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# Patient Web Portal Use Among Women with Gestational Diabetes

Megan Anderson

*University of Wisconsin-Milwaukee*

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PATIENT WEB PORTAL USE AMONG WOMEN WITH GESTATIONAL DIABETES

by

Megan M. Anderson

A Dissertation Submitted in  
Partial Fulfillment of the  
Requirements for the Degree of

Doctor of Philosophy  
in Nursing

at

The University of Wisconsin-Milwaukee

May 2017

## ABSTRACT

### PATIENT WEB PORTAL USE AMONG WOMEN WITH GESTATIONAL DIABETES

by

Megan M. Anderson

University of Wisconsin-Milwaukee, 2017  
Under the Supervision of Professor Dr. Jennifer Doering

*Background:* The prevalence of gestational diabetes mellitus (GDM) continues to increase. Research suggests that adverse maternal and newborn outcomes increase in relation to the mother's elevated blood glucose levels. Diabetes researchers discuss that utilizing information technology for self-management, particularly Internet-based modes of delivery, may result in individual improvements in diabetes outcomes. Scant research exists on the use of Internet-based tools such as patient web portals (PWP) for GDM self-management and outcomes.

*Purpose:* The purpose of this study was to examine PWP use in women with GDM. Specific aims of this study included: 1) compare the characteristics of nonusers and users of a patient web portal (PWP) for self-management including relationships between characteristics and PWP use, 2) in users of the PWP, describe the frequency and patterns of PWP use, and 3) compare glycemic control between PWP users and nonusers.

*Methods:* A retrospective study was conducted using electronic health record (EHR) review of PWP users (n=91) and nonusers (n=67) who sought care in a diabetes and pregnancy clinic for GDM management.

*Results:* PWP users were more likely to be employed fulltime than nonusers ( $p = .011$ ). There were no statistically significant differences between users and nonusers for the other patient characteristics. Most users accessed the PWP each month in the third trimester but the

number of days accessed varied greatly. The AVS [24.31 (SD 25.05)] and appointment reminders [15.44 (SD 17.00)] were accessed most frequently. Glycemic control did not differ significantly between users and nonusers ( $F(1.520, 191.474) = 184.428, p=.559$ ).

*Discussion:* This research provides insight into the patient characteristics of users and nonusers of a PWP for a non-chronic condition (GDM) and outlines the features of the PWP used. Patient web portals should be further stringently evaluated for their usability in this population of patients including facilitators and barriers to its use as well as dosage of utilization.

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## DEDICATION

This dissertation is dedicated to

Scott, Ben, Ian, Nathan, & Maya

To my amazingly supportive husband, Scott, this would not have been possible without you. Your ongoing support and encouragement kept me going in times when I wasn't sure I would succeed. You never stopped believing in me.

To my wonderful children Ben, Ian, Nathan, and Maya, I hope I have inspired you to set your goals high, work hard, and persevere.

Finally, to my parents, who never stop parenting me. Thank you for your unwavering love, your words of advice, and your ongoing support.

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## **Chapter 1**

### **Background/Problem Identification**

The prevalence of gestational diabetes mellitus (GDM) in the United States is as high as 9.2% according to a recent analysis performed by the Center for Disease Control and Prevention, and it has more than doubled since 1990 (DeSisto, Kim, & Sharma, 2014; Gethun, Nath, Ananth, Chavez, & Smulian, 2008). Research suggests that GDM may be associated with multiple pregnancies, obesity, sedentary lifestyle, insufficient sleep, and high maternal age at time of pregnancy (Kim et al., 2010; Qiu, Enquobahrie, Frederick, Abetew, & Williams, 2010).

The 2010 International Association of Diabetes and Pregnancy Study Group's (IADPSG) new screening guidelines revised the criteria for diagnosing GDM, to using a single fasting 75 gram 2-hour oral glucose tolerance test (OGTT). GDM rates are rising while the debate continues on whether evidence supports the IADPSG's new screening guidelines versus the traditional two step screen (e.g. a non-fasted one-hour, 50-gram test followed by a 3- hour, 100 gram OGTT). The new guidelines have the potential for the identification of women with GDM to nearly double (Metzger, 2010).

Gestational diabetes mellitus is unique in the sense that it is a condition that can adversely affect both the mother and the unborn baby. Newborns of mothers with poorly controlled GDM have higher rates of macrosomia, birth injuries such as fractures or nerve damage, and respiratory complications (Alwan, Tuffnell, & West, 2009). Infants born to mothers with GDM are also at increased risk for obesity and type 2 diabetes during childhood or adolescence (Ferrara et al., 2004). Mothers with poorly controlled gestational diabetes mellitus are at increased risk for cesarean delivery, preterm delivery, and preeclampsia (Bellamy, Casas, Hingorani, & Williams, 2009; Langer, Yogev, Xanakis, & Brustman, 2005). Women with GDM

are 2 to 3 times more likely to develop GDM with subsequent pregnancies and have a 7 times greater risk of developing type 2 diabetes later in life (Bellamy et al., 2009). Furthermore, there is a 2 to 3 times higher morbidity rate for women and their newborns when GDM is not adequately managed (Langer et al., 2005).

Conversely, when GDM is diagnosed in a timely manner and well managed, the maternal, fetal, and newborn health risks are reduced (Carolan, Gill, & Steele, 2012). Gestational diabetes is typically diagnosed between 24 and 28 weeks of pregnancy providing a short time (roughly 3 months) for these women to learn about their diagnosis and participate in health management of their diabetes to optimize outcomes and reduce adverse effects. GDM management plans typically consist of goal-setting for dietary modifications, exercise, and blood glucose monitoring (Hoffman, Nolan, Wilson, Oats, & Simmons, 1998). Results from the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study found that adverse maternal, fetal, and neonatal outcomes rise in relation to the mother's elevated glucose levels (Metzger, Lowe, Dyer, Trimble, Chaovarindr, & Coustan, 2008). Therefore, the goal of treatment is to maintain blood glucose levels within recommended ranges, which is accomplished through rigorous self-management of blood glucose testing, exercise, and dietary adjustments (Carolan, 2015; Hoffman et al., 1998). Women who are not able to maintain blood glucose levels within the target ranges with diet therapy and exercise may need insulin to control their GDM. The goal of insulin therapy in addition to diet therapy and exercise is to achieve glucose profiles similar to those of non-diabetic pregnant women (Moore, 2016).

A key component to GDM treatment and self-management is education. Education is time intensive for the healthcare team. Research suggests that health care information can be effectively communicated through the use of information technology by providers and nurses

thus; providing an additional mode of nurse/patient communication for care delivery (Jackson, Boren, Brancati, Batts-Turner, & Gary, 2006).

People who actively seek to learn about their health and attempt to manage their health are more likely to participate in healthy behaviors, engage in self-management of their health, have higher satisfaction, and achieve better health outcomes (Hibbard & Greene, 2013; Ricciardi, Mostashari, & Murphy et al., 2013). Patient web portals (PWP) are a part of electronic health records (EHR) that have shown to be a successful tool among a wide range of patients including women, those with chronic conditions, and potentially those with lower income (Ancker et al., 2011; Emont, 2011; Kruse, Bolton & Freriks, 2015; Lam et al., 2013; McMahon et al., 2005). The success of patient portals have gained the attention of the United States (US) Centers for Medicare and Medicaid Services (CMS) and are now part of the meaningful use measures for their EHR incentive programs for eligible professionals and hospitals (CMS, 2016).

Diabetes research suggests that utilizing information technology for care and self-management, particularly Internet-based modes of delivery results in individual improvements in diabetes clinical outcomes and quality of care (Kwon et al., 2004; McMahon et al., 2005; Meigs et al., 2003; Quinn et al., 2008). Specifically, studies of individuals with type 1 and type 2 diabetes who use a patient web portal (PWP) experience lower HgbA1c levels and lower blood pressure over time than individuals not using a PWP (Fonda, McMahon, Gomes, Hickson, & Conlin, 2009; McMahon et al., 2005; Quinn et al., 2008). While PWPs have been evaluated in persons with type 1 and type 2 diabetes their usefulness in patients with GDM has not.

Studies related to GDM note the desire for improved access to effective education and care delivery using a participatory model which includes chat rooms, message boards, and other

forms of technology (Nolan, McCrone, & Chertok, 2011). Furthermore, a study by Kaptein et al. (2014) points to the need to provide education and care to this population that minimizes travel and time commitments. Patient web portals potentially offer an effective care delivery and self-management tool that may minimize travel and time. Only one study exists in the literature on the use of a PWP for GDM self-management (Carolan, Steele, & Krenzin, 2015).

Identifying the differences between PWP users and nonusers could provide information to target and support nonusers in becoming more active in their diabetes self-management. Variations exist within the literature on definitions and categories of users and nonusers of PWPs (Ronda, Dijkhorst-Oei, & Rutten, 2015; Sarkar et al., 2011; Weingart, Rind, Tofias, & Sands, 2006; Yamin et al., 2011). For the purposes of this study nonusers will apply to subjects who log in only once. Users will be classified as either short-term users or persistent users. Short-term users are women who log in only during the first month after enrollment only. Persistent users are those who login throughout the third trimester.

In addition, the results of this study could assist organizations with future updates and revisions to PWPs for GDM management. Effective GDM self-management interventions have the potential to reduce adverse outcomes for mothers and babies during pregnancy and later in life. Patient web portals also have the potential to address some of the barriers to GDM self-management as identified by patients related to travel and time and may decrease health care costs. Keeping in line with Roger's Diffusion of Innovation Theory, this research can contribute to the body of knowledge related to early adopters of PWP use and the laggards or non-adopters so future modifications can be tailored to meet the needs across all levels of adopters (Sahin, 2006).

## **Purpose**

The purpose of this study was to examine patient web portal (PWP) use in women with gestational diabetes mellitus (GDM).

## **Specific Aims**

In women with gestational diabetes:

***Aim 1:*** Compare the characteristics of nonusers and users of a patient web portal (PWP) for self-management including relationships between characteristics and PWP use/nonuse.

***Aim 2:*** In users of the PWP, describe the frequency and patterns of PWP use.

***Aim 3.*** Compare glycemic control between PWP users and nonusers.

## **Theoretical Framework**

The Individual and Family Self-Management Theory (IFSMT) by Ryan and Sawin (2009) was the theoretical foundation of this study. This theory was chosen for several reasons. The IFSMT suggests applicability beyond chronic conditions and has been utilized in studies on health promotion and prevention including osteoporosis prevention and postpartum fatigue (Doering, 2013; Ryan & Sawin, 2009). Furthermore, the theory is comprehensive and maps well to the variables being studied. The major components of the IFSMT focus on risk and protective factors, which align with the patient characteristics of this study as well as the condition complexity. Likewise, the patient web portal (PWP) applies to the process domain of the IFSMT. Finally, glycemic control relates to the IFSMT as an outcome.

It should be noted that the intent of this study was not to examine the process of self-management rather to determine the patient characteristics (context) of users and nonusers of a PWP for gestational diabetes mellitus (GDM) self-management. The study explored the



frequency and patterns of PWP use over the last trimester of pregnancy. Specific features of the PWP that were measured included flowsheets, lab results, medication refills, secure messaging, appointment reminders, and patient instructions all of which relate to the process domain of the IFSMT. Finally, the relationship between PWP use and glycemic control, an outcome, in the IFSMT, was measured by percentage of blood glucose levels within target range. Figure 1 outlines the relationship of this study's variables to the IFSMT. The model in figure 2, which guides the study, includes three major dimensions based on the IFSMT model: Content, Process and Outcome. The variables for this study are organized into one of these three categories.

## **Context**

According to the IFSMT (Ryan & Sawin, 2009), the context dimension is defined by risk and protective factors including condition-specific factors, physical and social environments, and individual and family characteristics. Condition specific factors are structural, functional, or physiological characteristics of the condition or treatment and may include complexity of the condition.

**Condition specific factors.** Condition specific factors in this study were type of GDM (diet controlled or insulin), number of pregnancies with GDM, and BMI. The physical and social environment of the context dimension pertains to the physical and social factors that are barriers or facilitators to self-management. Examples of these factors, as outlined by Ryan and Sawin (2009), are access to healthcare, culture, and social capital. Race, ethnicity, marital status, employment, and health insurance were patient characteristics examined in this study that fit into the physical and social environment construct. The third and final construct of the context dimension are the individual and family characteristics. These are characteristics of the individual or family that could promote or inhibit self- management. Age is included as a

variable in this construct. Table 1 provides a visual of the variables for the study as they relate to the constructs and concepts of the IFSMT.

## **Process**

The process domain of the IFSMT encompasses the Integrated Theory of Health Behavior Change (ITHBC) model and includes knowledge and beliefs, self-regulation skills and abilities, and social facilitation (Ryan & Sawin, 2009). First, knowledge consists of factual information related to the specific condition and beliefs refer to the personal perceptions about the health condition or health behavior. Secondly, self-regulation is used to alter health behavior and includes goal setting, self-monitoring, decision-making, and management of responses associated with health behavior change. Self-regulation is defined as a process people use to incorporate a behavior change into their routine. Finally, social facilitation incorporates social support, social influence, and collaboration between individuals, health care providers, and families (Ryan and Sawin).

**Application of IFSMT to this study.** The patient web portal (PWP) in this study functions as the intervention, which may or may not influence the process dimension of the IFSMT. A PWP provides access to parts of the electronic health record (EHR). It is hypothesized that users of the patient portal will experience better glycemic control as measured by a higher percentage of blood glucose numbers within target range. Patient portals vary in their functionality but according to the National Learning Consortium and HealthIT.gov (2013), patient portals typically allow patients to check lab and test results, review health information, communicate to their health care team, access educational resources, request medication refills, issue appointment reminders, and handle other tasks such as entering in and monitoring blood sugar values.

The PWP in this study has the features listed above and are incorporated into Table 2 to outline its relationship to the process concepts of the IFSMT. For example, self-monitoring was measured through frequency of entering and reviewing blood sugars in the blood sugar log, reviewing lab results, and engaging in behavior to request medication refills using the PWP. The medication refills could also apply to decision-making. Social support was measured through the frequency of email communication to the healthcare team using the PWP. Finally, knowledge was measured through review of educational information on the PWP from the after visit summaries and flow sheets.

## **Outcomes**

The IFSMT (Ryan & Sawin, 2009) defined outcomes as proximal or distal. The proximal outcome is engagement in self-management behaviors to manage a condition or symptoms and pharmacological therapies. Distal outcomes include health status as defined by prevention, attenuation, stabilization, or worsening of a condition; quality of life; and direct and indirect costs.

**Outcomes of this study.** Proximal outcomes were not measured in this study because of the retrospective nature of the study and the inability to measure the full conceptual definition of PWP use which includes frequency and time spent in each feature of the PWP. Future research could incorporate the full conceptual definition of PWP use and potentially measure it as a self-management behavior. The distal outcome variable in this study was glycemic control as measured by percentage of blood glucose levels within target range. This is an indicator of health status and determines stabilization or worsening of GDM.

## Conceptual and Operational Definitions

This section provides conceptual and operational definitions relevant to this study.

**Gestational Diabetes.** Gestational diabetes (GDM) was defined as glucose or carbohydrate intolerance with onset or first diagnosis during the pregnancy (Carolan, Steele, & Margetts, 2010; Hui, Sevenhuysen, Harvey, & Salamon, 2014 ). Women who develop type 1 diabetes or who have undiagnosed type 2 diabetes that is verified during pregnancy are diagnosed with GDM (Nolan et al., 2011). It is a transient condition that can have serious adverse outcomes for mother and baby (Carolan, Steele, & Margetts, 2010).

**Glycemic control.** Target blood glucose levels were measured using the percentage of blood sugars reported each month within target range per subject. Target blood glucose levels were identified as less than 125 mg/dL for fasting and two hours post-meal (Moore, 2016).

**Self-management.** Self-management is a dynamic phenomenon consisting of context, process, and outcomes (Ryan & Sawin, 2009). Individual and family self-management includes the integration of health-related behaviors into a person and/or family's daily functioning (Ryan & Sawin, 2009).

**Electronic Health Record (EHR).** According to the National Alliance for Health Information Technology (2008) an EHR is an electronic health-related record on an individual that meets nationally established interoperability standards and that can be created and managed by staff across more than one healthcare organization. The Healthcare Information and Management Systems Society (HIMSS) adds that the EHR is a longitudinal electronic record of patient's health information gathered from sources such as office visits, hospital encounters, problem lists, medications, and allergies (HIMSS, 2016). Most EHRs today include patient demographics, financial information, lab and diagnostic results, medications, allergies, problem

lists, and clinical documentation (Seckman, 2014). Standards for EHRs were first developed in 2003 by the EHR Collaborative, under the direction of the U.S. Department of Health and Human Services (Seckman, 2014)

**Patient web portal (PWP).** An electronic personal health record that directly links to an EHR is referred to as a patient web portal (Irizarry, DeVito-Dabbs, & Curran, 2015). The operational definition of the PWP was the study organization's PWP, Epic MyChart. MyChart acts as the point of entry for all features of the PWP at this health care institution. More information on the functionality of MyChart is discussed in Chapter 3.

**Patient web portal use.** Patient web portal (PWP) use is not clearly defined in the literature. Some define it as the amount of time spent in the PWP and the frequency of use or log-in (Fonda et al., 2009). Others take a more comprehensive approach capturing frequency, consistency, and duration in their definition of PWP use (Jones, Weiner, Shah, & Stewart, 2015). The operational definition for pattern of use in this study included frequency and consistency. Duration was unable to be captured in this study and is noted as a limitation. Frequency was the utilization of PWP features from first appointment in the diabetes in pregnancy clinic to the time of delivery. It includes the PWP features accessed and the number of hits on each feature over the study period. Consistency captures the distribution of PWP use over the study period and was measured in hit days and hit months. Hit day was any day that the patient accessed the PWP in the third trimester regardless of the number of times accessed that day or features accessed. Hit month captured any individual month where the patient accessed any feature of the PWP at least once.

**Patient portal users and nonusers.** For the purposes of this study nonusers applied to subjects who logged in only once. Short-term users were women who stopped logging in after

the first month of enrollment. Persistent users were users that logged in throughout the third trimester.

### **Assumptions**

- 1) PWP use reflects an aspect of self-management (Ryan & Sawin, 2009).
- 2) PWP users have access to a computer and the technical skills to adequately navigate the PWP.
- 3) PWP users enter accurate information into the PWP and interpret PWP information accurately.

### **Significance**

#### **Practice**

Nurses represent one of the largest groups of EHR users therefore; their perspective is vital to current and future technology success (IOM, 2010; Seckman, 2014). Provider and clinician endorsement and continued use of PWP are key factors in a patient's decision to use a PWP (Logue & Effken, 2012; Wald, Businger, Gandhi et al., 2010). Knowledge of PWP and support of its use by nursing is crucial to the sustainability of this technology since nurses often are a key source of patient portal activation.

This study contributes to the knowledge of nursing practice as it relates to PWP by describing the patient characteristics of users versus nonusers of this technology for GDM self-management. This has the potential to better inform nursing on the similarities and differences of users and nonusers of PWP so future modifications to PWP can occur to either engage the nonusers or tailor patient education to meet the needs of these patients. This study also reveals the frequency by which specific features of the PWP were accessed and the patterns of use. This could prove valuable in providing insight on the key elements of PWP for self-management.

This and future studies could determine if there are certain features of a PWP that should be included in all PWP in order to work towards determining national standards for PWP or if variations should exist to meet the needs of specific populations and conditions.

