A PREGNANCY PHR APP
SYSTEM DEVELOPMENT & USER ADOPTION STUDY

A PERSONAL HEALTH RECORD MODULE FOR PREGNANT WOMEN: SYSTEM DEVELOPMENT AND USER ADOPTION STUDY

by
KAYVAN SAYYEDI VIAND, BSc, MBA

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AUTHOR: Kayvan Sayyedi Viand

SUPERVISOR: Dr. Norm Archer

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SUMMARY

As information technology advances, new products and services are introduced, becoming accessible to help people in day-to-day activities. While using technology on a regular basis to handle routine tasks has become the norm, when it comes to more important issues, like health and wellbeing, individuals are eager to use all available tools to search for required information, consult with field experts, and understand what similar experiences others have had.

Pregnancy for a woman is one of her most important periods of life, resulting in many changes in health condition and consequently lots of worries and concerns that need to be addressed. In North America, most first and second pregnancies occur between the ages 18 to 35. This age period is also reported to be the same age period in which people use smart electronic gadgets the most. Coupling these two pieces of information, it seems that delivering technology-based help to expectant mothers can help them to manage their pregnancies in an easy and efficient manner.

The primary objective of this research was to develop a Personal Health Record (PHR) module for pregnant women and invite a group of pregnant women to evaluate its ease of use and usefulness, as well as gather their opinions on whether they would intend to use it during their pregnancies. The module's design is to connect it to a PHR platform (Like McMaster's MyOSCAR) and the content is based

on clinical practice guidelines. Building on Davis's (1986) Technology Acceptance Model and using the scale designed by Venkatesh & Davis (2000) a 15-item questionnaire was prepared. Questionnaires were distributed to 30 pregnant women – upon their visits to Hamilton Maternity Centre. These women used the module for a time period between two consecutive visits. At the second visit they were asked to complete a questionnaire about their perceptions of the usefulness, ease of use, and intention to use the module during their current or future pregnancies.

The study showed that a pregnancy-specific PHR with evidence-based content could be used by expectant mothers if they perceive its usefulness in managing their pregnancies. Besides their answers to the 15-item questionnaire, participants also provided feedback about module design, content and functionalities. A log-recording feature embedded in the module showed that the most frequently used function was reading pregnancy related resources provided by the module. These resources were adopted from the published Health Nexus booklet for pregnant women. Information gathered in this study can be used in future studies to determine what architecture, functionalities, and content are necessary in such PHR applications.

This thesis is dedicated to my lovely wife who has always believed in me

ACKNOWLEDGEMENTS

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GLOSSARY

AHIMA   American Health Information Management Association

CHI   Consumer Health Informatics

DBMS   Database Management System

EBM   Evidence Based Medicine

EDD   Estimated Date of Delivery

GPS   Global Positioning System

HIREB   Hamilton Integrated Research Ethics Board

HTML5   Hyper Text Markup Language version 5

IDC   International Data Corporation

IOM   Institute of Medicine

LMP   Last Menstrual Period

NGC   National Guideline Clearinghouse

OSCAR   Open Source Clinical Application and Resources

PDA	Personal Digital Assistant
PHP	'Personal Home Page' or 'PHP: Hypertext Preprocessor'
PHR	Personal Health Record
RCT	Randomised Controlled Trials
SOGC	The Society of Obstetricians and Gynaecologists of Canada
SQL	Structured Query Language
TAM	Technology Acceptance Model

1. INTRODUCTION

Pregnancy is one of the most important periods of a woman's life, during which lots of potentially worrying changes occur in her body. Being aware of the nature of these changes can help her to make informed decisions and decrease her level of uncertainty and anxiety. Delivering information to pregnant women to help understand these changes is not a new idea. Brief searches of the web turned up many related resources and information. One important aspect of pregnancy that was found to be widely used was keeping daily records in a paper-based format. However, to the author's best knowledge, there is no pregnancy specific electronic personal health record (ePHR) currently being used in Canada. In this study, a preliminary pregnancy specific PHR module was developed, and its usefulness and usability evaluated.

