

Item 12.2 Are you Hispanic or Latino?
Yes
No

Life event

Item 6.1 hGDM
Have you ever been told by a doctor that you have diabetes (If "Yes" and respondent is female, ask "Was this only when you were pregnant?"
(Yes, but female told only during pregnancy)

Primary prevention

Item 18.6 Last Pap
How long has it been since you had your last Pap test?
(Last 12 months)

BRFSS 20008 Items Measuring Dependent Variable

Secondary Prevention (from Optional Module 1 Pre-Diabetes awareness question)

Item 1 Have you had a test of high blood sugar or diabetes in the past three years?
Yes 1=1
No 2=0
Else = missing

APPENDIX B

UTA INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

THE UNIVERSITY
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May 25, 2011

Johnnetta Kelly
Dr. Jennifer Gray
College of Nursing
Box 19407

Protocol Title: *Health screening beyond a history of gestational diabetes mellitus: A secondary analysis of the behavioral risk factor surveillance system data 2008*

RE: Exempt Approval Letter

IRB No.: **2011-0558e**

The UT Arlington Institutional Review Board (UTA IRB) Chair (or designee) has reviewed the above-referenced study and found that it qualified as exempt from coverage under the federal guidelines for the protection of human subjects as referenced at Title 45 Part 46.101(b)(4). You are therefore authorized to begin the research as of May 23, 2011.

Please be advised that as the principal investigator, you are required to report local adverse (unanticipated) events to this office within 24 hours. In addition, pursuant to Title 45 CFR 46.103(b)(4)(iii), investigators are required to, "promptly report to the IRB ***any*** proposed changes in the research activity, and to ensure that such changes in approved research, during the period for which IRB approval has already been given, are **not initiated without IRB review and approval** except when necessary to eliminate apparent immediate hazards to the subject."

All investigators and key personnel identified in the protocol must have documented Human Subject Protection (HSP) Training or *CITI Training* on file with this office. The UT Arlington Office of Research Administration Regulatory Services appreciates your continuing commitment to the protection of human research subjects. Should you have questions or require further assistance, please contact Robin Dickey at robind@uta.edu or you may contact the Office of Regulatory Services at 817-272-3723.

Sincerely,

Patricia Turpin

Digitally signed by Patricia Turpin
DN: o=The University of Texas System, ou=The University of Texas at Arlington CA, ou=www.verisign.com/repository/CPS Incorp. by Ref.,LIAB.LTD(c)99, cn=Patricia Turpin, email=pturpin@uta.edu
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BIOGRAPHICAL INFORMATION

The author, a registered nurse and family nurse practitioner, has practiced for three decades in multiple settings, including women's health, neonatal, and medical-surgical nursing. Additionally she has worked in various roles including staff nurse, nurse manager, mid-level provider, and nurse educator. Her academic preparation include an A.S. degree in nursing from the University of AR at Little Rock, 1975; a B.S.E. in health education from the University of AR at Little Rock, 1981; a M.N.Sc., with Family Nurse Practitioner role concentration from the University of AR for Medical Sciences in Little Rock, 1995. Her nursing experiences as a women's health nurse, family nurse practitioner, and a certified nurse educator led her to pursue a PhD degree in nursing. The emphasis of her PhD was focused on preparing academic nurse educators to assist students to care for diverse and vulnerable populations. Her clinical interest in high risk women's health care, health disparities, and women's health promotion led to this investigation of diabetes screening follow-up among a vulnerable population of women with a history of gestational diabetes. She is interested in diabetes research translation and nursing education research.

Her primary care experiences, research interest, and role in academia will be utilized to disseminate new knowledge, educate future nurse professionals, and to continue professional nursing service among women's health clients. She is an associate professor at Harding University Carr College of Nursing in Searcy, AR. She is also a member of the National League for Nursing (NLN) and has served as a member of NLN committees including the Diversity Task Group and presently serves as a commissioner with the NLN certified nurse educator program. Additionally, she is a member of the nursing honor society, Sigma Theta Tau International, Epsilon Omicron chapter and the American Nurses Association.