PWPs are a form of technology that applies to nursing informatics. Nursing informatics is identified as and has been recognized as a specialty by the American Nursing Association (ANA) since 2001 (ANA, 2001). Nurse informaticists have the ability to guide PWP engagement through their design and evaluation, determining what is relevant and user-friendly for portal users. This research can add to the nursing body of knowledge as it pertains to GDM PWP use.

### **Theory**

This study contributes to theory by utilizing and building upon concepts within Ryan and Sawin's IFSMT (2009). While the tenets of the IFSMT are not tested, the variables of this study represent the context, process, and outcomes domains of the Ryan and Sawin (2009) theory and this theory guided this study. This study extends the use of the IFSMT theory beyond chronic conditions into a more acute realm that is unique to pregnancy. Furthermore, it tests the utilization of a technology tool to aid in self-management. While this study does not determine if there is a direct correlation between PWP use/engagement and improved glycemic control, it provides some insight into the patient characteristics of PWP users and nonusers and guides future research that can further explore this relationship. This could subsequently inform future research about whether PWP use contributes to self-management.

### **Research**

Meaningful Use, EHRs, and PWP continue to evolve. The HITECH Act of 2009 and Meaningful Use incentives have accelerated EHR adoption and they have been the major drivers for PWP adoption (Gibson, 2014; Irizarry et al., 2015). It is clear that PWP use will continue to

be an integral part of the EHR and a means to meet Meaningful Use incentives in the foreseeable future. What is less clear is the population who will most likely benefit from these portals. Some research has been conducted on the positive impact of patient portals relative to chronic disease management such as cardiac disease or diabetes (McMahon et al., 2005; Quinn et al., 2008; & Fonda et al., 2009). There has been little research on more acute conditions or preventative management of health.

This research aims to provide insight into the patient characteristics of users and nonusers of a PWP for GDM self-management and outline the features of the PWP used and patterns of use. This research contributes to the increasing body of knowledge related to PWP use for a unique population that is non-chronic care related.

## **Policy**

This study has the potential to influence policy on several levels. At a local level it may influence policy at this health care organization. At a broader level, this study may contribute to the body of knowledge related to Meaningful Use. Stage 3 of the CMS EHR incentive program for Meaningful Use is scheduled to begin in 2017 and focuses on outcomes. The third stage is the use of EHR data to improve health outcomes, quality, safety, efficiency, and population health at the national level. The EHR will likely focus on self-management and shared management of health care including increased use of PWPs (Gibson, 2014; HealthIT, 2013).

There are several Meaningful Use measures that directly relate to the functionality of a PWP including (1) secure messaging, (2), clinical summary after each visit, (3) patient specific education, (4) patient reminders, (5) access to personal health record information, and (6) medication reconciliation (Ahren, Woods, Lightowler, Finley, & Houston, 2011; Irizarry et al., 2015). However, policy makers have yet to define the minimal criteria of a PWP and the



principles for an ideal PWP as they have for an EHR. This clarity will be necessary for future research and advancement of this technology.

This study addresses the specific patient characteristics of users and nonusers of a PWP for GDM self-management. If an expectation of Meaningful Use is to engage 5% of patients in the use of PWPs, it is essential that we understand the patient characteristics of users and nonusers (Irizarry et al., 2015). Understanding the differences between users and nonusers provides an avenue for future research on how to better tailor PWPs to convert nonusers to users before health policy dictates a certain practice. Finally, the research findings may point to patient characteristics such as insurance type, co-morbidities, or type of GDM that should be understood before financial incentives or penalties are instituted through Meaningful Use for this population.

### **Chapter Summary**

This chapter proposes a study to fill a gap in the literature on the effective GDM management and e-strategies to promote GDM self-management using PWPs. Studies exist demonstrating a relationship between the use of PWPs and improvements in hemoglobin A1c (HgA1c) in type 1 and type 2 diabetes however; only one study exists for GDM (Carolan, Steele, & Krenzin, 2015; McMahon et al., 2005; Quinn et al., 2008).

The study purpose and research questions were outlined in this chapter. The theoretical framework for the study was explained along with rationale and illustration of the link between the study variables and the IFSMT. In addition, study concepts were defined and assumptions discussed. Finally, the significance to nursing practice, theory, research, and policy was explained and expected limitations were discussed.

## **Chapter 2**

### **Review of Literature**

The layout of this chapter is structured to provide the reader with an in depth look at the literature on gestational diabetes, self-management, and patient web portals. The chapter begins with an overview of GDM including pathophysiology, diagnosis and management, and maternal, fetal, and newborn effects. Next, literature is reviewed on self-management in general and then more specifically related to GDM self-management. The final section of this chapter discusses EHR technology, specifically the use of PWPs, their functionality, their role in self-management with other conditions, and the overall proposal to study this technology for GDM self-management.

Information in this literature comes from electronic searches of computerized databases, journals, and texts. EBSCOhost Research Database, PubMed, Google Scholar, The Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Cochrane Database of Systematic Reviews were the databases used for this literature review. Other non-peer reviewed publications such as HealthIt.gov and Health Information Management Systems Society (HIMSS) were used for context and specific examples relative to PWPs.

The following search terms were employed to capture the literature: “patient web portals”; “e-health and gestational diabetes”; “patient web portals and diabetes”; “gestational diabetes self-management”; and “self-management”. Bibliographies and literature reviews from identified articles were used to identify additional studies. All publications were published in English. The publications ranged from 1976 through 2016. The earlier publications were used in reference to the physiology and diagnosis of GDM while more recent literature was referenced in terms of PWPs due to the rapidly evolving technology.

## **GDM**

Gestational diabetes mellitus (GDM) is the most common medical complication in pregnancy (Carr & Gabbe, 1998). The prevalence of GDM in the United States is as high as 9.2 percent according to a recent analysis performed by the Center for Disease Control and Prevention (DeSisto, Kim, & Sharma, 2014) and is projected to increase in the future. GDM is a result of insulin resistance and impairment of insulin secretion (American Diabetes Association [ADA], 2016). The identification and treatment of women with GDM is important to not only prevent perinatal morbidity but also improve long-term outcomes for mothers and their children.

### **Pathophysiology**

There are many metabolic changes that occur in pregnancy to support the growing fetus. For example, early in pregnancy, maternal estrogen and progesterone increase, which result in pancreatic  $\beta$ -cell hyperplasia and increased insulin release (Kuhl & Holst, 1976). As pregnancy progresses, increased levels of progesterone, estrogen, and other hormones lead to insulin resistance in peripheral tissues, which causes the pancreas to release more insulin to respond to the insulin resistance (Carr & Gabbe, 1998). Patients with normal pancreatic function are able to meet the increased demands however; patients with altered pancreatic function have difficulty increasing insulin secretion and therefore produce inadequate levels of insulin. GDM occurs when there is delayed or insufficient insulin secretion in the presence of increasing peripheral resistance (ADA, 2016). Cortisol and progesterone have their highest potency and peak effect between 26 and 32 weeks gestation, which is important in regard to GDM screening timelines (Carr & Gabbe, 1998).

## Diagnosis

In 1997, an Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, stated that universal screening may not be needed in women who meet all of the following criteria: 1) <25 years of age, 2) normal body weight, 3) no first-degree relatives with diabetes mellitus, 4) not African American, Native American, Asian, or Hispanic (ADA, 1997). In 2013, the American College of Obstetricians and Gynecologists (ACOG) recommended that all pregnant patients be screened for GDM based on risk factor identification or administration of 50 gram oral glucose challenge test (OGCT). Other organizations feel that screening by risk factors is inadequate, since almost half of all patients with GDM have no identifiable risk factors (Coustan, 1995). Proponents of universal screening for GDM stress that pregnancy is an opportune time to diagnosis this disease that has both short and long-term effects on mothers and babies (Carr & Gabbe, 1998). The setting for this study performs universal screening.

**Screening methods.** There are two methods of screening for GDM. In the 2-step approach, the 50-gram OGCT is performed between 24 and 28 weeks of gestation in a non-fasting state (U.S. Preventive Services Taskforce, 2015). If the screening threshold is met or exceeded, patients receive the oral glucose tolerance test (OGTT) (ACOG, 2004). A threshold of 140 mg/dl identifies roughly 90 percent of GDM cases with 15 percent of pregnant patients meeting criteria to take the 3-hour OGTT (ACOG, 2004). During the OGTT, a fasting glucose level is obtained. Then the patient is given a 100 gram glucose load and glucose levels are evaluated after 1, 2, and 3 hours. GDM is diagnosed when 2 or more glucose values fall at or above the specified glucose thresholds.

When the results of the 1 hour, 50 gram glucose screen results are  $\geq 185$  or a fasting glucose is  $\geq 126$ , the patient does not need to proceed with the 3-hour OGTTA due to the risk to

produce hyperglycemia (Landy, Gomez, & O'Sullivan, 1996). In these instances, the diagnosis of GDM can be assumed and treatment should begin.

The 3-hour OGTT should begin after an overnight fast for at least 8 hours, following at least 3 days of unrestricted diet ( $\geq 150$  g carbohydrate) and usual physical activity (Carr & Gabbe, 1998). After the 100 gram glucose load is delivered, venous plasma glucose is measured at fasting and at 1, 2, and 3 hours. ACOG recommends that two or more of the National Diabetes Data Group (NDDG) values be met or exceeded to make the diagnosis of GDM (ACOG, 2004).

Alternatively, a one time, 75-g glucose load can be administered after fasting and plasma glucose levels are evaluated after 1 and 2 hours (ADA, 2016). Gestational diabetes is diagnosed if 1 glucose value falls at or above the specified glucose threshold (U.S Preventative Services Taskforce, 2015). The 1 step approach has the potential for the identification of women with GDM to nearly double (Metzger, 2010). The 2-step approach to screening is used at this study setting.

**Other considerations.** Patients with certain factors, such as a history of a prior macrosomic fetus, family history of diabetes, or chronic steroid use, may benefit from earlier testing, at or before 20 weeks gestation (Gabbe, 1993). Testing can be repeated later in the pregnancy around 32 to 34 weeks with an initial negative result. A study by Javanovic and Peterson (1985) found GDM detection increased by about 50 percent by repeating the test at 33 to 36 weeks gestation in high-risk women who were obese, age  $>33$  years, or a positive 1-hour screen followed by a negative OGTT.

## **Maternal effects**

**Pregnancy/birth complications.** Mothers with poorly controlled gestational diabetes mellitus are at increased risk for many complications during pregnancy and later in life. Study results have found that women with poorly controlled GDM have increased incidence of cesarean delivery, preterm delivery, and preeclampsia (Bellamy et al., 2009; Langer et al., 2005; Yogev, Xenakis, and Langer, 2004). A prospective cohort study conducted by Sermer and associates (1995) evaluated maternal and fetal outcomes with increasing carbohydrate intolerance and found associations between glucose intolerance and increased incidence of preeclampsia, cesarean delivery, and maternal length of hospitalization ( $P < 0.05$ ). In addition, a key research study of over 25,000 women called the Hyperglycemia and Adverse Pregnancy (HAPO) study found associations between elevated fasting plasma glucose and increased primary cesarean section delivery and preeclampsia ( $P < 0.05$ , OR primary cesarean delivery = 1.11, OR preeclampsia = 1.21) (HAPO, 2008).

**Type 2 diabetes.** Women with GDM are 2-3 times more likely to develop GDM with subsequent pregnancies and have a 7 times greater risk of developing type 2 diabetes later in life (Bellamy et al., 2009). Coustan (1993) studied former GDM women and found diabetes or impaired glucose tolerance (IGT) in 6 percent of those tested at 0–2 years, 13 percent at 3–4 years, 15 percent at 5–6 years, and 30 percent at 7–10 years postpartum ( $P < 0.001$ ). A study by Metzger and associates (1985) report a prevalence of 38 percent up to one year postpartum. A systematic review of 28 studies by Kim, Newton, and Knopp (2002) concluded that most women progressed to diabetes at a similar rate in the first five year post pregnancy and then leveled off by 10 years. However, there remains some controversy on the overall risk, due to a large

Canadian study of more than 25,000 women that reported only a small increased risk of Type 2 diabetes to previous GDM women later in life (HAPO, 2008).

**Other complications.** The implications of GDM are significant, since women with prior GDM are at greater risk for developing hypertension, hyperlipidemia, and mortality (O'Sullivan, 1984). Women with GDM are also predisposed to later cardiovascular disease (CVD) (Reece, 2010). Carr et al., (2006) also compared women with and without a history of GDM and found that those with prior GDM were more likely to have CVD risk factors including metabolic syndrome (86.6 vs. 73.5%;  $P < 0.001$ ) and Type 2 diabetes (93.4 vs. 63.3%;  $P < 0.001$ ). They also experienced more CVD events at a younger age (15.5 vs. 12.4%; adjusted odds ratio 1.85 [95% CI 1.21-2.82];  $P = 0.005$ ) (Carr et al. 2006).

#### **Fetal/Newborn effects**

**Anomalies.** Infants of mothers with GDM are not at increased risk for congenital anomalies unless the woman had pre-existing diabetes mellitus and suboptimal glycemic control before conception (Carr & Gabbe, 1998). In these cases, the anomaly rate has been reported to be as high as 18% primarily involving the cardiovascular and central nervous system of the fetus (Becerra, Khoury, Cordero, and Erickson, 1990). Neural tube defects, genitourinary, gastrointestinal, and skeletal anomalies are also more common in diabetic pregnancies (Moore, 2016). Fortunately, clinical trials of intensive metabolic programs have reduced anomaly rates to those similar to the nondiabetic women when strict pre-conceptional glycemic control is evident (Dunne, Brydon, Smith, & Gee, 2003).

**Miscarriage.** It is also important to note that data suggests a strong association between the degree of glycemic control before pregnancy and the miscarriage rate. Poor glycemic control has been shown to double to quadruple the miscarriage rate in women with diabetes (O'Sullivan,

Charles, Mahan, & Dandrow, 1973; Pettitt, Knowler, Baird, & Bennett, 1980). Additionally, women with long-standing (>10 years) and poorly controlled diabetes (glycohemoglobin exceeding 11%) have been shown to have a miscarriage rate of up to 44% (Moore, 2016).

**Macrosomia.** Newborns of mothers with poorly controlled GDM have higher rates of macrosomia and birth injuries such as fractures or nerve damage (Alwan, Tuffnell, & West, 2009). Macrosomia complicates about 20 percent of GDM pregnancies and is defined as fetal weight >90th percentile for gestational age or  $\geq 4,000$  g (Kc, Shakya, & Zhang, 2015). Maternal hyperglycemia leads to fetal hyperglycemia and fetal hyperinsulinemia, which results in excess fetal growth. Macrosomic fetuses display a distinct growth pattern with overgrowth occurring in the abdominal and intrascapular areas (McFarland, Trylovich, & Langer, 1998). The increased growth in the shoulder region and not the head puts the fetus at risk for shoulder dystocia during delivery (Kc et al., 2015).

Shoulder dystocia is increased two- to six-fold in fetuses of GDM mothers and even further increased in newborns with fetal weight greater than 4000 grams (Moore, 2016). A brachial plexus injury is a serious complication associated with shoulder dystocia and involves the loss of movement or weakness of an arm from the stretching and pulling of the shoulders during vaginal delivery (Benedetti, 1991). Most brachial plexus injuries (80–90 percent) will resolve in the first year however; between 0.2 percent and 2 percent will result in permanent injury (Blank & Grave, 1992).

**Obesity.** Many studies highlight the increased risk of obesity in children born to mothers with GDM. This generational cycle of obesity further perpetuates the risk and incidence of future pregnancies with GDM. Children who were born to mothers with GDM have double the rates of obesity compared to children born to nondiabetic mothers (Plagemann, Harder,



Kohlhoff, Rohde, & Dorner, 1997; Silverman, Metzger, Cho, & Loeb, 1995; Vohr & Boney, 2008). Pettitt and associates studied the children of diabetic Pima Indians from 5 to 19 years of age and found a significantly higher body weight as compared to control subjects (Pettitt et al., 1987).

**Type 2 diabetes.** Children who were born to women with GDM or pregestational diabetes had 13 times the incidence of impaired glucose intolerance than children born to nondiabetic mother (Silverman et al., 1995). Between the ages of 10-16 years, McKinney and associates found, children of a diabetic pregnancy had a 19.3% rate of impaired glucose intolerance (McKinney, Parslow, Gurney, Law, Bodansky, & Williams, 1999). Fetuses that were born large for gestational age seem to be at the greatest risk (Eriksson, Forsen, Osmond, & Barker, 2003).

**Other complications.** There are several other complications that are common among newborns born to GDM mothers including hypoglycemia, respiratory distress, and neurodevelopmental changes (Ferrara, 2004). Neonatal hypoglycemia occurs in roughly 50 percent of macrosomic infants. Control of maternal diabetes during the latter half of pregnancy and during labor and delivery influences the occurrence of neonatal hypoglycemia (U.S. Preventative Services Taskforce, 2015). In addition, babies born to women with GDM have a higher incidence of respiratory distress syndrome (DeLuca et al., 2009). Although the reason is not completely understood, there is evidence that hyperglycemia delays fetal lung maturity thus, periods of poorly controlled diabetes could delay fetal lung maturity in fetuses born to mothers with GDM (DeLuca et al., 2009). Infants born to mothers with GDM are also at increased risk for long-term neurodevelopmental changes (Ferrara et al., 2004). A study by Rizzo and associates of 196 pregnant women and their singleton children concluded that children had poorer performance of psychomotor development at 6 and 9 years of age if their mother had

GDM or pregestational diabetes during pregnancy ( $P < 0.001$ ) (Rizzo, Dooley, Metzger, Cho, Ogata, & Silverman, 1995).

Clearly, the detection and appropriate management of GDM provides the opportunity to prevent adverse outcomes for both mothers and their children.

## **Management**

After the diagnosis of GDM is established, treatment is focused on diet/nutrition, exercise, and glucose monitoring (ADA, 2016).

**Nutritional therapy.** Diet or nutrition therapy is an important component of GDM management that often includes nutritional counseling and a personalized nutrition plan with the goal of achieving normoglycemia and preventing ketosis (ACOG, 2013). The goal of dietary therapy is to avoid large meals and foods with a lot of simple carbohydrates by dividing meals into a total of 6 feedings per day, typically with 3 meals and 3 snacks to limit the amount of glucose circulating in the bloodstream at any given time (Moore, 2016). A study by Gunderson reviewed intensive nutritional therapy, and emphasized limiting total carbohydrates and distributing carbohydrates throughout the day via several meals and snacks in order to maintain normal blood glucose levels (Gunderson, 1997). This is particularly important in pregnancy due to the continuous fetal draw of glucose from the mother so hypoglycemia can be avoided (ADA, 2008). A minimum of 175 grams of carbohydrate/day should be given and may be increased or adjusted based on hunger, plasma glucose levels, and ketone levels (Institute of Medicine [IOM], 2002).

The American Diabetes Association recommends that carbohydrates should be no more than 50 percent of the women's diet, with fats and protein accounting for the rest (ADA, 2013). However, Meltzer and colleagues noted that a carbohydrate restriction to 35 to 40 percent of the

diet decreased maternal glucose levels and improved maternal and fetal outcomes (Meltzer, Snyder, Penrod, Nudi, & Morin, 2010). The ADA also notes that moderate caloric restriction of up to 30 percent of energy needs in obese women with GDM may reduce weight gain and improve glycemic control without ketonemia (ADA, 2008).