1.1.   Pregnancy in Canada

According to Statistics Canada, approximately 380 thousand pregnancies were reported for 2012, 37% of which were in Ontario (Government of Canada, Statistics Canada, 2012). In 44.1% of these pregnancies, women had their first live birth, and in about 35.2% they had their second live birth (Government of Canada, Statistics Canada, 2013).

Generally for pregnant women and specifically for those who experience their first pregnancies (primigravida), there is a range of issues that can cause anxiety and stress,

such as the baby's health, delivery complications, and miscarriage. The mother's own health is another major concern. Besides health related issues, there are financial issues, health service availability, and demands of the newborn that can distress a mother(Öhman, Grunewald, & Waldenström, 2003). Brown and Smith (2004) suggest that if women can maintain their own health records during pregnancy, they will feel more "maternal control and satisfaction". They also found other benefits for providing pregnant women with their own health records, including "increased availability of antenatal records".

1.2. Mobile Technology

Mobile Technology is in a rapidly changing stage, and every day we witness new products, services and innovations. The past twenty years have experienced many drastic changes in mobile technology. After the introduction of IBM's Simon, as the first smart phone, in 1992, competition started between Ericson and Nokia in the late 90s. New operating systems e.g. Symbian OS, Palm OS, BlackBerry OS, Windows CE, Apple's iOS and Google's Android were major influences that have created the mobile phone industry in the last 20 years[1]

Today, manufacturers try to win a bigger market share by making their mobile devices more powerful and easy to use. These devices also offer a wide range of features such as global positioning system (GPS) services, Internet access, wireless connectivity,

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[1] http://thenextweb.com/mobile/2011/12/06/the-history-of-the-smartphone/#!qy6bu

front and back cameras, etc. Having all these characteristics in a small mobile device encourage people to adopt new products such as Tablets and Smart Phones as replacements for their personal computers and laptops (Huberty et al., 2011). Sharples and Beale forecasted two major trends for the mobile industry a decade ago:

- Single devices with multiple functionalities such as mobile phones, multimedia computers and digital cameras
- A host of mobile activities, such as digital imaging, video, location sensing, etc. and many different devices offering subsets of these (2003).

Taking a deeper look into the features and services available in today's mobile industry, both trends can be detected separately and in combination. This synergistic combination of two trends has made smart devices very popular. The Pew website in May 2013 (Figure 1) reported that 91% of American adults have a cell phone, 56% have a smartphone (Figure 2), and 34% have a tablet computer (Pew Research Center, 2013b).
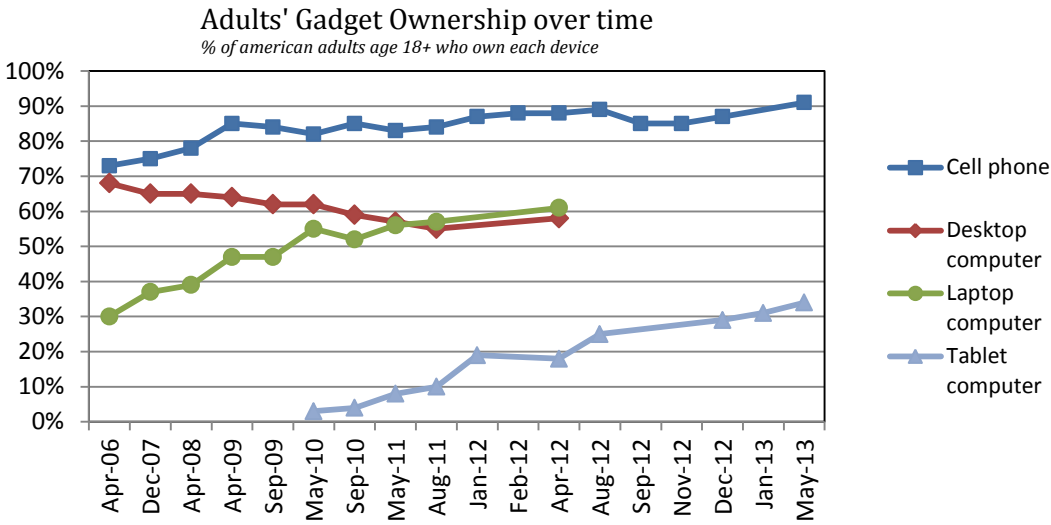
Figure 1. Adult Gadget Ownership Over Time (adapted from Pew Reseach Center)
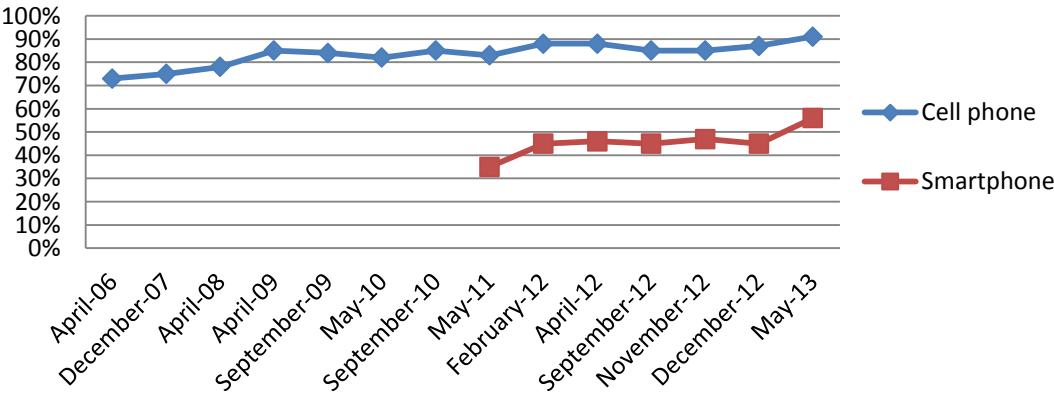
Figure 2. Percent Adult Cell Phone and Smartphone Ownership, Over Time (adapted from Pew Reseach Center)