**Exercise.** Exercise has been suggested as an adjuvant therapy in GDM, since exercise has shown to improve glycemic control in patients with GDM (Bung, Artal, Khodiguin, & Kjos, 1991). Additional studies support the benefits of exercise on glycemic control. A study by Jovanovic-Peterson and associates compared 50 women with GDM who were assigned to a dietary treatment with those assigned to diet plus exercise treatment. The study results suggest significantly lower fasting blood glucose levels in the diet plus exercise group than diet alone (Jovanovic-Peterson & Peterson, 1990). A meta-analysis of exercise and pregnancy studies conducted by Lokey and associates concluded that pregnant women can exercise up to 3 times per week for roughly 40 minutes with no harm to either herself or the fetus ( $P=.20$ ) (Lokey, Tran, Wells, Myers, & Tran, 1991).

**Glucose monitoring.** Hemoglobin A1c (HbA1c) has been an accepted marker of glycemic control since the mid-1970s and is clinically used to assess glycemic control in people with diabetes (Saudek & Brick, 2009). In pregnancy, however, A1c may not be the most reliable measure of glycemic control due to normal physiological increases in red blood cell turnover, resulting in reduced A1c levels (Nielsen et al., 2004). Furthermore, A1C is an integrated measure of glucose and may not fully detect postprandial hyperglycemia, which drives macrosomia (Nielson et al., 2004). As a result, blood glucose self-monitoring and targets are the primary measures of glycemic control in women with GDM. It is also the outcome measure of this study.

According to ACOG, there is insufficient evidence to outline the optimal frequency of glucose monitoring but the general recommendation is four times daily, one fasting and then 1 or 2 hours postprandial (ACOG, 2013). The most recent American Diabetes Association (ADA) guidelines for diabetes in pregnancy glucose monitoring targets are: fasting  $\leq 95$  mg/dL (5.3 mmol/L) and; one-hour postprandial  $\leq 140$  mg/dL (7.8 mmol/L) or two-hour postprandial  $\leq 120$  mg/dL (6.7 mmol/L) (ADA, 2016). These targets may result in hypoglycemia for some individuals thus the ADA recommends, in these cases, less stringent targets based on clinical experience and individualized care (ADA, 2016).

Postprandial glucose measurements are preferred over preprandial measurements. A retrospective study of women with GDM experienced lower glycosylated hemoglobin values and had fewer macrosomic babies when postprandial glucose values were used (Major, deVeciana, Morgan, & Henry, 1993). In a follow up randomized trial of 42 women, de Veciana and colleagues concluded that fasting and 1-hour postprandial glucose monitoring demonstrated improved glycemic control and decreases in shoulder dystocia, hypoglycemia, macrosomia, and cesarean delivery in comparison to preprandial glucose monitoring (de Veciana et al., 1995).

**Medication.** Women who cannot maintain blood glucose levels within target ranges or women who have greater initial degrees of hyperglycemia may require pharmacological therapy. Insulin is the first-line agent recommended for treatment of GDM in the U.S. (ADA, 2016). The ACOG criteria for initiating insulin therapy include a fasting plasma glucose level  $\geq 105$  mg/dl and 2-hour plasma postprandial levels  $\geq 120$  mg/dl (ACOG, 2013). If insulin is required, the target plasma glucose levels are fasting glucose value 60–90 mg/dl, preprandial value 60–105 mg/dl, 2-hour postprandial value  $< 120$  mg/dl, and 1-hour postprandial value not  $> 130$ –140 mg/dl (ACOG, 2013; ADA, 2016).

Pharmacologic therapy with oral agents such as glyburide and metformin are becoming more popular. Randomized controlled trials demonstrate the efficacy and short-term safety for mother and fetus when administering metformin (pregnancy category B) and glyburide (pregnancy category B) although the potential for long-term adverse effects remains unclear (Coustan, 2007; Langer, Conway, Berkus, Xenakis, & Gonzalez, 2000; Rowan, Hague, Gao, Battin, & Moore, 2008). Metformin may be the preferable over insulin for maternal health but holds a higher risk of prematurity (Balsells, Garcia-Patterson, Sol al Roque, Gich, & Corcoy, 2015).

**Outcomes.** Studies exist that point to improved perinatal outcomes when treatment includes nutrition therapy, blood glucose monitoring, and insulin therapy when needed. In a study by Crowther and associates, 1000 women with GDM were randomized to an intervention group (dietary advice, blood glucose monitoring, and insulin therapy) or routine care (Crowther, Hiller, Moss, McPhee, Jeffries, & Robinson, 2005). The 490 women in the intervention group experienced significant reductions in complications such as large for gestational age newborn, shoulder dystocia, and perinatal death (1% vs. 4%,  $P=0.01$ ) (Crowther et al., 2005). Langer and colleagues expressed similar findings in their matched controlled study of nondiabetic women, women treated for GDM, and women diagnosed with GDM after 37 weeks gestation (Langer et al., 2005). Untreated women experienced a two to four fold increase in macrosomia and metabolic complications (Langer et al., 2005).

## **Self-Management**

### **Concept**

The concept of self-management is widely used in the literature, yet it differs across disciplines, programs of research, and authors (Ryan & Sawin, 2009). Self-management can be

described as a group of daily behaviors that individuals perform to manage a condition (Glasgow & Anderson, 1999). It is a dynamic process in which individuals and families engage in processes to improve their health versus comply with prescribed orders (Ruggiero et al., 1997).

The vast majority of self-management research resides in chronic disease management and has resulted in numerous self-management frameworks (Corbin & Strauss, 1988; Grey, Knafl, & McCorkle, 2006; Lorig & Holman, 2003; Ryan & Sawin, 2009). Corbin and Strauss (1988) categorized the chronic disease self-management (CDSM) behaviors into three realms: (1) medical management, (2) adopting new behaviors, and (3) dealing with emotions. In 2001, Lorig, Sobel, Ritter, Laurent, and Hobbs outlined five core self-management behaviors that are seen in most chronic conditions: problem solving, decision making, resource utilization, forming of a relationship with a provider, and taking action. Later, Lorig and Holman (2003) and Unger and Buehlow (2009) further defined CDSM as the actions people take to manage their chronic disease and its effects including medication and treatment compliance, safety, event management, and lifestyle management.

Grey et al. (2006) expanded self-management knowledge by including the family in their framework as well as suggest its application beyond those already diagnosed with a chronic illness. The authors state that their framework provides an approach for “understanding, development, and testing of self- and family-management interventions for people with chronic conditions, or at risk for their development” (Grey et al., 2006, p. 281). Their Self and Family Management Framework outline risk and protective factors along with outcomes of self-management.

Ryan and Sawin (2009) further incorporate the family into their Individual and Family Self-Management Theory (IFSMT). The IFSMT combines previous research on Ryan’s

Integrated Theory of Health Behavior Change (ITHBC) and Sawin's Ecological Model of Secondary Conditions and Adaptation into one framework with context, process, and outcomes dimensions. The context dimension includes risk and protective factors including physical and social environment, condition specific factors, and individual/family characteristics.

The processes dimension of the IFSMT encompasses knowledge and beliefs, self-regulation of skills and abilities, and social facilitation. Ryan and Sawin (2009) include the actual engagement of self-management behaviors as a proximal outcome of their Individual and Family Self-Management Theory (IFSMT) while distal outcomes are health status, quality of life, and cost of health.

While most of the existing research on self-management theory revolves around chronic conditions, the IFSMT expands its utility into health promotion and more acute conditions. A 2013 study by Doering used the IFSMT when exploring the physical and social environment of sleep self-management in postpartum women. In addition, Ryan and colleagues are currently engaged in research on an osteoporosis prevention app using the IFSMT (NIH Reporter).

Recently, Shulman-Green et al., (2012) completed a metasynthesis of 101 self-management articles to describe the processes of self-management. The authors identified three categories of self-management processes: 1) focusing on needs due to the chronic condition; 2) activating resources; and 3) living with a chronic illness (Shulman-Green et al., 2012). The synthesis also outlined additional task and skills mentioned in the articles. It is surprising that the use of computers, patient portals, or secure messaging was not a skill listed.

In this day in age of technology evolution and governmental financial incentives for EHR use, it seems logical to research and incorporate technology into self-management frameworks. There is a growing body of evidence that self-management interventions and programs improve

outcomes in individuals with chronic illnesses (Ryan & Sawin, 2009). Yet, little research exists on the impact self-management interventions can offer for more acute conditions or health promotion. This research will further expand the use of the IFSMT to the GDM population incorporating self-management concepts using a PWP as a technology based intervention.

### **GDM Self-management**

While the emphasis of treatment for GDM is on dietary modifications, exercise, and blood glucose monitoring, a standard on how to implement strategies for successful self-management is lacking. Literature on GDM self-management is primarily qualitative and identifies themes associated with diagnosis and management of GDM and barriers or facilitators to GDM self-management.

**Themes.** Several qualitative studies exist on the lived experience of women with GDM (Abraham & Wilk, 2014; Devsam, Bogossian, & Peacock, 2013; Morrison, Lowe, & Collins, 2014). While the number of themes and titles varied among the studies, common themes in all the studies revolved around initial shock and emotions with diagnosis of GDM, adapting to GDM, social support, and staying healthy to prevent Type 2 diabetes.

Morrison and colleagues conducted a postal survey of the experiences of women with GDM in Australia and outlined eight themes: 1) shock, fear, and anxiety, 2) uncertainty and skepticism, 3) opportunity to improve one's health, 4) adapting to life with GDM, 5) the need for support, 6) better awareness, 7) abandoned, and 8) staying healthy and preventing diabetes. Women taking insulin were more likely to feel shock, fear, and anxiety ( $p=0.001$ ).

Similarly, Abraham and Wilk (2014) conducted a phenomenological study of 10 women with a history of GDM within the last five years. They identified five themes: 1) Authentic



emotion; 2) Judgement; 3) It's only a matter of time; 4) I can't do this alone; and 5) Missed opportunities.

Devsam et al. (2013) performed an interpretive review of women's experiences with GDM that incorporated both qualitative and quantitative research. Nineteen studies were reviewed and three themes were identified: 1) Responses which included the core concepts of initial response to GDM, negative thoughts about GDM, struggle to manage GDM, loss of control, changes to identity, and adapting to change; 2) Focus of concern with core concepts of concern for baby's health, concern for own health, perceived seriousness of GDM, perceived fear of Type 2 diabetes; and 3) Influencing factors with core concepts of cultural roles and beliefs, social support and stigmas, professional support, adequate information, and barriers to self-care. The authors propose using these themes as a guide when caring for women with GDM.

**Facilitators/Barriers.** Studies suggest that facilitators to health behavior change after diagnosis of GDM are concern for the health of the baby, to stay healthy for the other children, to be a role model for the children, and desire to avoid type 2 diabetes (Devsam et al., 2013 ).

Barriers identified in the literature include lack of motivation, lack of time, lack of clear and timely information, and lack of interventions that fit into women's multiple roles as caregivers, workers, and patients (Parsons, Ismail, Amiel, & Forbes, 2014). The dietary and activity modifications required may be difficult for many women due to their current lifestyle habits and as a result many women struggle to adhere to GDM guidelines (Carolan, Gill, & Steele, 2012; Hui et al., 2014).

Research findings suggest that effective glycemic control is a vital component to good maternal and fetal outcomes, which is influenced by a woman's self-management behaviors (Carolan et al., 2010). While many women feel they have knowledge related to GDM, they often

seek additional information through family, friends, and online sources. Women in the Hui et al. (2014) study felt the dietary information they were given by providers was insufficient and was not meeting their personal needs. Women felt frustrated about the limited amount of time they had to adapt their lifestyle choices and they also felt the information was not tailored to them specifically (Hui, 2014).

Recognizing the barriers and facilitators to GDM self-management is a first step to designing interventions and programs to promote GDM self-management. Very few studies exist in the literature related to GDM self-management interventions despite literature supporting the value of GDM self-management on reducing obesity, reducing pregnancy complications, and improving glycemic control (Cheung, 2009; Glastras & Fulcher, 2012). The majority of studies focus on type of medical management including medication and the threshold for glycemic control (Alwan et al., 2009).

**GDM Interventions.** To address this gap, Carolan (2015) conducted an integrative review of the literature to guide GDM management. The goal of the review was to provide background information for the development of future GDM management programs and interventions. Twelve papers were reviewed and all of them used quantitative methods with comparison groups (Carolan, 2015). The results of the review indicated that GDM interventions fall into three categories: (1) self-monitoring of blood glucose levels, (2) dietary and exercise interventions, and (3) behavioral interventions/counseling. These interventions reduced insulin requirements, reduced macrosomia, and improved knowledge and pregnancy outcomes (Brankston, Mitchell, Ryan, & Okun, 2004; Carolan, 2015; Hoppichler & Lechleitner, 2001; Landon et al., 2009; Moses, Barker, Winter, Petocz, & Brand-Miller, 2009).

**Use of Technology.** Most of the research on GDM self-management has been with in-person education and counseling (Mendelson, McNeese-Smith, Koniak-Griffin, Nyamathi, & Lu, 2008; Murphy, Guilar, & Donat, 2004) despite the successful outcomes using telehealth and PWP among people with type 1 and type diabetes (Po, 2000). This author was only able to find two studies related to the use of such technology for GDM self-management.

Ferrara et al. (2012) studied whether a referral to a nurse-based management program that offered supplemental GDM care via telephone counseling on diet, activity and blood glucose monitoring was associated with improved perinatal outcomes as defined by macrosomia low birthweight babies, and postpartum glucose testing. This was a multicenter, retrospective study of 12 medical centers with over 11,000 subjects. The results suggest that receiving care at the centers with higher referral frequency (>70%) compared to those with lower referral frequency (<30%) for telephonic nurse management for GDM was associated with decreased risk of macrosomic infant and increased postpartum glucose testing (multiple-adjusted odds ratio, 22.96; 95% confidence interval, 2.56 –3.4 and multiple-adjusted odds ratio, 0.75; 95% confidence interval, 0.57– 0.98) (Ferrara et al., 2012).

In the second study, Carolan, Steele, and Krenzin (2015) created a web-based GDM intervention aimed at multi-ethnic women in Melbourne, Australia. A pretest/posttest design explored the impact of the intervention on GDM self-management principles, knowledge of GDM, and food values for 21 women with GDM using the Knowledge of GDM questionnaire. Results suggested that the intervention was effective in improving knowledge scores but less effective in improving food values and self-management principles. The Fisher's Exact test P-value for the association between GDM score improvement and education was 0.294; the association between food score improvement and education was 0.347; and the association

between self-management score improvement and education was 0.170. The authors explain that a misunderstanding of specific survey questions and interpretation of the web resource may have contributed to the lower improvement noted in the self-management area (Carolan, Steele, & Krenzin, 2015). Revisions will be made and the authors have plans for a clinical trial.

While the number of themes and titles varied among studies, common themes identified in women with GDM revolve around initial shock and emotions with diagnosis of GDM, adapting to GDM, social support, and staying healthy to prevent Type 2 diabetes. Furthermore, facilitators to health behavior change after diagnosis of GDM include concern for the baby's health, desire to stay healthy for their other children, be a role model to their kids, and desire to avoid type 2 diabetes (Devsam et al., 2013 ). These themes and facilitators offer insight into the emotional journey and motivation for health behavior change among women with GDM. Barriers identified in the literature such as lack of time, lack of clear and timely information, and difficulty adjusting to diet modifications point to the struggles women with GDM experience and should be addressed when designing future interventions to care for this population. Literature on the interventions for GDM self-management revolve around three topics; self-monitoring of blood glucose, diet and exercise, and behavioral interventions.

Web-based patient portals for GDM management have the potential to address the facilitators and barriers noted above and could potentially provide a cost-effective alternative to strictly in-person diabetes clinic visits. For instance, portals can be accessed at any time so timely information could be a benefit of a portal designed for GDM management. The limited existing research on PWP use and other health information technology interventions for GDM self-management is worth further exploration and is the intent of this research study.

## **Patient Web Portals**

### **History**

Patient web portals were first introduced and adopted by large health care organizations in the late 1990s (Halamka, Mandl, & Tang, 2008). It was not until about 2006 that patient web portals gained widespread use due to the launch of personal health records (ePHRs) by Microsoft and Google and the general public's adoption to communication sharing tools like social media and smartphones (Weitzman, Kaci, & Mandl, 2009). Ultimately, the main driver of PWP adoption and sustainability is the meaningful use (MU) criteria set forth by the Centers for Medicare and Medicaid Services (CMS) EHR incentive program as part of the American Reinvestment and Recovery Act of 2009 (Wright, Feblowitz, Samal, McCoy, and Sittig, 2014). PWPs could be viewed as a transformative piece of technology that offers unlimited online access to online health information and care however; simply building a PWP will not ensure its use or success (National Learning Consortium, 2013; Weingart, Rind, Tofias, & Sands, 2006). The PWP needs to be user-friendly, engaging, and structured in a manner that supports patient-centered outcomes. Furthermore, the PWP should be integrated into clinical practice so it becomes part of the care delivery model and method to communicate with patients, provide support, and information (National Learning Consortium, 2013).

### **Definition**

A PWP is an interactive internet-based website that allows patients and providers to communicate and give patients access to their medical record, review clinical data, graphs, and education points (Sorensen, Shaw, & Casey, 2009). Patient portals are managed by a health care institution or health care provider. The purpose of the portal concept is to engage patients in actively participating in their health care rather than being passive recipients of care (Shaw &

Ferranti, 2011). Irizarry, DeVito-Dabbs, and Curran (2015) describe a patient portal as an ePHR [electronic personal health record] that directly links, or is “tethered” to an EHR (p. 2).

The HealthIT.gov (2016) definition is more specific stating that a patient portal is a secure online website that gives patients convenient 24-hour access to personal health information from anywhere with an Internet connection. While most of these definitions are similar in nature they lack clarity on the specific components of a PWP.

HealthIT.gov’s definition includes a list of possible features that people can access within the portal such as discharge summaries, medications, allergies, and lab results. They note that some patient portals also allow patients to request medication refills, schedule appointments, and secure message to healthcare providers (HealthIT.gov, 2013). Meaningful Use requirements outline six specific functionalities of patient portals for their incentive program: (1) secure messaging, (2) clinical summaries after visits, (3), patient specific education, (4) patient reminders, (5) medication reconciliation, and (6) access to personal health information (Irizarry et al., 2015).

Patient web portals (PWP) vary in their content and what is available for patients to view. This lack of clarity on minimal components of a patient portal creates confusion when designing a study or interpreting results. Each study may incorporate a different set of PWP features which in turn could influence the results. Generalizing the results beyond a specific institution can be difficult when common PWP features are not used.

## **PWP Users**

**Definition.** Variations exist within the literature on definitions and categories of people who use and don’t use patient web portals (Ronda et al., 2015; Sarkar et al., 2011; Weingart et al., 2006; Yamin et al., 2011). The terms adopters and nonadopters were used in a 2011 study by

Yamin and associates regarding personal health record (PHR) use. Adopters were those individuals who registered for the PHR and activated their account while nonadopters did not have an active account (Yamin et al., 2011). A 2006 study by Weingart and colleagues, describe individuals as enrollees or nonenrollees of a patient portal called PatientSite. The terms users and nonusers of PWPs is all cited in studies (Ronda et al., 2015; Sarkar et al., 2011). Ronda and associates further classified patients into two groups: 'early quitters' and 'persistent users'.

For the purposes of this study nonusers apply to subjects who logged in only once. Short-term users were subjects who logged in during the first month after enrollment. Persistent users were users that logged in throughout the third trimester.

While PWPs have shown to be an effective tool to promote diabetes self-management and received an overall positive reception by patients, adoption rates vary (McMahon et al., 2005; Ronda et al., 2015). Study results suggest that there are differences between users and nonusers of PWPs in regards to demographic and other variables (Osborn, Mayberry, Wallston, Johnson, & Elasy, 2013; Ronda et al., 2015). These differences are important to understand so that PWP designs can be refined and individualized to meet the needs of specific individuals.

A case-control study of 200 patients by Weingart and colleagues (2006) found that PatientSite enrollees were younger, more educated, and had fewer medical problems than nonenrollees ( $P < 0.001$ ). However, seven percent of users were at least age 65. Similar results were also noted in a 2015 study by Ronda and associates. Ronda and colleagues administered a survey to 1,500 type 1 and type 2 diabetes patients within 62 primary care clinics and one hospital outpatient clinic. 632 patients (42.1%) responded to the survey. Their study on the use of a diabetes PWP concluded that persistent users were younger ( $61.9 \pm 12.7$  in early quitters vs.  $58.5 \pm 13.3$  for persistent users,  $P = .02$ ), employed (36.3 for early quitters vs. 47.1 in persistent

users,  $P=0.01$ ), and more often used insulin (45.9 in early quitters vs. 63.2 in persistent users,  $P<0.001$ ) (Ronda et al., 2015).

In contrast, a study by Sarkar (2011) of 14,102 adults with diabetes in Northern California concluded that older adults, those with less education (OR compared to college graduates, 2.3(1.9-2.7)) and African Americans and Latinos (OR 2.6(2.3-2.9); (OR 2.3(1.9-2.6)) were less likely to access a PWP. However; those with computer access, older adults were more likely to use the PWP than younger adults. Interestingly, Mayberry and colleagues identified family member support as a reason for why patients of all health and computer literacy levels might access and use PWPs (Mayberry, Kripalani, Rothman, and Osborn, 2011).

**Gender.** Several studies indicate that women adopt PWP technology more quickly than men (Fleming, Cullen, & Luna, 2015; Kruse et al., 2015). This result is likely due to women having more interactions with the healthcare system. Even when reproductive visits (e.g., pregnancy, birth control) were removed, Courtenay noted that women are encouraged to pay more attention to their health and seek routine care (Courtenay, 2009 as cited in Broom & Tovey). Vaidya, Partha, and Karmakar (2012) also validated similar findings through a study that found women to be the highest consumers of preventative health services, perceiving PWPs as another form of preventative care and a way to stay updated about their health.

A review of 17 research studies by Emont (2011) on PWP use concluded that the majority of consumers are female and the most used features of the PWP are secure messaging, viewing lab results, scheduling appointments, and medication refill requests. Furthermore, the author suggests that people become more engaged in their health and medical care when their health information is accessible online (Emont, 2011). Certainly this information is encouraging



to researchers of PWP intervention studies focused on women, particularly those focused on women.

**Outcomes.** The use of patient web portals (PWP) as a tool to promote diabetes self-management is prevalent in the literature (Fonda et al., 2009; Grant et al., 2008; Kim, Kim, & Ahn, 2006; McCarrier et al., 2009; Quinn, et al., 2008). Many of the studies to date are randomized controlled trials that focus on the biological outcomes of hemoglobin A1c levels, blood pressure, and lipid levels (Fonda et al., 2009; Grant et al., 2008; Kim, Kim, & Ahn, 2006; McCarrier et al., 2009, McMahon et al., 2005; Noel, Vogel, Erdos, Cornwall., & Levin, 2004; Quinn et al., 2008).

Several randomized and nonrandomized controlled studies demonstrate a decrease in hemoglobin A1c levels with PWP use (Fonda et al., 2009; Grant et al., 2008; Kim et al., 2006; Quinn et al., 2008). See Table 3 for specific details on each study and results. Conversely, reductions in blood pressure and lipid levels with PWP use are not as conclusive nor are they as relevant in the gestational diabetes population (Grant et al., 2008; McMahon et al., 2005; Shaw & Ferranti, 2011).

Research has also shown that PWP use is associated with lower diabetes distress scores. For example, a randomized controlled trial of 102 patients with type 1 and 2 diabetes found lower diabetes distress in subjects who used their PWP and the lowest diabetes distress scores among more frequent PWP users (Fonda et al., 2009). Diabetes distress scores were measured at baseline and quarterly for 12 months using the Problem Areas in Diabetes (PAID) questionnaire. The PAID scores of sustained, regular users of the PWP were 14.7 points lower than subjects who did not use the PWP ( $P=0.006$ ).

Additionally, research exists related to the components of diabetes self-management such as self-efficacy and PWP use. McCarrier and colleagues (2009) conducted a randomized controlled trial of 77 patients with type 1 diabetes to determine if a web-based case-management program in an EHR could improve glycemic control and diabetes-specific self-efficacy. The intervention group experienced a significant increase in diabetes-related self-efficacy compared to the usual care group (group difference of 0.30; 95% confidence interval 0.01 to 0.59;  $P = 0.04$ ). Self-efficacy is a key component to self-management (Ryan & Sawin, 2009).

### **Research Gaps**

While studies exist related to counseling and educational programs for GDM self-management, only one study was found in the literature on the use of a PWP for GDM self-management (Carolan, et al., 2015). Patient web portals have successfully been used to promote self-management in patients with type 1 and type 2 diabetes resulting in improved hemoglobin A1c levels (Kim et al., 2006; McMahon et al., 2005; Noel et al., 2004; Shaw & Ferranti, 2011; Smith et al., 2004). This concept should be tested in the GDM patient where motivation is high and barriers to self-management include time and travel (Carolan et al., 2012). Effective GDM self-management interventions have the potential to control glucose levels and reduce the risk of adverse outcomes for mothers and babies during pregnancy and later in life.

Unfortunately, few intervention studies have been performed on this population of women. Most of the literature is qualitative in nature and points out facilitators and barriers to GDM self-management. There is solid evidence on the negative consequences for the mother and infant in terms of GDM and the importance of dietary modifications, exercise, and tight blood glucose monitoring. In addition, evidence suggests and recognizes the need for resources and programs to promote GDM self-management (Carolan et al., 2010). However there is a gap

in the literature on how best to promote GDM self-management, what resources and technology are most effective.

Furthermore, little is known about the patient characteristics of users and nonusers of PWP and patterns of use (Jones et al., 2015). Understanding how women with GDM use PWP is essential to refining this technology to further meet the needs of the patients, providers, and clinicians.

### **Chapter Summary**

This chapter discussed the physiology, negative effects of GDM, and its management course to provide a foundation of evidence to this study topic. The concept of self-management and literature related to self-management for GDM was explicated. The literature on diabetes self-management with a focus on the use of technology was examined as was the literature on use of such technology for GDM self-management. Finally, literature on PWP were synthesized including definitions, specific populations of users, and outcomes of PWP use in type 1 and type 2 diabetes. Research gaps were identified and the rationale for additional research related to GDM self-management using a PWP is outlined.

## **Chapter 3**

### **Methods**

#### **Research Design**

The study was a retrospective cohort design that followed participants from entry into a diabetes and pregnancy clinic between 28 to 32 weeks gestation through childbirth, accounting for roughly a three month period of time. All patient care data and communication regarding the patient's GDM care are documented within the same electronic health record (EHR).

A retrospective design was used for several reasons. First, a prospective study would involve a great deal of time in order to obtain an adequate sample size (Polit & Beck, 2012). The health care organization for this study cares for a total of about 100 women with GDM a year, which means a prospective approach would require recruiting patients for over two years and then tracking them for the last three months of their pregnancy. With an estimated sample size for an experimental or quasi experimental design of 200 subjects the data collection period of a prospective study could be even longer. A retrospective design provides a large sample size in a feasible amount of time.

#### **Setting/Sample**

The sample included all pregnant women in their third trimester with a diagnosis of GDM according to the International Classification of Diseases, ICD-9 and ICD-10 codes that were referred to and received services at a diabetes and pregnancy clinic in two hospitals in a Midwestern state in the United States. The women received health care at the clinic between January 2013 and January 2016.

Inclusion criteria were the following: (a) age 18 years and older, (b) diagnosis of gestational diabetes (insulin or diet controlled), (c) in the third trimester of pregnancy but before

32 weeks gestation, and (d) singleton pregnancy. Exclusion criteria were (a) women who first presented to the clinic after 32 weeks gestation due to the decreased ability to impact blood sugar numbers with less than three months of care, and (b) multiple gestation.

An estimated sample size of 300 women was targeted for this study. A power analysis was conducted using G\*Power software indicating a sample size of 128 was needed with 80 percent power for detecting a medium sized effect with 0.05 significance level assuming two groups (users and nonusers) in the ANOVA model (Faul, Erdfelder, Lang, & Buchner, 2007). A sample size of 159 was needed with 80 percent power for detecting a medium sized effect with a 0.05 significance level if there were three groups (nonusers, short-term users, persistent users) in the ANOVA model. This power analysis was performed and validated by Dr. Weiming Ke, University of Wisconsin-Milwaukee College of Nursing.

### **Data Source**

The data sources for this study included a departmental Excel database, Epic EHR, and the MyChart server log files. Epic's MyChart is the PWP portion of the Epic system. Epic's MyChart is the most widely used patient portal according to a recent KLAS survey (Pennic, 2012). This healthcare organization has been utilizing Epic and portions of MyChart since October 2011.

### **Patient Web Portal**

Patients were able to activate their PWP by creating a username and password. Once activated, the patients were able to view their health information and utilize the features of the PWP. All women receiving care at the diabetes and pregnancy clinic received a log-in to access the PWP for health care purposes. At their first visit in the clinic, women were asked about enrollment and encouraged to consider enrollment if they have not already. Nurses at the clinic

assisted patients who were interested in enrollment to sign up at the time of their visit or patients were provided a code to enroll at their convenience at home. The code was printed on their patient instructions and given to them after the visit. Patients were instructed that communication between the staff and patients could occur via secure messaging, blood glucose numbers could be entered into the flowsheet tab in MyChart or communicated through secure messaging or phone/fax, and explanation was given about lab results and AVS instructions.

After an account was established, patients could login to the PWP to access various information and features including laboratory results, appointment reminders, medication refill requests, blood sugar flow sheets, patient instructions, and secure messaging. All communication between the patient and provider are stored in the EHR. The specific features included in this study are further discussed in the variables and measurements section. This section does warrant discussion on how each PWP feature is utilized in the diabetes and pregnancy clinic.

Appointment reminders are sent automatically through MyChart for each diabetic visit confirming the appointment date, time, location, and any special instructions. The AVS provides patient instructions and medical information to the patient via MyChart after each diabetic visit. The AVS for the diabetic visits used a standard template of problem list, allergies, diagnosis, medications and treatment team for all patients. In addition, there are patient specific instructions and education that are included in the AVS specific to the diabetic patient and that visit which may include specific patient goals or dietary instructions and follow-up. The AVS is typically 3 pages or longer in length. The lab results section allows patients to review their lab results, specifically hemoglobin A1c and glucose tolerance test results as a specific result and trending over time. Medication refills is a request to the provider to refill a prescription which in this case would be insulin. The blood glucose flowsheet was built to have patients submit their blood

glucose numbers via MyChart and then be electronically filed. Finally, the secure messaging feature allows the patient to communicate with the nurse or provider via MyChart to ask questions, send blood glucose information, or seek clarifications. The workflow in the diabetes and pregnancy clinic is to respond to these messages on a daily basis.

Use of the PWP was in addition to routine care within the clinic. Routine care typically consisted of diabetes visits every two weeks with the certified diabetic nurse educator, then weekly at 36 weeks and thereafter until delivery unless otherwise specified by the provider.

All patient level usage of Epic MyChart was timestamped and stored in the organization's server log files. The server files provided time information and frequency of PWP use regarding each feature of the PWP for purposes of this study.

### **Procedures for Data Collection**

After IRB approval was obtained, a report from the healthcare organization's data warehouse was created by IT analysts of all women who sought care in the diabetes and pregnancy clinic between January 2013-January 2016 with a diagnosis of GDM and who met the inclusion criteria. The report excluded women who did not meet the inclusion criteria. In addition, the IT analysts created a report from the MyChart server log files that provided the PWP activity by each woman as defined by the number of hits to a particular feature of the PWP. This report was used to separate subjects into three groups- nonusers, short-term users, and persistent users. It also served as the data source for PWP usage. It captured the date and time of each activity to a PWP feature by individual over the third trimester of pregnancy. The usage report was exclusive to the PWP activity within the diabetes and pregnancy clinic and the GDM diagnosis and not the user's PWP use in general. The data was then categorized according to the

PWP feature accessed, number of hits, and over what period of time to establish the pattern of use. The data was then imported into SPSS.

A second report was created by an IT analyst from Epic based on the inclusion criteria that outlined the patient characteristics per individual. Target blood glucose levels for each woman collected via the PWP, telephone, or office visit, were gathered by the PI via a hospital-based Excel database. The percentage of blood glucose levels within target range for each woman per month were entered into the SPSS spreadsheet.

All data was stored on a personal, password protected laptop in a locked office. The initial reports required a patient's name and MRN number so the PI could match the blood glucose levels, PWP activity, and patient characteristics to the correct patient. Once files were merged, the subject was assigned a number and the data became de-identified. The legend of the patient name and assigned number was stored in a separate file outside of SPSS in a locked file cabinet. A codebook was developed and stored electronically in SPSS.

### **Study Variables and Measurements**

The study variables included measures of (a) patient characteristics, (b) PWP features and patterns of use, and (c) targeted blood sugar achievement.

**Patient Characteristics.** A set of patient characteristics was collected for all subjects. These characteristics were collected at the entry point into the study which was the first visit to the diabetes in pregnancy clinic. Some of the variables, (e.g. race and ethnicity) may have been documented in the EHR prior to referral to the clinic, and the most recent entry was used. Age, race, ethnicity, marital status, insurance, and employment were abstracted from the demographics section of the EHR in the data warehouse. Clinical data such as BMI, type of GDM, and number of pregnancies with GDM, were abstracted from the clinical flowsheets and



documentation within the EHR. More specifically, they were abstracted from the prenatal flowsheets at the point of the first diabetes in pregnancy clinic visit. Conceptual and operational definitions for each variable are described in Table 4.

**PWP Features.** Since PWPs features are not standardized across institutions, each feature was defined and outlined for this study. The features included for this study were patient/provider messaging, flowsheets/blood sugar logs, after visit summaries/ instructions, labs, appointment reminders, and medication refills. Conceptual and operational definitions for each of these variables are outlined in Table 4.

Each feature was analyzed based on the frequency and pattern of use during the third trimester of pregnancy. Access to each feature was reported in whole numbers. The starting point was the date of the patient's first diabetes in pregnancy appointment and terminated at the date of delivery. To expedite the abstraction process a report was created from the MyChart web server log files that produced the number of times a PWP feature was accessed, what was accessed, and the date/time for each woman during the study period.

**PWP frequency.** The number of times that each patient logged into the PWP and the number hits for each feature they used per login session was captured. Frequency of use was measured by the number of "hits" or times the patient accessed a feature of the PWP. This may include more than one "hit" within the same minute. All "hits" were included in the data.

For the purposes of this study, the category "nonusers" applied to subjects who logged in only once. "Short-term users" were women who logged in during the first month after enrollment but not thereafter. "Persistent users" were users that logged in throughout the third trimester.

**PWP patterns of use.** This study also examined user's patterns of PWP use during the third trimester. A "pattern of use" is defined as the utilization of PWP features from first appointment in the diabetes in pregnancy clinic to the time of delivery. It includes frequency and consistency of PWP use. Duration of use was unable to be captured. Frequency of PWP use was defined as the PWP features accessed and the number of hits on each feature over the study period. Consistency was measured in hit days and hit months. Hit day was any day that the patient accessed the PWP in the third trimester regardless of the number of times accessed that day or features accessed. Hit month captured any individual month where the patient accessed any feature of the PWP at least once.

**Target blood glucose levels.** Target blood glucose levels were measured using the percent of blood glucose levels reported each month within target range per subject. Target blood glucose levels were identified as less than 125 mg/dL for fasting and post-meals. A fasting plasma glucose level  $>126$  mg/dl (7.0 mmol/l) or a casual plasma glucose  $>200$  mg/dl (11.1 mmol/l) meets the threshold for the diagnosis of diabetes, if confirmed on a subsequent day, and precludes the need for any glucose challenge (ADA, 2003). All reported blood glucose levels for the month were recorded into a hospital password protected shared folder and then a percentage is calculated monthly using the number of blood sugars reported within target range divided by the total number of blood glucose levels reported. This process is repeated monthly during the third trimester until delivery.

### **Plans for Data Analysis**

The data were analyzed using SPSS version 23. To answer aim 1, descriptive statistics were performed using a frequency table including mean and standard deviations as well as

independent t-tests on the continuous variables of age and pre-pregnancy BMI. A Pearson's chi-square test of independence was performed on all categorical variables using cross tabulation.

To answer aim 2, categorical variables were expressed as percentages and continuous variables as means with standard deviation (SD) and range. A histogram was generated to assess distribution, and then skew was calculated (Meyers, Gamst, & Guarino, 2013). Independent t-tests were performed for age and pre pregnancy BMI between PWP users and nonusers, and chi square tests were conducted on the remaining patient characteristics.

To answer aim 3, a repeated measures ANOVA was performed to compare glycemic control between users and nonusers. Groups included users and nonusers. The intervention was PWP use with the outcome variable being glycemic control. Glycemic control was measured monthly over the third trimester. An F-statistic was calculated and an alpha of 0.05 was used.

### **Human Subjects/Institutional Review Board**

Institutional Review Board approval was obtained through the University of Wisconsin-Milwaukee (UWM). An application of deferral was completed and granted in September 2016 from ProHealth Care to defer all IRB activities for this study to UWM. The ProHealth Care deferral is located in Appendix A. The UWM IRB approval can be found in Appendix B.

### **Summary of Chapter**

This study used a retrospective cohort design to address the following research aims: 1) compare the characteristics of nonusers and users of a patient web portal (PWP) for self-management including relationships between characteristics and PWP use/nonuse, 2) in users of the PWP, describe the frequency and patterns of PWP use and, 3) compare glycemic control between PWP users and nonusers. The data sources for this study included the Epic EHR,

MyChart server log files, and a departmental Excel database. Data collection methods are clearly outlined along with data analysis techniques to elicit the best outcomes for the study questions.

## **Chapter 4**

### **Results**

Between January 2013 and January 2016, 181 patients met the inclusion criteria. Of the 181 patients, 23 patients were further excluded from the analyses due to lack of data on target blood sugars (meaning there were no data for any months within the third trimester) (n=17) or they were a duplicate patient (n=6). Patients with more than one pregnancy during the three year study timeframe were included and captured as a separate subject for each pregnancy. In other words if a patient had a pregnancy in 2014 and met the inclusion criteria, her data was captured for 2014. If she also had a subsequent pregnancy in 2016, and again met the inclusion criteria, her 2016 data was captured and analyzed as well but, the data was recorded as a separate occurrence. This was the case for 2 records. Of the 158 patients with complete data for analysis, 6 (4%) were considered short-term users, 85 (54%) were persistent users, and 67 (42%) were nonusers. Due to the power analysis discussed in the methods section suggesting the need for a minimum of 159 patients with 80 percent power for detecting a medium sized effect with a 0.05 significance, short-term users and persistent users were combined into a single user group. The final groups consisted of 67 (42 %) nonusers and 91 (58%) users.