In another study, Pew Research Center (2013a) showed that the number of adult

cellphone owners who use their phones to access the Internet had doubled from 2009

to 2013, currently standing at 63%. One out of three of these cell-Internet users most often used their phones, rather than any other electronic device, to access the Internet. This suggests that 21% of all adult cellphone owners do most of their online browsing on their mobile phones. People under 45, well-educated people, and those who are financially well-off, have high levels of smartphone adoption. (Pew Research Center, 2013f)

The numbers are not much different in Canada. Results of a survey – by Google in early 2013 – showed that 56% of Canadians use smartphones. Compared to 33% who owned and used smartphones in early 2012, this is very rapid growth. Almost 80% of smartphone users do not leave home without their devices and two-thirds of them use their devices on a daily basis. Mobile device addiction is a term introduced in the report, focusing on the negative side effects of over-using these smart devices (Pew Research Center, 2013g). It is needless to say that this trend also opens up new opportunities to enhance quality of life and well-being of smart device users.

Figure 3 How Smartphone Owners Describe Their Phones (adapted from Pew Reseach Center)

The convenience and satisfaction that smartphone owners get from their devices are visible in the word-cloud (Figure 3) of the results of a survey conducted by Pew (2013e) between April 26 and May 22, 2011. This survey asked 2,277 smartphone owners to use a word to describe how they feel about their phones. About seven in ten used a positive word and less than one-sixth used a negative word. "GOOD" with 10%, and "GREAT" and "CONVENIENT", both with 7%, were the first three most common words.

Tablet ownership in Canada is very similar to that in the USA. Based on a poll from fall 2012, the Media Technology Monitor's report suggests 28% of anglophone Canadians owned a tablet at the time of the survey, more than double the 12% who had one in the fall of 2011 and seven times the 2010 figure (Oliveira, 2013).

1.3.   Age, Pregnancy and Mobile Technology

Being exposed to new technologies, younger generations are more familiar with these technologies and more frequently use them in their daily lives. For example, among adults who own a cellphone, 63% of Millennials (adults between 18 and 34 years old), 42% of Gen X (adults between 35 and 46 years old), 25% of younger boomers (adults between 47 and 56 years old) and 15% of older boomers (adults between 57 and 65 years old) use cellphones to access the Internet (Zickuhr, 2011).

There are interesting similarities between the age distribution of people using technology and the age distribution of the first live births of women in Canada.

Statistics Canada's findings show that 63.17% of first live births are among mothers between 20 and 34 years old (Government of Canada, Statistics Canada, 2013). It seems likely that the demand for a pregnancy specific PHR application among Primigravida Millennials (women between 18 and 34 years old in their first pregnancy) should be more than for other age groups of women.

1.4.   Mobile Technology Trends in Healthcare

Healthcare is a subject in which most people have a very keen interest, especially if it is about themselves or their loved ones. A survey showed that 59% of U.S. adults have used the Internet to find general health information and 35% used it explicitly to understand the medical conditions of themselves or someone else (Pew Research Center, 2013c). After the topics of symptoms and treatments, information about health professionals and medical facilities are the popular subjects that users search for on the Internet (Pew Research Center, 2013d).

In addition to using technology for getting information, users also use it to keep their health records. According to a survey by Pew Research Center's Internet & American Life Project (2013h), for every ten adults in the U.S., seven track at least one health indicator for themselves or a loved one. 60% track their weight, diet, or exercise routines and 33% track health indicators or symptoms, such as blood pressure, blood sugar, headaches, or sleep patterns. Tracking health indicators changed 46% of individual approaches to health, led 40% to ask a doctor new questions or to get a second opinion, and affected one-third of their decisions on how to treat an illness or

condition. Half of these individuals said they used an organized way to record their notes: 29% on paper, 16% using technology, and 5% a combination of both.

Growth of wireless/mobile Internet access has been identified as one of several factors that have contributed to the growth and interest in consumer health informatics (Hoyt, Yoshihashi, & Bailey, 2012). Surveys showed that using cellphones to find health information had almost doubled between 2010 and 2012, from 17% to 31%. More than half of smartphone owners (52%) collect health information on their phones and only 6% of non-smartphone owners use their phones to do so. Smartphone owners with a college degree or those who are between the ages of 18-49 are more likely to seek health information by phone (Pew Research Center, 2012).

The idea of using Information Technology in healthcare originated in 1950's by Ledley (Hersh, 1992), but it was the invention and commercial use of the Internet that made significant change in the healthcare field. In 1991, the Institute of Medicine recommended using electronic health records, which had already been under discussion since the 1970's (Hoyt et al., 2012). Healthcare related software applications and communication networks that provide tools, processes, and communications to support electronic healthcare practices are known as e-health applications (Hernandez et al. 2001). These have come to be fairly widely used in professional healthcare facilities as well as in homes (Ball & Lillis, 2001).

In 1996, when the Palm Pilot Personal Digital Assistant (PDA) was introduced, residents in training started using PDAs loaded with medical software (Hoyt et al., 2012). Advances in mobile technology made it a suitable option for healthcare professionals. More modern smart mobile devices offer media-rich and context-aware features that are highly useful for e-health applications. Mobile phone portability has made them very popular options in gaining acceptance as target devices for supporting e-health applications (apps), for what is now termed the m-health (mobile-health) field (Liu, Zhu, Holroyd, & Seng, 2011). Istepanian et al. (2006) defined m-health as "emerging mobile communications and network technologies for healthcare systems". m-health is playing a crucial role in healthcare. In rural areas in particular, affordable and efficient healthcare can be provided through m-health applications. It is widely expected that m-health will become increasingly important in e-health (Liu et al., 2011).

1.5. PHRs

Eysenbach (2001) counted 10 essential e's to describe what eHealth is or should be. *Efficiency* and cost cutting, *Enhancing* quality of care, being *Evidence based*, *Empowering* consumers and patients, *Encouraging* communication between patient and provider, *Educating* professionals and consumers, *Enabling* information exchange, *Extending* the scope of healthcare, promoting *Ethical* approach to issues, to make health care more *Equitable*. To address these issues, considerable interest has emerged around using consumer centered information and communication technologies in

health care management, referred to as Consumer Health Informatics (CHI). PHRs play a very important role in CHI applications (Hoyt et al., 2012).