#### **Results for Aim 1**

Research aim 1 sought to compare the characteristics of nonusers and users of a patient web portal (PWP) for self-management including relationships between characteristics and PWP use/nonuse (see Table 5).

Users of the PWP were more likely to be employed fulltime and this difference was statistically significant ( $p = .011$ ). Marital status was somewhat similar between the groups with

50 (74.6%) of nonusers and 74 (81.3%) of users being married and 28 (17.7%) of nonusers and 14 (20.9%) of users being single. Similarly, the chi-square test illustrates that there is not a statistically significant difference in marital status between users and nonusers of the PWP ( $p=.522$ ). Two categories of marital status, divorced and significant other, had expected counts less than five. Legally separated and widowed were zero for both PWP users and nonusers.

No statistically significant difference existed between users of the PWP and nonusers for history of previous pregnancies with GDM ( $p=.192$ ), although a greater percentage of users had no prior history of GDM in a previous pregnancy (71.1%) versus nonusers (61.2%). Similarly, a greater percentage of users had diet controlled gestational diabetes [ $n=76$  (83.5%)] than did nonusers [ $n=50$  (74.6%)] however; this was not statistically significant ( $p=.169$ ). Most patients had private insurance with a greater percentage noted in the user group [ $n=79$  (86.8%)] versus the nonuser group [ $n=51$  (76.1%)]. Nine (13.4%) of nonusers and five (5.5%) of PWP users did not have an insurance type on file.

This study sample was homogenous in terms of race. One hundred twenty five of the 158 subjects (79.1%) noted their race as White/Caucasian with a greater percentage being users of the PWP [ $n=78$  (85.7%)] compared to nonusers [ $n=47$  (70.1%)], ( $p=.023$ ). While statistically significant, there were numerous expected counts less than five when performing the chi-square test. The same holds true for ethnicity ( $p < .001$ ).

Table 5

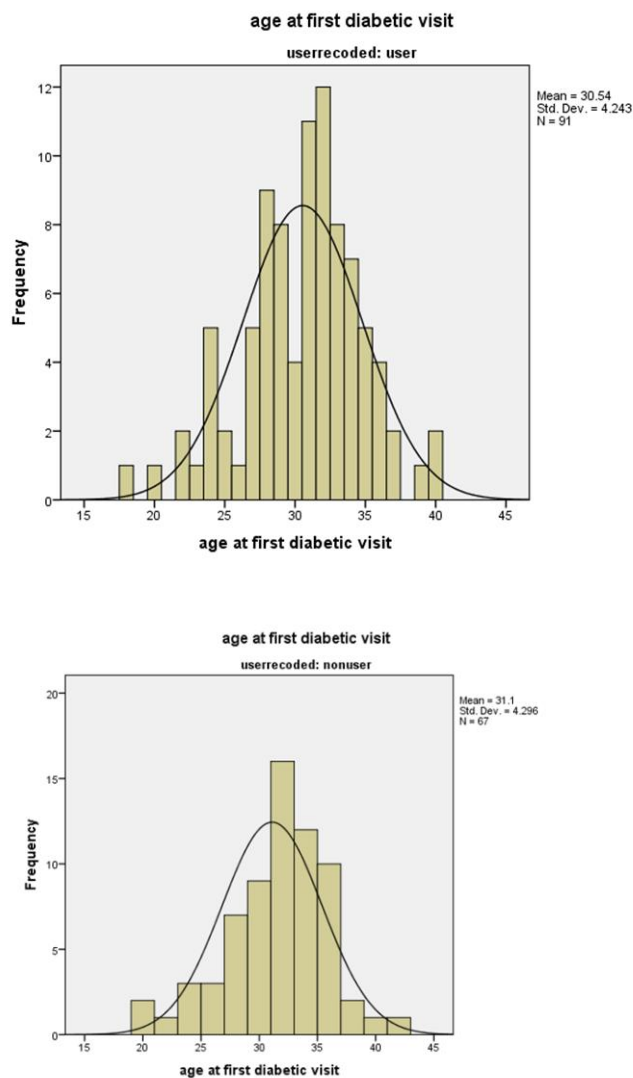
*Patient Characteristics of PWP Users and Nonusers for GDM self-management*

|                                 | Total       | Nonusers<br>N=67 | Users<br>N=91  | (p-value) |
|---------------------------------|-------------|------------------|----------------|-----------|
| <b>Age (mean)</b>               | N=158       | 31.1 (SD 4.30)   | 30.5 (SD 4.24) | .411      |
| <b>Race</b>                     | N=158       |                  |                | .023      |
| White/Caucasian                 | 125 (79.1%) | 47(70.1%)        | 78 (85.7%)     |           |
| Black/African American          | 4 (2.5%)    | 1(1.5%)          | 3 (3.3%)       |           |
| Asian                           | 16 (10.1%)  | 8 (11.9%)        | 8 (8.8%)       |           |
| Hispanic                        | 3 (1.9%)    | 3 (4.5%)         | 0 (0%)         |           |
| Hawaiian/Pacific Islander       | 0 (0%)      | 0/0%             | 0 (0%)         |           |
| American Indian/Native Alaskan  | 0 (0%)      | 0/0%             | 0 (0%)         |           |
| Other                           | 6 (3.8%)    | 4 (6.0%)         | 2 (2.2%)       |           |
| Unknown                         | 4 (2.5%)    | 4 (6.0%)         | 0 (0%)         |           |
| <b>Ethnicity</b>                | N=158       |                  |                | < .001    |
| Nonhispanic Latino              | 137 (86.7%) | 49 (73.1%)       | 88 (96.7%)     |           |
| Hispanic/Latino                 | 19 (12.0%)  | 16 (23.9%)       | 3 (3.3%)       |           |
| Patient chose not to answer     | 2 (1.3%)    | 2 (3.0%)         | 0 (0%)         |           |
| <b>Marital Status</b>           | N=158       |                  |                | .522      |
| Married                         | 124 (78.5%) | 50 (74.6%)       | 74 (81.3%)     |           |
| Single                          | 28 (17.7%)  | 14 (20.9%)       | 14 (15.4%)     |           |
| Divorced                        | 5 (3.2%)    | 2 (3.0%)         | 3 (3.3%)       |           |
| Significant Other               | 1 (0.6%)    | 1 (1.5%)         | 0/ 0%          |           |
| Legally Separated               | 0 (0%)      | 0/0%             | 0/0%           |           |
| Widowed                         | 0 (0%)      | 0/ 0%            | 0/ 0%          |           |
| <b>Insurance</b>                | N=158       |                  |                | .164      |
| Public                          | 14 (8.9%)   | 7 (10.4%)        | 7 (7.7%)       |           |
| Private                         | 130 (82.3%) | 51 (76.1%)       | 79 (86.8%)     |           |
| Not reported                    | 14 (8.9%)   | 9 (13.4%)        | 5 (5.5%)       |           |
| <b>Employment</b>               | N= 158      |                  |                | .011      |
| Fulltime                        | 89 (56.3%)  | 28 (41.8%)       | 61 (67.0%)     |           |
| Part-time                       | 18 (11.4%)  | 9 (13.4%)        | 9 (9.9%)       |           |
| Self employed                   | 5 (3.2%)    | 2 (3.0%)         | 3 (3.3%)       |           |
| Not employed                    | 46 (29.1%)  | 28 (41.8%)       | 18 (19.8%)     |           |
| <b>Prepregnancy BMI (mean)</b>  | N=152       | 28.6 (SD 6.16)   | 29.6 (SD 6.74) | .322      |
| <b>Type of GDM</b>              | N=158       |                  |                | .169      |
| Diet controlled                 | 126 (79.7%) | 50 (74.6%)       | 76 (83.5%)     |           |
| Insulin                         | 32 (20.3%)  | 17 (25.4%)       | 15 (16.5%)     |           |
| <b>Prior pregnancy with GDM</b> | N= 157      |                  |                | .192      |
| No                              |             | 41 (61.2%)       | 64 (71.1%)     |           |
| Yes                             |             | 26 (38.8%)       | 26 (28.9%)     |           |

Note. SD= standard deviation.

The histogram examining age in users and nonusers demonstrated a fairly normal distribution (see Figure 3). The skewness for nonusers was -.43 and the skewness for users was -.40 both within the conservative acceptable threshold of  $\pm .5$  for normality (Meyers et al., 2013). The mean age of nonusers (with standard deviations in parentheses) was 31.1 (4.30) and ranged from 20 to 42 years. Users of the portal ranged from 18 to 40 years of age with a mean of 30.5 (4.24).

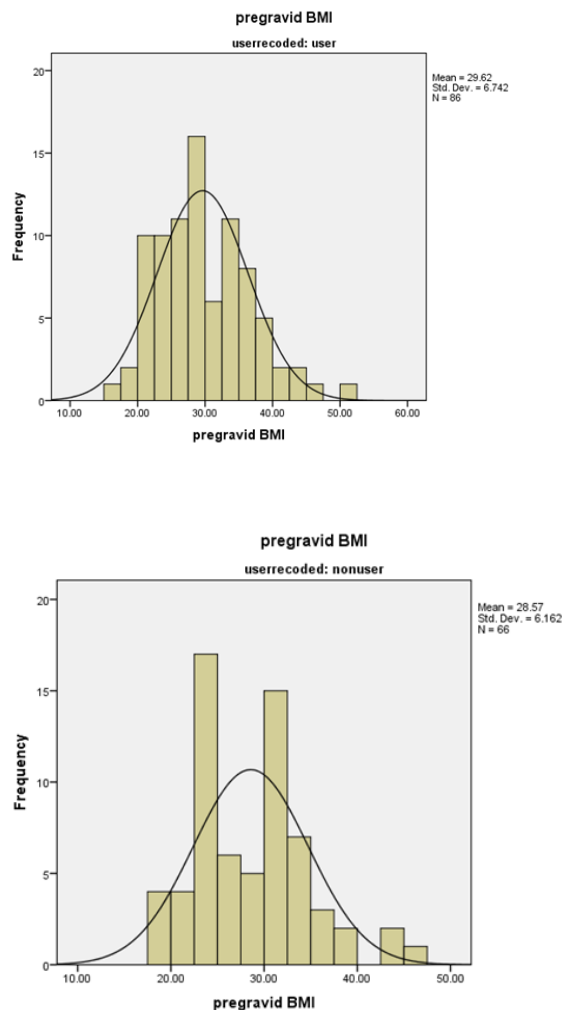
Figure 3. Histograms Showing Frequency Count of Age with Normal Curve Superimposed among Users and Nonusers of the PWP





The mean pre-pregnancy BMI was 28.6 (6.16) for nonusers and 29.6 (6.74) for users. The skewness for pre-pregnancy BMI was greater than age for both users and nonusers of the PWP. Skewness for nonusers was .542 and .601 for users. Despite this, the histogram displayed a fairly normal distribution for pre-pregnancy BMI in both groups (Figure 4). Of note, one missing value existed for pre-pregnancy BMI in the nonuser group and five missing values existed in the user group.

Figure 4. Histograms Showing Frequency Count of Pre-pregnancy BMI with Normal Curve Superimposed among Users and Nonusers of the PWP



An independent t-test was also conducted on the age and pre-pregnancy variables. For both age and pre-pregnancy BMI, the Levene's test for Equality of Variances  $p > .05$  so the equal variances assumed line was utilized for analysis. The results suggest that there was no significant difference in age for nonusers ( $M=31.10$ ,  $SD= 4.30$ ) and users of the PWP ( $M=30.54$ ,  $SD= 4.24$ ),  $t(156)= .82$ ,  $p= .411$ . Additionally, there was not a statistically significant difference in pre pregnancy BMI between nonusers ( $M= 28.57$ ,  $SD= 6.16$ ) and users of the PWP ( $M= 29.62$ ,  $SD= 6.74$ ),  $t(150)= .993$ ,  $p =.322$

Table 6

*Independent T-Tests for Age and Pre-pregnancy BMI among PWP Users and Non-users*

|                             | F    | Sig. | t     | df     | Sig. (two-tailed) | Mean dif. | Std. Error Diff. |
|-----------------------------|------|------|-------|--------|-------------------|-----------|------------------|
| <b>Age at first visit</b>   |      |      |       |        |                   |           |                  |
| Equal variances assumed     | .003 | .954 | .824  | 156    | .411              | .566      | .687             |
| Equal variances not assumed |      |      | .823  | 141.37 | .412              | .566      | .688             |
| <b>Pregravid BMI</b>        |      |      |       |        |                   |           |                  |
| Equal variances assumed     | .250 | .618 | -.993 | 150    | .322              | -1.06     | 1.06             |
| Equal variances not assumed |      |      | -1.00 | 145.44 | .316              | -1.06     | 1.05             |

*Note.* Sig.= significance; dif.= difference; Std= standard

## Results for Aim 2

Aim 2 sought to describe the frequency and patterns of PWP use in users of the PWP. The PWP was accessed 4,870 times by the 91 users over the study period from January 2013-Januray 2016. Descriptive statistics for each PWP feature are reported in Table 7. Three outliers were excluded from the analysis, resulting in 88 users. The most commonly used PWP feature

was the appointment reminders with a mean of 24.31 (*SD* 25.05) hits with a broad range from 0 to 93 hits. Of note, three patients accessed this feature more than 100 times and were excluded from the analysis. The after visit summary (AVS) was the second most frequently accessed feature during the third trimester of pregnancy with a mean of 15.44 (*SD* 17.00) ranging from 0 to 67. One patient was noted to have reviewed the AVS more than 100 times and was excluded from the analysis. Labs, secure patient messaging, and flowsheets were accessed less frequently and many people did not access these features at all. No patients utilized the insulin refill feature of the PWP (n=15).

Table 7

*Frequency of Use Related to Specific Features of the PWP*

| PWP feature    | <i>n</i> | Min | Max | Mean  | Mode | SD    |
|----------------|----------|-----|-----|-------|------|-------|
| Appt reminder  | 88       | 0   | 93  | 24.31 | 1    | 25.05 |
| AVS            | 88       | 0   | 67  | 15.44 | 3    | 17.00 |
| Labs           | 88       | 0   | 23  | 2.47  | 0    | 3.36  |
| Flowsheet      | 88       | 0   | 30  | 1.31  | 0    | 5.02  |
| Pt message     | 88       | 0   | 11  | .35   | 0    | 1.46  |
| Insulin refill | 88       | 0   | 0   | .00   | 0    | .000  |

*Note.* Min= minimum; Max= maximum; SD= standard deviation; Pt= patient; Appt= appointment; AVS= after visit summary

Patterns of PWP use were also measured in terms of consistency. Hits were any days that the patient accessed the portal regardless of the number of hits within that day. Hit month was any month that the patient accessed the PWP at least once in that month. Again, wide variation existed in terms of individual access as noted in Table 8.

Table 8

*Consistency of PWP Use among PWP Users*

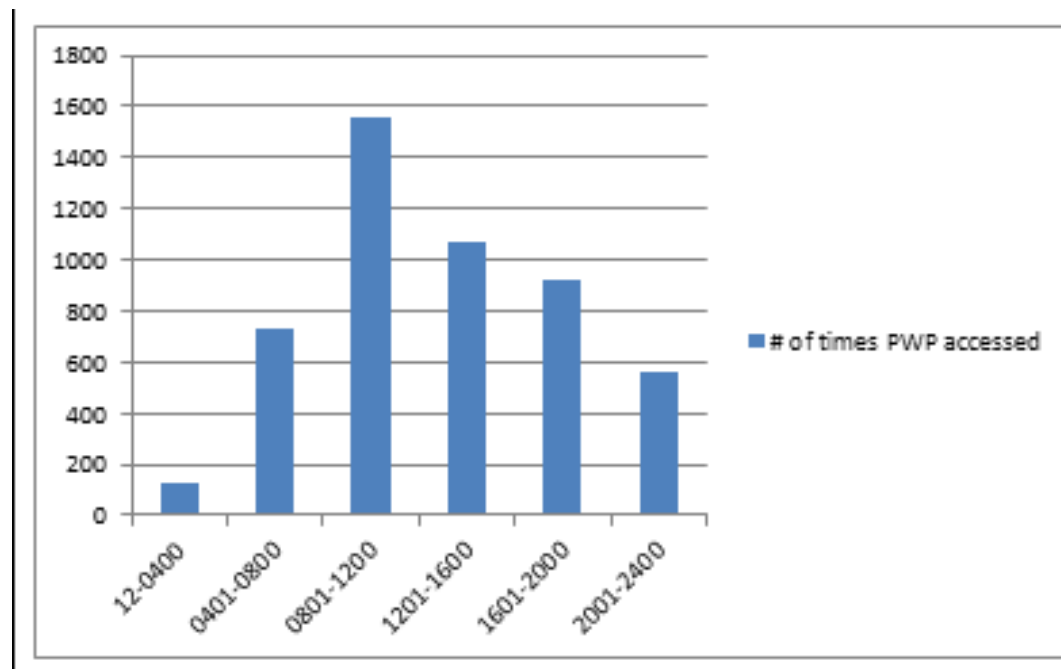
|            | Min | Max | Mean  | Mode | SD    |
|------------|-----|-----|-------|------|-------|
| Hits/day   | 1   | 61  | 13.60 | 6    | 10.16 |
| Hits/month | 1   | 3   | 2.76  | 3    | .06   |

Note:  $n=91$ ; Min= minimum; Max= maximum; SD= standard deviation

Duration or length of time spent on each PWP feature was unable to be measured in this study.

The most common time of day that the PWP was used was between 0801 and 1200, followed by 1201 and 1600. See Figure 5 for breakdown of PWP access by time of day.

*Figure 5. Frequency of PWP Access Throughout the Day Over the Third Trimester*



Due to the low usage overall, it was difficult to establish additional patterns of use. As noted earlier, six users only accessed the PWP for the first month. Four users only accessed the PWP once after initial log in while one person accessed features within the PWP 319 times.

### Results for Aim 3

Aim 3 sought to compare glycemic control between PWP users and nonusers. A repeated measures ANOVA was conducted to compare the effect of PWP use (IV) on percentage of blood glucose levels at month one, two, and three of the third trimester of pregnancy (DV). Target blood glucose levels were measured as the percentage of reported blood sugars per subject that was less than 125 mg/dL each month. The mean target blood glucose levels for nonusers of the PWP was similar to that of users however; users of the PWP continued to see improvement over all three months of the last trimester. Descriptive statistics for users and nonusers of the PWP are outlined in Table 9.