The term PHR is usually used to describe the records – whether on paper or electronic –and the information system that supports them (Archer, Fevrier-Thomas, Lokker, McKibbon, & Straus, 2011), but the American Health Information Management Association (AHIMA) website defines PHRs as electronic, lifelong resources of health information needed by individuals in order to make health decisions. According to this definition either individuals or providers produce health information, but it is the individual who owns, controls access to, and manages PHR information, which is kept in a secure and private environment. It is essential to realize that a PHR does not replace legal records maintained about the patient by a healthcare provider (AHIMA, 2013).

1.6.   The History of Pregnancy Health Record

The first ideas of pregnancy health record have been originated in 1950s when Hamilton introduced the 'Co-op (co-operation) card' in United Kingdom. He used a version of Paper Hand-held Record (also abbreviated as PHR) to record maternity care(1956). After that, a Paper Hand-held Record has been used widely to simplify communication between the mother and her healthcare providers. These paper hand-held records are carried by pregnant women and have all cares they received in every prenatal visits documented (Hawley, Janamian, Jackson, & Wilkinson, 2014). Phipps interviewed twenty one women in a randomised controlled trials (RCT) study and

found that women's reaction toward owning their antenatal records are extremely positive. The woman who held her records had more willingness to share and communicate with healthcare provider as well as family members and her partners were more informed and prepared to involve in the pregnancy (2001).

Invention of electronic health record (EHR) made health information available in digital format on devices and media such as USB sticks, web-applications on personal computers, Tablets and smart phones(Hawley et al., 2014) and both patients and healthcare providers have access to these information whenever they want and wherever they are(O'Sullivan, Billing, & Stokes, 2011). Considering the benefits of using ePHR, there is a tendency to shift from paper hand-held records to ePHR(Hawley et al., 2014).

- In a study 80% of women said that they feel safer when they have their maternity notes on a USB stick and 65% regularly used USB sticks during their pregnancies. (Wäckerle et al., 2010).
- Another study with 193 pregnant women showed that level of satisfaction is higher among 97 women who have access to their prenatal record via internet and these women thinks the EPHR is useful, easy to understand and helps them to gather pregnancy related knowledge, make informed decisions and reminds them important events and appointments.(Shaw et al., 2008).

1.7. Sustainable PHR Implementation

Archer et al. (2011) suggested that in order for a PHR to be implemented sustainably, characteristics such as adoption, use, acceptance, satisfaction, and usability should be addressed in a positive way. Ten years after introducing their model of information system success, Delone and McLean (2003) showed that most of these characteristics are significantly correlated. Based on their results, they suggested an updated success model in which information quality, system quality and service quality have a positive effect on user satisfaction and intention to use. They listed success metrics for each of these characteristics:

- reliability and usability for system quality,
- ease of understanding and personalization for information quality, and
- having support for service quality

System acceptance is an issue that was not directly mentioned in Delone and McLean's (2003) model of information system success. Using Davis's (1986) technology acceptance model (TAM), this study will address system acceptance by measuring perceived usefulness and perceived ease of use by user testing, based on the following hypotheses:

i.   *Pregnant women are more likely to adopt a pregnancy specific PHR module when they find it useful.*

ii. *Pregnant women are more likely to adopt a pregnancy specific PHR module when they find it easy to use.*

1.8. Objectives

The objectives of this thesis are listed as follows:

- To develop a PHR mobile web module to support pregnancy health records and functionalities for pregnant women. In order to utilize module's full functionality it needs to connected to a PHR platform like McMaster's MyOSCAR.
- To evaluate the perceived usefulness and perceived ease of use of the developed module and its effect on user intention to use:

The following hypothesis will be tested statistically by comparing the obtained results from participants:

i. Pregnant women are more likely to record detailed pregnancy history using the app when they find the app useful.

ii. Pregnant women are more likely to record detailed pregnancy history using the app when they find the app easy to use.

The next chapter summarizes the research literature on this topic. The third chapter covers app development stages including testing ease of use and usefulness. In the fourth chapter results gathered from system testing by 18 pregnant women are

provided. The final chapter covers discussion of results, scope for future research, and conclusions.

2. LITERATURE REVIEW

Literature on the topic and the three main constructs used in the model is reviewed in this chapter. First, the definition, functionalities, and adoption of PHRs are covered. Then the published literature on pregnancy and how evidence-based medicine affects its various aspects is summarized. The main focus in this part is on evidence-based prenatal care and its support through a PHR module. Finally, technical aspects and usability of PHRs and related functionalities is discussed.

2.1.   PHRs

2.1.1. Functionality of PHRs

PHRs are a relatively new idea and even though millions of dollars have been invested in them, there is no universal agreement on their best architecture, value propositions, and descriptions (Kaelber, Jha, Johnston, Middleton, & Bates, 2008). At this stage researchers are looking for similarities they can find in published papers on PHR characteristics, functionalities, and benefits. Tang et al. (2006) suggested that, besides easy access to test results, better communication with clinicians is the benefit that PHR consumers value most. PHRs are also very suitable tools to educate patients on healthy lifestyles (Archer et al., 2011), or help them share information about their health condition with other patients who have similar problems (Frost & Massagli, 2008). In several cases, PHRs coupled with care plans and mechanisms for frequent data entry have been used for health self-management (Archer et al., 2011).

After reviewing twelve web sites promoting PHRs, Kim and Johnson (2002) identified five prospective functions of PHRs:

- personal medical information access

- summarizing personal medical information for the use of health care providers

- patient-specific consumer-level health information portal support

- access to lab and diagnostic study results in understandable language, and

- health self-management.

In another study Kaelber et al. (2008) investigated the use of information from consumer perspectives and categorized primary PHR functions into four general groups:

- information collection

- information sharing (one-way)

- information exchange (two-way), and

- information self-management.

Results from both of these studies were used in the design of the primary module presented in this thesis, concentrating on features with higher priorities for pregnant women and field experts. More description is available in Chapter 3, 'Design'.

2.1.2. Adoption Motives and Barriers

As has been mentioned, PHRs are in the early stages of development and application, and there is no universally agreed framework for them. But some field experts believe, for successful adoption by today's consumers, PHRs need to have certain features. Information in a PHR should be portable and transferable from one provider to the other. PHR data should be interoperable so it can be shared among different providers using different systems. Users may also expect their PHRs to be auto-populated by data such as lab and test results. Finally, consumers should have full control over their longitudinal records, which should be simultaneously integrated into their clinicians' workflows and kept in a secure and private environment. (Hoyt et al., 2012)

Arguing that correlation between the adoption and use of PHRs -as patient empowering tools- and intense interest in patient health self-management, Archer et al. (2011) suggested that PHR adoption rates are higher among people who depend on healthcare services more, including chronically ill people, individuals with disabilities, parents, ultra health-aware people, and the elderly or their caregivers.

Like any other new technology, PHR adoption has various barriers to surmount. In order to understand and overcome these barriers, researches should address issues like: functionalities needed in the fields of data collection, sharing, exchange, and self-management; the priorities and interests of different players, e.g. patients and physicians; privacy and security; the most effective architectures; and alignment between key player interests (Kaelber et al, 2008).

Primary care physicians play a crucial role in patient health and consequently in patient adoption of PHRs. To increase adoption success, healthcare provider issues need to be addressed (e.g. resistance to adopting new workflows, inadequate technology literacy, validity and reliability of health information received from PHRs, and risks of privacy and confidentiality) (Weitzman, Kaci, & Mandl, 2009). Patient high expectations in some cases and the need for educating and supporting their access to and use of PHRs are other barriers recognized from consumer perspectives (Archer et al., 2011).

2.2. Pregnancy and Evidence Based Prenatal Care

2.2.1. Pregnancy

Pregnancy is a period in women's lives in which they pass through dramatic changes in their biological, psychological and social conditions (Lederman, 1990). Normal pregnancy takes 41 weeks and is divided into three trimesters. In the first trimester (known as the period of fusion) the mother's body accepts the fetus as a physically integrated part of its own. In the second trimester, which is described as the differentiation period, the fetus starts to develop as a separate individual. In the third trimester, successive psychological separation occurs and the mother becomes increasingly curious about meeting her baby (Raphael-Leff, 2004).