Table 9

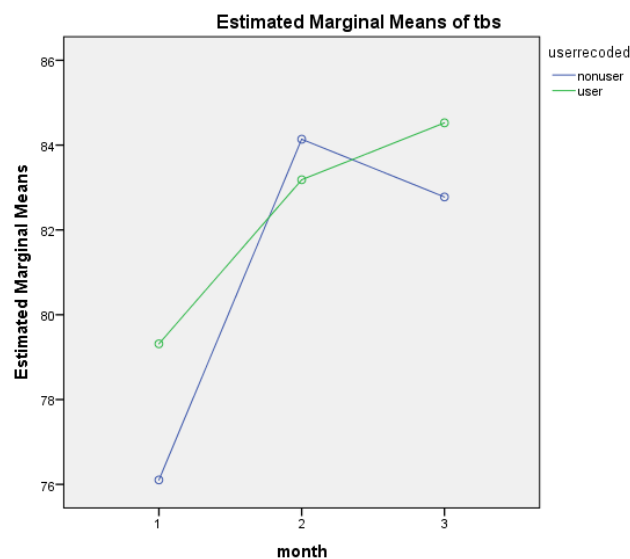
#### *Descriptive Statistics for Target Blood Glucose Levels among PWP Users and Nonusers*

|          | Month | Mean | Min | Max | SD   |
|----------|-------|------|-----|-----|------|
| Nonusers | 1     | 76.0 | 23  | 100 | 17.4 |
|          | 2     | 84.1 | 30  | 99  | 13.6 |
|          | 3     | 82.8 | 27  | 100 | 13.9 |
| Users    | 1     | 79.1 | 21  | 100 | 17.9 |
|          | 2     | 83.0 | 29  | 100 | 13.8 |
|          | 3     | 84.4 | 25  | 100 | 15.2 |

Note: Min=minimum; Max= maximum; SD= standard deviation

A Mauchly's Test for Sphericity was performed. This test assesses for the assumptions that the levels of within-subjects variable display equal variances and the variances are the same at each point (Meyers et al., 2013). The Mauchly's Test of Sphericity indicated that the assumption of sphericity was violated, [ $X^2(2) = 47.494, p < .001$ ] therefore, the Greenhouse-Geisser correction was used to generate sphericity-corrected  $F$  ratios. The Greenhouse-Geisser correction in the Tests of Within-Subjects Effects determined that the percentage of blood glucose levels within target range differed significantly over the three months ( $F(1.520, 191.474) = 1946.330, p = < .001$ ) but did not differ significantly between PWP users and nonusers ( $F(1.520, 191.474) = 184.428, p = .559$ ). The between groups test also indicates that there was not a statistically significant difference between PWP users and nonusers. The estimated marginal means graph (Figure 6) illustrates the improvement of target blood glucose levels in both PWP users and nonusers over time. There was a small decrease in target levels in the third month for nonusers that were not apparent in the PWP user group.

Figure 6. Estimated Marginal Means for Target Blood Glucose Between PWP Users and Nonusers



*Note.* Tbs= target blood sugars (blood glucose levels); Month= month 1, 2,3 of third trimester. Target blood glucose levels were measured as the percentage of reported blood sugars per subject that was less than 125 mg/dL each month .

### **Chapter Summary**

Data analysis was performed on a total of 158 women. This number was insufficient to divide the sample into the original three groups of nonusers, short-term users, and persistent users. As a result, short-term users and persistent users were combined into one group which resulted in 91 users and 67 nonusers. There were no statistically significant differences between PWP users and nonusers for age, pre pregnancy BMI, marital status, insurance, history of previous pregnancy with GDM, or type of GDM. A significant difference was noted for race and ethnicity but skewed by the numerous expected counts less than five in the analysis. There was a statistically significant difference between employment status among PWP users and nonusers with PWP users more likely to be employed fulltime and nonusers more likely to not be employed.

Users of the PWP tended to access the portal each month in the third trimester. However, consistency on the number of individual days in which the PWP was accessed varied greatly with the greatest number of patients accessing the PWP on six individual days throughout the third trimester. PWP users accessed the portal most frequently during the day between 0800-1200 and 1200-1600. The most frequently accessed features within the PWP were the AVS and appointment reminders. Finally, the percentage of blood glucose levels within target range differed significantly over the three months but did not differ significantly between PWP users and nonusers.

## **Chapter 5**

### **Discussion**

Patient web portals are increasingly being used to assist with diabetes self-management and have become a focus for meaningful use incentives and engaging patients in their care. Limited research exists on the use of PWP for GDM self-management. This study attempted to address this gap by describing the patient characteristics of users and nonusers of a GDM PWP, explore patterns of PWP use, and determine relationships between PWP use and glycemic control.

#### **Patterns of Use**

Patterns of use were measured through frequency, consistency of use, and time of day. As noted in the results section, the PWP features were accessed 4,870 from January 2103-January 2016 among 91 patients. There appears to be a wide range of use among the various features of the PWP with appointment reminders being the most frequently accessed followed by the AVS. Medication refills were not accessed at any point by any patient in this study. Although the majority of patients in the study were diet controlled, there were still 15 women on insulin who used the PWP, yet none of them requested a medication refill through the PWP. A plausible reason for this is the short duration in which insulin is prescribed. A patient may not need to request a medication refill if the original prescription was dispensed in an amount that could last three months by which point she gave birth and the GDM resolved.

Secure messaging was also used infrequently, which is incongruent with other studies. In fact, secure messaging and prescription refill requests are the most commonly accessed PWP features in many studies (Halamka et al., 2008; Silvestre, Sue, and Allen, 2009; Yamin et al., 2011). A possible reason for the decreased use of secure messaging in this study may be the frequent appointments that are involved with managing GDM. If questions are answered during



the appointment visit, there may be less reason to use secure messaging. That being said, frequent communication of blood glucose levels between the patient and diabetic educator is necessary to promote optimal blood glucose control and decrease maternal-fetal complications.. Secure messaging could be one method of this communication.

The consistency of PWP use showed most patients accessed the PWP over all three months in the third trimester. Variation existed among patients in terms of the number of individual days they accessed the PWP ranging from 1 to 61 days. Most patients accessed the PWP a total of six days throughout the third trimester. Other studies on PWP use in this population have not reported on this, which offers new insight into PWP use for patients with GDM. It appears that women with GDM who use the PWP do so over the course of the third trimester, which suggests that PWPs may provide health care providers with an opportunity to target information throughout the last three months of pregnancy to optimize blood glucose levels.

### **PWP Use and Glycemic Control**

While there was not a statistically significant difference in target blood glucose levels between PWP users and nonusers, the findings do illustrate improvements in target blood glucose levels in both groups over time. This would be expected given a well-established current educational program and frequent provider contact to assist with GDM management for pregnant women. Studies conducted in Australia and the United States demonstrated fewer perinatal complications, lower birthweights, and less preeclampsia in women who engaged in counseling and treatment programs specific to GDM (Crowther et al., 2005; Landon et al., 2009).

Interestingly, the nonusers only saw the improvement in the third trimester from month one to month two and then had a slight decline in month three. Moreover, the target blood

glucose levels of PWP users improved steadily over the three months, beginning in month one with a higher blood glucose percentage and ending with a higher blood glucose percentage in month three than nonusers. These differences cannot be directly attributed to PWP use, but suggests that further investigation into these differences should occur.

### **Patient Characteristics**

Except on the variable of employment, users and nonusers of the PWP did not display significant differences in terms of patient characteristics. There was a statistically significant difference in employment status between users and nonusers of the PWP; however, the results should be interpreted cautiously, since some of the categories of patient characteristics had fewer than 5 responses. Users were more likely to be employed fulltime. These results support a previous Italian study conducted by Scailoli and colleagues (2015) whereby pregnant women who were employed more often used the internet for health related information pertinent to pregnancy. In addition, these findings align with Kaptein and associates (2014) who concluded women with GDM desired education and care that minimized travel and time commitments. Similarly, Parson and colleagues (2014) identified several barriers to GDM management that are relevant to fulltime employment including lack of time, lack of clear and timely information, and lack of interventions that fit into women's multiple roles as caregivers, workers, and patients. Fulltime employees may find PWPs as a means to overcome some of these barriers. The PWP was most frequently accessed between the hours of 0800-1200. These results may speak to the accessibility of the PWP at a time when many people are at work.

Users and nonusers of the PWP primarily identified themselves as non-Hispanic white. The results of this study do not suggest a significant difference in insurance type among users and nonusers of the PWP. These findings are incongruent with some of the literature that

suggests a “digital divide” exists among users and nonusers of PWP. Previous studies by Laz and Bereson (2012) and Yamin et al. (2011) found a significant difference between PWP adoption rates with white patients adopting the PWP and internet significantly more than other racial and ethnic groups. Future analysis using a larger sample size should be conducted to validate the findings of this study for women with GDM.

Pertinent clinical related history did not appear to play a role in PWP use. Pre-pregnancy BMIs were fairly consistent among the user and nonuser groups as was the type of GDM. This was similar to findings in a study by Jones et al. (2015) regarding PWP use in 2,282 patients with cardiovascular disease and/or diabetes who sought care at Geisinger’s primary care clinics. The mean BMI was 31.36 in the nonuser group and 31.34 in the user group. The Jones et al. study did not outline diabetes type in their results.

The results of this author’s study mirror the total sample with more women diagnosed with diet controlled GDM than insulin for both the user group and nonuser group. Interestingly, slightly more insulin controlled GDM women were nonusers of the PWP than users of the portal. This may be due to the medical complexity of insulin management which at times requires more clinical appointments. Other studies have found that patients with more complex conditions or multiple co-morbidities have more frequent clinical appointments and less PWP adoption (Yamin et al., 2011).

Nonusers of the PWP may more often be women with insulin dependent GDM due to perceived lack of functionality or preferences in the existing PWP. A study by Ronda and colleagues (2015) found that insulin dependent diabetes patients wanted functionalities in the PWP such as the ability to add their injected insulin doses to the electronic diary and receive educational updates. The authors concluded that one uniform PWP may not be suitable for all

diabetes patients; rather designing separate PWP for different types of diabetes may be more successful. A follow-up study of women with GDM could be conducted to determine frequency of visits with patient's attitudes or values of the PWP. Furthermore, a future study could qualitatively explore the perceived barriers of PWP use for patients with insulin controlled GDM.

It was thought that women with no previous history of GDM would perhaps use the PWP more than women who had a previous pregnancy with GDM. While more women without a history of GDM did use the PWP, the difference was not statistically significant.

### **Limitations**

There were several limitations to this study. A common problem with retrospective designs is the sample size. In an effort to capture enough patients, a power analysis was conducted. Unfortunately, the numbers fell short to divide the groups into the original three groupings of nonusers, short-term users, and persistent users resulting in the consolidation of short-term users and users into one group.

Another limitation of this study was the unmeasured provider and clinic level behaviors that may have influenced the patient's use of the PWP. For example, this study did not measure the provider or RN preferences for the PWP, nor whether or not their preference affected the patient's use or nonuse of the PWP. Furthermore, specific clinic practices such as reminder phone calls for appointments and response time to secure messages were also not captured in this study. Previous research has suggested that provider and clinician preferences can greatly influence adoption of patient PWP use (Izarry et al., 2015; Logue & Effken, 2012). Future studies should capture these variables on this specific population.

This study also is limited to one Internet portal used within one organization therefore; the results may not be generalizable to other portals, patients, or health care systems (Polit &

Beck, 2012). This is notable given the wide variation and lack of standardization on the core elements of each PWP. This particular study encompassed the following PWP features: secure messaging, appointment reminders, AVS, lab results, flowsheets, and medication refills. Other studies on PWPs may include other features thus, generalizability is limited. The author acknowledges that the lack of standard definitions for users and nonusers of PWPs complicates the overall generalizability of the results. Definitions for users and nonusers were defined for this study however, vary immensely in the literature.

Finally, the inability to capture time spent in each feature of the PWP was a major limitation to this study. Number of log-ins or hits within a particular feature of the PWP does not capture the actual time spent within each feature of the PWP. Many PWP studies exist whereby usage is measured by the number of log-ins and hits to individual features of the PWP, but greater clarity is found when both the frequency and duration of PWP use is measured. In fact, a study by Jones et al. (2015) measured PWP usage by frequency, consistency, intensity, and duration of PWP use to outline user phenotypes and distinct patterns of use. The authors claim that amount of use/frequency captures just one domain of effective PWP use (Jones et al.). The Jones et al. study was the basis for the operational definitions of this study.

### **Significance**

#### **Practice**

Nurses play an important role in the promotion and sustainability of PWP use and are often the gateway to patient enrollment (IOM, 2010; Logue & Effken, 2012; Seckman, 2014). Nurses are also patient educators and themselves, are one of the largest groups of EHR users within a healthcare system making it critical that nurses have adequate knowledge of PWP features and offer insight into future design development (IOM, 2010).

This study informs nursing practice in several ways. First, it provides insight into the patient characteristics of users and nonusers of a PWP for GDM self-management. Scant research exists on this type of technology for GDM management much less the patient characteristics of these women (Carolan et al., 2015; Osborn, Mayberry, Mulvaney, & Hess, 2010). Understanding the patient differences between users and nonusers of the PWP is key to overcoming barriers to PWP use and instrumental in the design of future PWP enhancements for individual preferences. For instance, fulltime employment may be a motivator for PWP use. Future enhancements to the PWP should engage employed patients in the development and usability testing prior to implementation. Equally important, is to explore the barriers to PWP utilization for women who are not employed.

Furthermore, this study highlights some patterns of PWP use. Appointment reminders and the AVS were the most frequently accessed features of the PWP. Women who frequently accessed the appointment reminders could potentially respond positively to completing activities prior to a clinic visit. Examples of such activities include completing health questionnaires, goals, or administrative forms. Completion of these activities prior to the visit could save time during the actual appointment.

Women who frequently accessed the AVS may respond to additional factual information or resources regarding GDM. This may include links to credible websites and/or specific information embedded in the document. Prior studies suggest that between 70 to 90 percent of pregnant women are e-health users and 83 percent used the internet to influence a pregnancy related decision (Lagan, Sinclair, & Kernohan, 2010; Narasimhulu, Karakash, Weedon, & Minkoff, 2016). As primary educators to patients, nurses have an opportunity to provide

accurate, credible resources to patients through the AVS, which remains accessible to the patient throughout the pregnancy.

The PWP may serve as a repository for trusted and credible patient education resources or website links related to GDM management that are accessible to patients. Specifically, the PWP could provide nutrition details perhaps including carbohydrate counting guidelines and links to food/carbohydrate calculators. Exercise guidelines could also be outlined in the PWP. Previous research indicates that effective GDM management programs and interventions should include the three categories: (1) self-monitoring of blood glucose levels, (2) dietary and exercise interventions, and (3) behavioral interventions/counseling (Brankston et al., 2004; Carolan, 2015, Hopichler & Lechleitner, 2001, Landon et al., 2009; Moses et al., 2009). Certainly, if the intent of a GDM PWP is to improve maternal, fetal, and neonatal outcomes, the PWP itself should incorporate these three categories. The results of this PWP study suggest the Carolan (2015) framework was not used when developing and implementing the PWP however; suggestions on how incorporate its categories are discussed above.

Another key finding in this study was the consistency of PWP use among users. Users of the PWP tended to access the PWP over the full third trimester. This is valuable information as it provides an avenue for ongoing self-management possibilities. Certain strategies could be delivered at set time periods throughout the third trimester. For instance, currently patients are provided with a diabetes educational folder at their first visit which is reviewed between the patient and certified diabetic nurse educator. If PWP users tend to access the PWP throughout the third trimester, relevant information could be re-sent or reviewed with patients in different time increments to encourage sustained engagement with the PWP.

It is surprising that secure messaging and medication refills were so underutilized given most prior research finds these features to be the heavily utilized (Halamka et al., 2008; Silvestre

et al., 2009; Yamin et al., 2011). As discussed previously, a plausible reason for the lack of medication refill requests could be the short time period in which the women are taking insulin. If the initial prescription for insulin was issued in the third trimester and refills were issued for three or more months, there would be no reason for the patient to request a refill. This explanation was not validated in this study, but warrants further follow-up.

The infrequent use of secure messaging requires more investigation. Specifically, it is important that barriers and motivators to secured messaging are further explored. Nurses have the ability to influence this practice by supporting its use through their own practice and informing patients of these features. Moreover, nurses can explore other potential barriers to using any of the PWP features including usability and timeliness of communication and devise strategies to overcome the barriers.

## **Theory**

The use of the Individual and Family Self-Management Theory (IFSMT) guided this study (Ryan & Sawin, 2009). This study evaluated the current use of a particular organization's PWP for GDM self-management and did not test the IFSMT directly. Part of the reason for choosing the IFSMT as the guiding framework was its prior use in studies related to health promotion and more acute conditions (Doering, 2013; NIH reporter). The PWP in this study was the intervention that had the potential to influence the process of self-management and impact the distal outcome of glucose levels. Unfortunately, time spent on each feature of the PWP could not be measured in this study therefore; a connection between PWP use and self-management behaviors could not be investigated or validated.

This study does address several dimensions of the IFSMT. This study unveils the patient characteristics of users and nonusers of a PWP for GDM self-management incorporating the context domain of the IFSMT. White race, private insurance, and fulltime employment may be



viewed as protective factors for women with GDM to engage in PWP use. This study informs the process domain of the IFSMT by introducing a novel technology tool to promote self-management. Patients engaged most in the concepts of knowledge and beliefs by frequently accessing the AVS and social facilitation by reviewing appointment reminders. While the study results do not suggest a statistically significant difference in target blood glucose levels (distal outcome) over the third trimester, they do illustrate continuous improvement over the three months unlike the nonuser group. This suggests engagement of the self-management process on some level. Future research should measure the dosage of PWP use in terms of length of time to determine if patients are utilizing this tool for self-management guidance.

Due to the low overall PWP use, it is worth taking a step back. This study evaluated a current PWP already in production. It may be advantageous to supplement this study with usability testing and utilize a more technology based model before future evaluation should be performed on PWP use for GDM self-management. Usability studies enable PWP designers to understand the needs of the users and address barriers to improve utilization and effectiveness (Britto, Jimison, Munafo, Wissman, Rogers, et al., 2009). To the best of this author's knowledge no usability testing was conducted for the GDM PWP nor was a framework used. The Technology Acceptance Model (TAM) was created by Davis and explains computer usage behavior including the cognitive and affective determinants of computer acceptance (Davis, Bagozzi, & Warshaw, 1989). The TAM postulates that behavioral intention to use computer technology is influenced by external variables, perceived usefulness, and perceived ease of use. This model could be the theoretical framework for a future usability study with this PWP for GDM patients.

## **Health Policy**

This study could inform improvements in local policy. The healthcare system from which the study sample was pulled is committed to the use of PWP for its patients and has already adopted several practices to increase enrollment. Enrollment with a PWP does not always equate to ongoing use and additional strategies should be instituted to promote sustained use of the PWP among its users. Beyond the enrollment information, nurses and other clinicians should provide patient information on the features of the PWP and how they relate to their patient/provider interactions. This also means that nurses need to be knowledgeable on the components of the PWP which may require additional and ongoing training for them as well.

The development and use of PWP have primarily been promoted for chronic conditions within the primary care setting since this is where much of the meaningful use financial incentives reside for providers and healthcare organizations. However, PWP use has been expanding into certain specialty areas without much modification to its original format. The idea of “build it and they will come” is not evidenced-based and should not be utilized.

Administrators and clinical staff should explore patient differences and preferences based on clinical conditions and modify the PWP accordingly. Usability assessments and testing should be standard when developing and implementing any PWP in any organization. Modifications should be made based on patient and provider feedback prior to implementation. This study provides insight into the current use for the GDM population and begins to suggest opportunities for improvement.

This study also lends itself to a further evaluation of clinician and provider workflow. Administrators and clinicians alike should appreciate the required changes in outpatient workflow as compared to in-person visits. Izarry et al. (2015) point to the difficulty of coordinating PWP management tools with current provider/clinician workflow and priorities

suggesting that a greater understanding of the adjustments is needed and may require changes in current roles and responsibilities. A clinician or provider's work day no longer consists of a patient schedule with a set number of patients to see in person. It has evolved to be a multi-faceted plan of in-person visits, email messages, prescription refills, results review, and other communication that needs to be coordinated amongst various members of the healthcare team.

Ultimately the adoption of PWP in any setting, for the population of women with GDM, or another population, will require time and resources to thoroughly assess the needs of the patient population, the features needed, the readiness for adoption, usability testing, and ongoing modifications. This study offers some beginning insights into the characteristics and patterns of PWP use among current users. Opportunities exist for modifications, enhancements, and usability testing.

On a more global level, this study contributed to the body of research on PWP use beyond chronic conditions and primary care. As meaningful use expands it is important to take a proactive approach to PWP application beyond chronic care and make modifications that are specific for that patient population.

## **Research**

Since scant research exists on PWPs for GDM management, this study provides just a glimpse into this subject for a particular healthcare system and offers ample future research possibilities. It is suggested that this study be replicated in other systems with the same or similar PWP features and measure patterns of use as defined by frequency, intensity, consistency, and duration as described by Jones et al. (2015).

Additional research could also explore other outcomes beyond glucose levels. Studies of PWP use among men and women with diabetes have demonstrated positive effects on diabetes

distress scores with PWP use (Fonda et al., 2009). For example, an initial study could be conducted to validate the Diabetes Distress Screening Scale or similar scale on the GDM population. Then, another study could determine if a relationship exists between PWP use and diabetes distress. There are additional possibilities to examine medication adherence in this population of patients. Although insulin use is less frequent than diet management for GDM control, it is worth investigating whether there is greater medication adherence among women with GDM who use a PWP. A study by Kim and colleagues (2006) concluded that PWP users diagnosed with diabetes had greater medication adherence than nonusers of the PWP. However, given the study is almost a decade old and the additional features of PWPs, this study should be replicated.

Several opportunities also exist for future qualitative studies. One of great importance is to explore the barriers of using a PWP for GDM self-management particularly for features such as secure messaging and medication refills. Beyond the barriers, virtually nothing is known about what functionality or enhancements users are looking for within a PWP that would promote GDM self-management or the usability of the current PWP. Other research results have demonstrated the benefits of early usability testing and patient portal design (Izarry et al., 2015). Usability testing was not conducted for this organization's PWP specific to GDM management. Finally, provider preferences, workflow, and barriers should be explored.

## **Conclusions**

The following conclusion can be made based on the results of this study:

1. Appointment reminders were the most frequently accessed PWP feature.
2. The AVS was the second most commonly accessed PWP feature.
3. Medication refills were not accessed at all by any patient in the study.

4. PWP users most often accessed the PWP each month in the third trimester.
5. The PWP was most frequently accessed between the hours of 0800-1200.
6. PWP users tended to be employed fulltime.
7. PWP users saw improvements in target blood glucose levels in each of the three months in the third trimester.

An assumption cannot be made that improvement in target blood glucose levels is directly correlated with PWP use. Furthermore, healthcare delivery factors such as PWP usability and provider/clinician endorsement was not measured in this study, but does contribute to patient's adoption of the PWP as noted in previous studies (Logue & Effken, 2012; Wald et al., 2010). It is clear that with the continued CMS and Medicaid incentives for meaningful use, PWPs will continue to evolve and should be evaluated for their effectiveness. Future research should aim to determine barriers and facilitators to PWP use for GDM self-management, conduct usability testing on existing PWPs, and determine which, if any, features of the PWP and length of time contribute to GDM self-management. . Finally, future studies should not negate nonusers. It is equally important to understand the self-management activities of this group of women as they navigate through their pregnancy with GDM. Healthcare systems should not view PWPs as a panacea, especially for populations of people that may eschew technology for cultural or other beliefs.

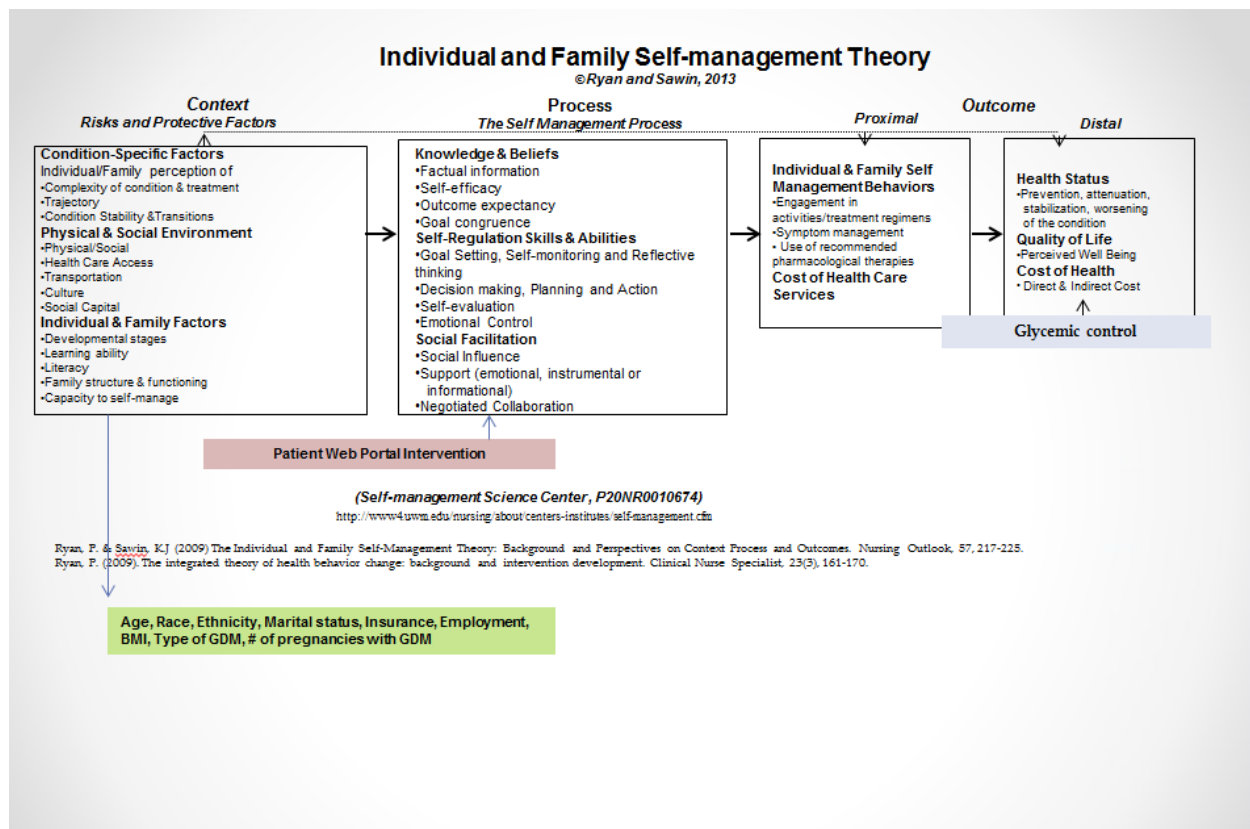
The emergence of health information technology (HIT) and PWPs has created new opportunities for patient involvement in their healthcare. This technology can only be successful with the input of patients and the acceptance and adoption of clinicians and providers. It is clear that future research is needed in order to fully implement a patient-centered PWP that optimizes

technological capabilities while addressing barriers to its use. Specific user characteristics and needs should be addressed. Specific features of PWP should be studied and outcomes measured.

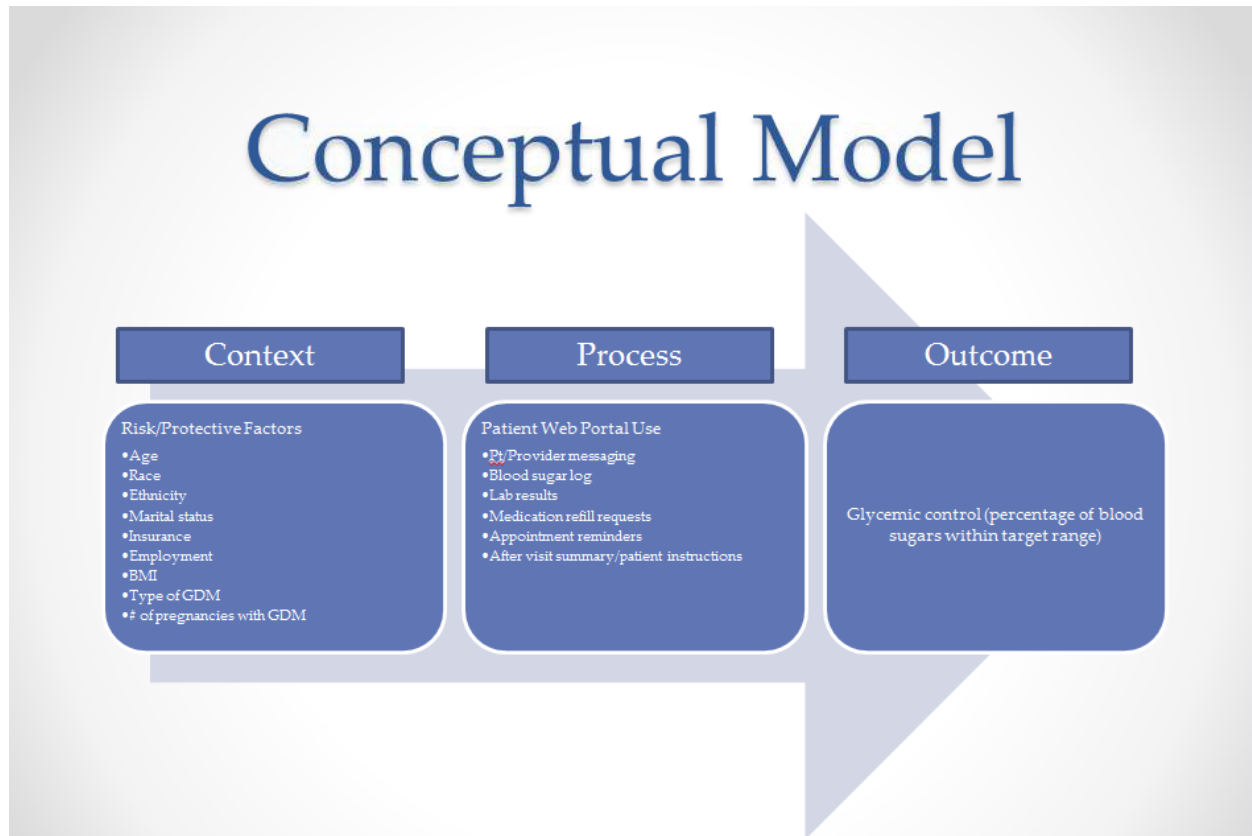
### **Chapter Summary**

The findings of the study were discussed and connections to existing literature outlined. Limitations of the study were clearly reviewed. Significance to practice, theory, policy, and research were discussed in addition to overall conclusions that can be drawn from this study. Finally, future research recommendations were suggested.

**Figure 1.** A mapping of study variables using the Individual and Family Self-Management Theory



**Figure 2.** Conceptual Model using the Individual and Family Self-Management Theory



*Figure 2.* Conceptual model for study adapted from the IFSMT of Ryan and Sawin (2009). Variables of the study are listed according to the IFSMT dimensions: Context, Process, and Distal Outcome.



**Table 1***Context Dimension Variables*

| Construct                     | Concept                | Variable                  | Measure  |
|-------------------------------|------------------------|---------------------------|--|
| Condition specific            | Complexity, trajectory | Type of GDM               | Documentation within the EHR of diet controlled GDM or insulin. If at any point the patient was started on insulin, code for insulin.                              |
| Condition specific            | Complexity             | BMI                       | Weight in kilograms divided by the square of height in meters (CDC). This is a calculation in the EHR based on data entered for weight and height.                 |
| Condition specific            | Complexity             | # of pregnancies with GDM | Number of pregnancies (including current pregnancy) with a diagnosis of GDM as noted within the EHR and validated by patient's report. With or without live birth. |
| Physical & social environment | Culture                | Race                      | Self-reported race according to the choices outlined by the Office of Management and Budget with the U.S. government   |
| Physical & social environment | Culture                | Ethnicity                 | Self-reported ethnicity according to the choices outlined by the Office of Management and Budget with the U.S. government  |
| Physical & social environment | Social support         | Marital status            | Self-reported marital status according to the EHR provided choices   |
| Physical & social environment | Social capital         | Insurance                 | Scanned insurance card information at time of first visit to diabetes in pregnancy clinic.   |
| Physical & social environment | Social capital         | Employment                | Self-reported employment status according to the EHR choices of yes, or no   |
| Individual & family factors   | Developmental stage    | Age                       | Self-reported years that have passed since the person's date of birth. Reported in a whole number over the age 17.   |

**Table 2***Process/Outcome Dimension Variables*

| Construct           | Concept                               | Variable                             | Measure  |
|---------------------|---------------------------------------|--------------------------------------|--|
| Knowledge & Beliefs | Knowledge through factual information | Self-initiated review of EHR data    | Number of times flowsheets and After Visit Summaries (AVS) reviewed              |
| Self-regulation     | Self-monitoring                       | Blood sugar self-monitoring          | Number of times blood sugars entered or reviewed in the log                      |
| Self-regulation     | Self-monitoring                       | Self-initiated review of lab results | Number of times lab results reviewed (Hemoglobin A1c and glucose tolerance test) |
| Self-regulation     | Self-monitoring and decision making   | Request for medication renewal       | Number of medication renewal requests  |
| Social facilitation | Social support                        | Use of appointment reminders         | Percentage of appointment reminders reviewed                                     |
| Social facilitation | Social Support                        | Email communication use              | Number of secure messages to providers related to GDM management.                |
| Distal Outcome      | Health Status                         | Glycemic control                     | Percentage of blood sugars within target range each month                        |

**Table 3.**

Studies of the Impact of Patient Web Portals on Diabetes Patient Outcomes

| Author/year           | Study design/level of evidence*                  | Duration of Study | Subjects   | Intervention/Control groups (if applicable)   | Measures  | Outcomes/Results   |
|-----------------------|--|-------------------|--|---|---|--|
| Fonda et al./ 2009    | RCT<br><br>Level II                              | 12 months         | N= 102<br>N= 52 intervention,<br>N=52 control<br>Type 1 and Type 2<br>DM<br><br>USA                                | <u>Intervention:</u> Internet-based care management (MyCare Team website, glucose and BP readers)<br><br><u>Control:</u> Usual care                                   | Diabetes distress<br><br>HbA1c levels   | Decreases in HbA1c and diabetes distress based on level of usage.<br><br>Distress scores lower among users than nonusers   |
| Grant et al. /2008    | Cluster randomized control trial<br><br>Level II | 12 months         | N= 126 intervention group<br><br>N= 118 control group<br>Type 2 DM<br><br>11 primary care clinics in Massachusetts | <u>Intervention:</u> access to DM specific application with medication management, view of current treatment, BP, & preventive care<br><br><u>Control:</u> usual care | HbA1c levels, BP, lipid levels  | Decreased rate of primary care visits<br><br>Decrease in HbA1c level after 1 yr (0.16% vs. 0.26%, p=0.62)<br><br>Slight improvement in BP & lipids after 1 yr (not significant)<br><br>Medication adjustment for hyperglycemia (29% vs. 15%, p=0.1).<br><br>Medication adjustment for hyperlipidemia (11% vs. 0%, p=0.03)  |
| Holbrook et al./ 2009 | RCT<br><br>Level II                              | 5 months          | N=511<br>Type 2 DM<br><br>Primary care setting<br><br>Canada   | <u>Intervention:</u> web-based color-coded diabetes tracker and messaging<br><br><u>Control:</u> Usual care   | Continuity of care<br><br>Quality of life satisfaction<br><br>Clinical and process composite scores | Process composite score significantly better in intervention vs. control (difference 1.27, p<0.001)<br><br>Intervention group vs. control had improvement (difference 19.1%, p<0.001)<br><br>Clinical composite score significantly better in intervention vs. control (0.59, p=0.02)<br><br>Intervention group reported greater satisfaction with diabetes care |

**Table 3.**

Studies of the Impact of Patient Web Portals on Diabetes Patient Outcomes

| Author/year           | Study design/level of evidence* | Duration of Study | Subjects  | Intervention/Control groups (if applicable)   | Measures   | Outcomes/Results  |
|-----------------------|---------------------------------|-------------------|---|---|--|---|
| Kim et al./ 2006      | Pre-post<br>Level IV            | 3 months          | N=45<br>Type 2 DM<br><br>Korea  | <u>Intervention:</u> short message by cell phone and internet web portal<br><br>No control  | HbA1c levels, 30 min. exercise (days/week), adherence to medication (days/week), & foot care (days/week) | HbA1c difference $-1.1\% \pm 2.1$ ( $p<0.006$ )<br>Exercise difference: $0.9 \pm 2.0$ days/week ( $p<0.036$ )<br>Medication adherence difference: $1.1 \pm 1.9$ days/week ( $p<0.032$ )<br>Foot care difference: $1.1 \pm 2.2$ days/week ( $p<0.030$ )  |
| McCarrier et al./2009 | Pilot, RCT<br>Level II          | 12 months         | N= 77<br>29-49 years old<br>Type 1 diabetes<br>Last HgA1c level $>7.0\%$<br><br>Seattle, WA | <u>Intervention:</u> usual care plus the nurse-practitioner-aided Web-based case management program<br><br><u>Control:</u> usual clinic care  | HgA1c<br>Self-efficacy   | intervention group had decrease in HgA1C test values of $0.37\%$ , control group had slight increase of $0.11\%$ . (difference of $-0.48\%$ was not significant)<br><br>beneficial treatment effect on self-efficacy  |
| McMahon et al./ 2005  | RCT<br>Level II                 | 12 months         | N=104<br><br>Type 1 and Type 2 DM<br><br>USA  | <u>Intervention:</u> diabetes education class + web-based care management (glucose, BP monitoring devices, & website)<br><br><u>Control:</u> usual care of diabetes education class | HbA1c levels<br>BP<br>HDL<br>LDL<br>Triglycerides  | HbA1c levels $-1.2$ in control vs. $-1.6\%$ in intervention group ( $p<0.05$ )<br><br>BP levels significantly decreased in intervention group ( $-10 \pm 17$ ) vs. control ( $-7 \pm 21$ mmHg) $p<0.01$<br><br>LDL change- not significant, HDL levels increased in intervention group ( $3 \pm 6$ mg/dl) vs. control ( $1 \pm 6$ mg/dl) $p<0.05$ . Triglycerides significantly decreased in intervention group ( $-38 \pm 99$ mg/dl) vs. control ( $-2 \pm 60$ mg/dl) $p<0.01$ |

**Table 3.**

Studies of the Impact of Patient Web Portals on Diabetes Patient Outcomes

| Author/year        | Study design/level of evidence*                             | Duration of Study                  | Subjects  | Intervention/Control groups (if applicable)   | Measures   | Outcomes/Results  |
|--------------------|---|------------------------------------|---|---|--|---|
| Noel et al. /2004  | RCT<br><br>Level II   | 12 months                          | N=104<br>Single co-morbid diagnoses: heart failure, chronic lung disease, diabetes<br><br>USA   | <u>Intervention:</u> home telehealth (electronic monitoring and alert system) + nurse case management<br><br><u>Control:</u> Usual home health care + nurse case management | HbA1c levels<br><br>Quality of Life (cognitive status, functional level, patient satisfaction, self-rated health)<br><br>Urgent & total visits | HbA1c levels: +0.8% in control vs. -1% in intervention (p<0.01)<br>Cognitive status: 19.4 in control vs. 20.0 in intervention (p<0.01)<br>Urgent visits: +5 in control vs. -83 in intervention group (p<0.05)<br>Functional level, pat. satisfaction, self-rate health, & total visits- not significant |
| Osborn et al./2013 | Mixed methods study, cross-sectional design<br><br>Level IV | Not defined                        | 75 adults with Type 2 DM receiving medications<br><br>English speaking<br><br>Recruited from VUMC primary care clinics in Nashville, TN | Focus groups, surveys, and medical chart review   | Use of portal<br><br>Methods portal users use to manage their medication<br><br>Ideas to improve functionality of portal                       | Portal users more likely to be White, have higher incomes, & have private insurance<br><br>More frequent use of portal was associated with better A1C (Spearman rho= - 0.30, p=.02)<br><br>Suggestions to improve functionality- link to pharmacy, deliver med information in a user-friendly format    |
| Osborn et al./2010 | Systematic review   | Studies published from 1/2000-2010 | 26 articles reviewed<br>Type 1 or Type 2 diabetes   | Impact of diabetes interventions using PWP on improving self-care behaviors, glycemic control, and health outcomes  | Self-care behaviors, glycemic control, health outcomes   | PWP-delivered interventions:<br>Enhance patient-provider communication, expand access to health information, improve disease management and patient outcomes  |

**Table 3.**

Studies of the Impact of Patient Web Portals on Diabetes Patient Outcomes

| Author/year          | Study design/level of evidence*                    | Duration of Study | Subjects  | Intervention/Control groups (if applicable)   | Measures   | Outcomes/Results  |
|----------------------|--|-------------------|---|---|--|---|
| Ralston et al./2009  | Pilot RCT<br><br>Level II                          | 12 months         | N= 83<br>18 to 75 years old with type 2 diabetes<br><br>HbA1c in the prior 12 months was $\geq 7\%$<br><br>Seattle, WA  | <u>Intervention</u> : access to electronic medical records, secure e-mail with providers, feedback on blood glucose readings, education, and an interactive online diary<br><br><u>Control</u> : usual care | HgA1c<br>BP<br>Total cholesterol   | HgA1c levels declined by 0.7% (95% CI 0.2–1.3) on average among intervention patients compared with usual-care patients.<br><br>Systolic blood pressure, diastolic blood pressure, total cholesterol levels, and use of in-person health care services did not differ between the two groups. |
| Shaw & Ferranti/2011 | Cross-sectional secondary analysis<br><br>Level IV | 5 months          | All patients with Type 1 or Type 2 DM and enrolled in a provider-centered decision support tool included<br><br>From DUMC Portal users n= 5,937, nonusers n= 14,085 | N/A   | % of diabetes patients that use a portal<br><br>HbA1c levels<br>Lipid levels | 29.7% of patients with diabetes use the portal<br><br>Portal use was a significant predictor of HbA1c ( $p < .0001$ )<br><br>Portal use not a significant predictor of LDL and total cholesterol levels   |
| Smith et al./2004    | Pre-post test<br><br>Level IV                      | 9 months          | N=16<br>Type 1 and Type 2 DM<br><br>USA   | <u>Intervention</u> : MyCareTeam program- web-based diabetes management program. Pts entered blood glucose levels, exercise log, and got messages<br>No control   | HbA1c levels, BP, HDL, LDL, triglycerides                                    | HbA1c levels -2.2% ( $p < 0.0001$ ) reduction in heavy users<br><br>BP, HDL, LDL, & triglycerides- not significant  |

**Abbreviations Used in Evidence Table**

**&**: and **BMI**: body mass index **BP**: blood pressure **btwn**: between **diff**: different **DM**: diabetes mellitus **DUMC**: Duke University Medical Center **ER**: emergency room **govt**: government **HbA1c**: hemoglobin A1c **HDL**: high-density lipoprotein **LDL**: low-density lipoprotein **mg/dl**: milligrams per deciliter

**MHAV**: MyHealthAtVanderbilt **mmHg**: millimeters of mercury **min**: minutes **N**: number **PCP**: primary care provider **pts**: patients **PWP**: patient web portal **RCT**: randomized control trial **SES**: socioeconomic status **vs**: versus **VUMC**: Vanderbilt University Medical Center **yr**: year

**Table 4.***Conceptual and Operational Definitions of Study Variable*

| Variable               | Conceptual Definition   | Operational Definition  | Response Type  |
|------------------------|---|---|--|
| <b>CHARACTERISTICS</b> |   |   |  |
| Age                    | the number of years since a person's date of birth.   | Self-reported number of years since the person's date of birth. Reported in a whole number over the age 17.               | 18-100   |
| Race                   | Category of humankind that share distinctive physical traits (Merriam-Webster dictionary)   | Self-reported race according to the choices outlined by the Office of Management and Budget with the U.S. government      | American Indian/Alaska Native<br>Asian<br>Black or African American<br>Native Hawaiian or Pacific Islander<br>White/Caucasian<br>Other<br>Unknown<br>Patient refused |
| Ethnicity              | Ethnic quality or affiliation (Merriam-Webster dictionary)  | Self-reported ethnicity according to the choices outlined by the Office of Management and Budget with the U.S. government | Hispanic/Latino<br>NonHispanic Latino<br>Patient refused<br>Unknown  |
| Marital Status         | The condition of being married or unmarried   | Self-reported marital status according to the EHR provided choices  | Divorced<br>Legally separated<br>Married<br>Significant Other<br>Single<br>Widowed<br>Unknown  |
| Insurance              | Private insurance is coverage obtained through an employer, union, or individual purchase. Public insurance is Medicaid, Medicare, other government-sponsored programs, or a military health plan (TRICARE, VA, or CHAMP-VA). Adults covered by both private and public | Scanned health insurance card information at time of first visit to the diabetes in pregnancy clinic                      | Will then categorize to:<br>Private<br>Public<br>Uninsured<br>Nothing on file  |

|                            |  |  |  |
|----------------------------|--|--|--|
|                            | insurance were considered to have private insurance. Persons without private or public insurance and those with only Indian Health Service coverage or only a private plan that paid for one type of service such as accidents or dental care are considered uninsured (CDC, 2012) |  |  |
| Employment                 | Work for another in return for financial or other compensation.  | Self-reported employment status according to the EHR choices of yes, or no.  | Fulltime<br>Part-time<br>Self-employed<br>Not employed |
| BMI                        | Measure of body fat based on height and weight in the adult male/female  | Weight in kilograms divided by the square of height in meters (CDC). This is a calculation in the EHR based on data entered for weight and height. | 1-100  |
| Type of GDM                | Blood sugars are maintained through diet alone or in combination with insulin  | Documentation within the EHR of diet controlled GDM or insulin. If at any point the patient was started on insulin, code for insulin.              | Diet controlled<br>Insulin                             |
| Preg. with GDM             | Any prior pregnancies with a diagnosis of GDM  | Any prior pregnancies with a diagnosis of GDM as noted within the EHR and validated by patient's report. With or without live birth.               | Yes<br>No  |
| <b>PWP FEATURES</b>        |  |  |  |
| Patient/Provider messaging | Exchange secure e-mail with their health care providers via the patient portal (HealthIT.gov)  | Measured by the number of times the patient sent a secure message to the GDM provider (Nurse or MFM) in the third trimester.                       | Whole number   |
| Flowsheets/Blood sugar log | Enter/review blood sugar numbers in a secure flowsheet via   | Measured by number of times the patient enters or reviews data in blood  | Whole number   |



|                                  |   |  |   |
|----------------------------------|---|--|---|
|                                  | the patient portal. Patient and provider as access to this data.  | sugar log flowsheets during the third trimester.   |   |
| After visit summary/instructions | Summary and/or instructions regarding the clinic visit for a specific date. Sent via secure messaging via patient portal.             | Measured by the number of times the patient selects the after visit summaries related to GDM visits during the third trimester.            | Whole number  |
| Labs                             | Results of any diagnostic test that can be reviewed via the patient portal  | Number of times Hemoglobin A1c levels and Glucose tolerance tests are reviewed via patient portal during the third trimester of pregnancy. | Whole number  |
| Appointment reminders            | A scheduled reminder via the patient portal of an upcoming appointment for the patient.   | The number of times the appointment reminder for GDM visits were reviewed by the patient during the third trimester of pregnancy.          | Whole number  |
| Medication refills               | Medication refill message sent by patient to provider via secure messaging.   | Insulin medication refill requests sent to GDM provider via secure messaging during the third trimester of pregnancy.                      | Whole number  |
| <b>OUTCOME</b>                   |   |  |   |
| Target blood sugars              | Percentage of blood sugars that are within the target range for adequate glycemic control for GDM                                     | Percentage of reported blood sugars per subject that is less than 125 mg/dL each month   | Percentage per month and then for entire third trimester                          |
| <b>PWP USE</b>                   |   |  |   |
| PWP frequency of use             | number of “hits” or times the patient accesses a feature of the PWP.  | Number of times a subject logs-in or accesses a certain feature of the PWP related to GDM during the third trimester                       | Whole number  |
| PWP pattern of use               | Utilization of features of the PWP over time. Examples: clustered activity to first month then stopped using or only used one feature | <ul style="list-style-type: none"> <li>• PWP features accessed</li> <li>• number of hits to each feature</li> <li>• Consistency</li> </ul> | Based on categories of users<br>List of what features used over the study period. |

|  |                        |   |  |
|--|------------------------|---|--|
|  | of the PWP entire time | <p>Hit day= any day the patient accessed the PWP in the third trimester regardless of the number of times accessed that day or features accessed.</p> <p>Hit month = captured any individual month where the patient accessed any feature of the PWP at least once.</p> <ul style="list-style-type: none"> <li>• Time of day</li> </ul> | <p>Reported in mean</p> <p>Reported in mean</p> <p>Reported in 4 hour increments</p> |
|--|------------------------|---|--|

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## Appendix A

### Institutional Review Board Deferral, ProHealth Care

#### Institutional Review Board (IRB) Authorization Agreement

**Name of Institution Providing IRB Review (Institution A):**

University of Wisconsin – Milwaukee (UWM)

IRB Registration #: IRB00000263; Federalwide Assurance (FWA) #FWA00006171

**Name of Institution Relying on the Designated IRB (Institution B):**

ProHealth Care, Inc.

IRB Registration #: IORG0002642; FWA #: FWA00014941

The Officials signing below agree that ProHealth Care Inc, IRB may rely on the University of Wisconsin Milwaukee's IRB for review and continuing oversight of its human subjects research described below: (*check one*)

☐ This agreement applies to all human subjects research covered by Institution B's FWA.

☒ This agreement is limited to the following specific protocol(s):

**Name of Research Project:** Patient Web Portal Use among Women with Gestational Diabetes

**Name of Principal Investigator:** Megan Anderson (UWM and ProHealth); Jennifer Doering (UWM)


**Sponsor or Funding Agency:** N/A

☐ Other (*describe*): \_\_\_\_\_

The review performed by the designated IRB will meet the human subject protection requirements of Institution B's OHRP-approved FWA. The IRB at Institution A will follow written procedures for reporting its findings and actions to appropriate officials at Institution B. Relevant minutes of IRB meetings will be made available to Institution B upon request. Institution B remains responsible for ensuring compliance with the IRB's determinations and with the Terms of its OHRP-approved FWA. This document must be kept on file by both parties and provided to OHRP upon request.

This Agreement shall become effective upon the last date signed below and will automatically renew for successive one-year periods upon UWM IRB's approval of the continuation unless the agreement is terminated or the study is completed/closed. This Agreement may be terminated at anytime upon 30 days written notice to the other party's Institutional Official. Upon termination, each institution must assume oversight of the activities of its own employees or agents.

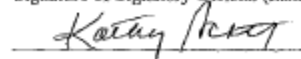
Signature of Signatory Official (Institution/Organization A):



Date: 10/28/16

Name: Geoffrey Hurtado Institutional Title: Associate Vice Chancellor, Facilities Planning and Management

Signature of Signatory Official (Institution/Organization B):



Date: 10/11/16

Name: Kathy Scott

Institutional Title: Chief Integration Officer



## Appendix B

### Institutional Review Board Approval, University of Wisconsin-Milwaukee



Department of University Safety & Assurances

Melissa Spadanuda  
IRB Manager  
Institutional Review Board  
Engelmann 270  
P. O. Box 413  
Milwaukee, WI 53201-0413  
(414) 228-3173 phone  
(414) 228-6729 fax

<http://www.irb.uwm.edu>  
[spadanud@uwm.edu](mailto:spadanud@uwm.edu)

#### New Study - Notice of IRB Expedited Approval

Date: December 20, 2016

To: Jennifer Doering, PhD  
Dept: Nursing

Cc: Megan Anderson

IRB#: 17.136

Title: Patient Web Portal Use Among Women with Gestational Diabetes

After review of your research protocol by the University of Wisconsin – Milwaukee Institutional Review Board, your protocol has been approved as minimal risk Expedited under **Category 5** as governed by 45 CFR 46.110. Your protocol has also been granted approval to waive informed consent as governed by 45 CFR 46.116 (d) for use of existing records.

The Institutional Review Board has also granted a Waiver of Authorization to collect and access the following Protected Health Information for the purpose of this study:

- Data related to gestational diabetes and use of patient web portal

This protocol has been approved on **December 20, 2016** for one year. IRB approval will expire on **December 19, 2017**. If you plan to continue any research related activities (e.g., enrollment of subjects, study interventions, data analysis, etc.) past the date of IRB expiration, a continuation for IRB approval must be filed by the submission deadline. If the study is closed or completed before the IRB expiration date, please notify the IRB by completing and submitting the Continuing Review form found in IRBManager.

Any proposed changes to the protocol must be reviewed by the IRB before implementation, unless the change is specifically necessary to eliminate apparent immediate hazards to the subjects. It is the principal investigator's responsibility to adhere to the policies and guidelines set forth by the UWM IRB, maintain proper documentation of study records and promptly report to the IRB any adverse events which require reporting. The principal investigator is also responsible for ensuring that all study staff receive appropriate training in the ethical guidelines of conducting human subjects research.

As Principal Investigator, it is your responsibility to adhere to UWM and UW System Policies, and any applicable state and federal laws governing activities which are independent of IRB review/approval (e.g., [FERPA](#), [Radiation Safety](#), [UWM Data Security](#), [UW System policy on Prizes, Awards and Gifts](#), state gambling laws, etc.). When conducting research at institutions outside of UWM, be sure to obtain permission and/or approval as required by their policies.

Contact the IRB office if you have any further questions. Thank you for your cooperation and best wishes for a successful project.

Respectfully,  
*Melissa C. Spadanuda*  
Melissa C. Spadanuda  
IRB Manager

## CURRICULUM VITAE

# Megan M. Anderson

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### EDUCATION

2013- present

University of Wisconsin-Milwaukee

- PhD- Nursing, anticipated May 2017

2000-2002

University of Illinois-Chicago

- Master's Degree Nurse Midwifery
- Graduated with Honors, 4.0 GPA

1995-1999

University of Wisconsin-Madison

- Bachelor of Science-Nursing
- Graduated with Honors

### HONORS/AWARDS

|           |  |
|-----------|--|
| 2016-2017 | ProHealth Care nursing scholarship     |
| 2013-2016 | Chancellor's Award scholarship         |
| 2000-2002 | Advanced Nurse Traineeship scholarship |
| 1999      | Independent Study-Cuba                 |
| 1998-1999 | Honor's Research Grant                 |
| 1998-1999 | Sigma Theta Tau                        |
| 1998      | Independent Study-Europe               |
| 1997-1999 | Honor's Program                        |

## **PROFESSIONAL EXPERIENCE**

2014- Present                      Director, Women & Children's Services and Inpatient Behavioral Health/Partial Program  
ProHealth Care  
Waukesha, WI

- Oversees Women's Health service line.
- Strategic and operational oversight for 9 different specialty services both inpatient and outpatient at 4 different locations with 251 reports.
- Currently planning and developing a substance use in pregnancy program for women and babies during pregnancy and post-delivery.
- Engaged in the development of a maternity bundled payment program.

2010-2014                      Manager, Women's Center, ProHealth Care  
Waukesha, WI

- Oversaw operations and clinical work for urogynecology, perinatal, gyn oncology, and women's sexual health clinics at 3 locations.
- Recruitment of staff and providers for all clinic locations.
- Developed growth strategy for urogynecology and perinatal services. Also planned and implemented a new sexual health program.
- Ranked as a Tier 1 department in employee engagement survey, scoring 100% on each of the following items: "the person I report to treats me with respect", "the person I report to encourages teamwork", "the person I report to is open to change", "I respect the abilities of the person to whom I report", and "the person I report to is a good communicator."

2003-2010                      Perinatal Advanced Practice Nurse, Waukesha Memorial Hospital  
Waukesha, WI

2001-2003                      Registered Nurse, Birthing Center, Waukesha Memorial Hospital  
Waukesha, WI

2000-2001                      Registered Nurse, Alternative Birthing Center, Illinois Masonic  
Medical Center, Chicago, IL

1999-2000                      Registered Nurse, Birthing Center, Waukesha Memorial Hospital  
Waukesha, WI

## **PROFESSIONAL COMMITTEES/INVOLVEMENT**

2014                              Co-Chair of Women's Health Service Line  
2013-2014                      Development of Women's Health Service Line  
2011-2012                      Development of Women's sexual health program  
2009-2010                      Pilot with GE data integration from Centricity Perinatal-Centricity Enterprise  
2008                              Pilot with GE data integration from Centricity Perinatal-PeriData  
2008-2010                      Member, WHA CheckPoint Perinatal Indicators development workgroup

|           |   |
|-----------|---|
| 2007-2008 | Pilot with GE data integration from Centricity EMR-Centricity Perinatal     |
| 2003-2010 | Member, WAPC PeriData Committee   |
| 2007-2010 | Community Advisory Board, National Children's Study, Waukesha               |
| 2007-2010 | Chair, ProHealth National Children's Study Core Team                        |
| 2005-2009 | Chair, Perinatal Symposium Planning Committee, ProHealth Care               |
| 2005-2008 | Member, Nursing Strategic Planning Committee, ProHealth Care                |
| 2005-2008 | Co-Chair Nursing Strategic Initiative- SBAR rollout                         |
| 2003-2010 | Chair, Maternal/Newborn Transport Committee, ProHealth Care                 |
| 2003-2010 | Centricity Perinatal System Manager, Waukesha Memorial Hospital             |
| 2000-2002 | Master's research-Hispanic women and breast and cervical cancer, UI-Chicago |
| 2001-2002 | Advanced Nurse Traineeship, UI-Chicago                                      |
| 1998-1999 | Student Representative on Faculty Recruitment Committee, UW-Madison         |
| 1998-1999 | Honor's Research Grant, UW-Madison  |
| 1998-1999 | Co-President Student Nurse's Association, UW-Madison                        |

### **SERVICE/COMMUNITY INVOLVEMENT**

|               |   |
|---------------|---|
| 2015-present  | Volunteer for United Way campaign at ProHealth Care |
| 2013- present | Volunteer Lake Country Caring                       |
| 2010- present | Mentor for nurses and administrative staff          |
| 2008-2012     | Nursing preceptor                                   |

### **PUBLICATIONS**

Nelson, L., Doering, J.J, Anderson, M., & Kelly, L. (2012). Outcome of clinical nurse specialist-led hyperbilirubinemia screening of late preterm newborns. *Clinical Nurse Specialist*, 164-168. doi: 10.1097/NUR.0b013e3182506ad6

### **PROFESSIONAL ORGANIZATIONS**

American Organization of Nurse Executives  
Midwest Nursing Research Society

### **LICENSURE AND CERTIFICATIONS**

Registered Nurse (RN) License- Wisconsin  
Advanced Practice Nurse Prescriber (APNP) License- Wisconsin  
Certified Nurse Midwife  
AONE- Certified nurse manager and leader