Poor pregnancy adaption and poor coping with anxiety are the main causes of a large number of medical symptoms (Shereshefsky, Yarrow, & Shereshefsky, 1973). Glazer

studied 100 pregnant women and categorized 29 concerns recognized by more than 50% of them in six groups: baby, self, medical care, child birth, finances, and subsequent pregnancies. Three concerns that were mentioned by more than 90% of the participating women were: (94%) baby's health, (93%) the delivery, and (91%) how they look (1980). The level of worry among mothers is higher during the first weeks of pregnancy and, after a drop in mid-pregnancy, it begins to rise again at 35 weeks (Statham, Green, & Kafetsios, 1997).

Being single, over or under aged, less educated, having low income, and experiencing first pregnancy are factors that have been claimed to be positively correlated with anxiety during pregnancy (Lederman, 1990; Light & Fenster, 1974). Amongst all of these factors, first pregnancy has a very specific importance. For a woman it is a transition from one stage of development to another and affects her self-image, values, behaviour and relationship with others (Bibring, 1959; Lederman, 1990; Shereshefsky et al., 1973) .

2.2.2. Evidence-Based Practice

Evidence-based decision making is one of the essential e's that Eysenbach (2001) suggested for eHealth. First originating in mid-nineteenth century Paris, Evidence-Based Medicine (EBM) is still a very hot topic for healthcare providers, planners, and the public (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). Moreover, providing Evidence-Based care has increasingly become an accepted standard among healthcare providers (Walker, McCully, & Vest, 2001). Unlike traditional healthcare

provision that relies on a provider's current knowledge, the counsel of colleagues, or readily available literature, EBM depends on a vast, documented, and ever increasing and changing literature of healthcare knowledge (McKibbon, 1998).

Sackett et al. (1996) defined EBM as "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients". "The best evidence possible" and "the most appropriate information available" are two essential items that healthcare providers use to make clinical decisions in Evidence-based practice. Beside available evidence, these decisions are influenced by patient characteristics, situations, and preferences (McKibbon, 1998). Evidence has different forms and, according to their potential for bias, their value can be ranked. Expert opinion is considered the lowest grade of evidence, while high-quality meta-analysis, systematic reviews of RCT, and randomised controlled trials with a very low risk of bias have the highest validity and reliability (Belsey & Snell, 1997).

Using Clinical Practice Guidelines by medical decision makers to support effective care is a common implementation of EBM (Timmermans & Mauck, 2005). Clinical guidelines have been defined by the Institute of Medicine (IOM) as "systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances" (Grossman, Field, & Lohr, 1990). The U.S. National Guideline Clearinghouse (NGC) is a public resource for evidence-based clinical practice guidelines. It currently contains 2743 individual guideline summaries in different areas including prenatal care ("National Guideline Clearinghouse | Home,"

2013). Prenatal care is a field in which routine procedures and protocols are continuously evaluated and improved - two characteristics that are necessary for providing evidence-based care (Walker et al., 2001). The Society of Obstetricians and Gynaecologists of Canada (SOGC) produces national clinical guidelines for both public and medical education on important women's health issues including prenatal care (SOGC, 2013). Most of the features used in designing the PHR module in this research were adopted from SOGC's guidelines for prenatal care. It is however critical to properly disseminate the high level evidence on this subject to the public and in particular to pregnant women.

2.2.3. Prenatal Care

According to a Policy Statement published by the SOGC, modern prenatal care's target is to help pregnant women in ways that reduce perinatal mortality and morbidity and support women's medical, social and psychological needs at the same time (Schuurmans et al., 1998). In traditional prenatal care, low-risk pregnant women needed to have about 14–16 prenatal visits. In 1989, an expert panel proposed that the frequency of prenatal visits could be limited to specific tests or events that occur during pregnancy (Walker et al., 2001).

In developed countries, pregnant women usually visit their healthcare providers seven to eleven times during pregnancy (National Collaborating Centre for Women's and Children's Health., 2008). These visits include: first prenatal visit which should be in the first 12 weeks; one visit each four or six weeks during the first 30 weeks; one visit

in each two or three weeks between weeks 30 and 36; and one visit per week or bi-weekly after week 36 (Schuurmans et al., 1998). These visits are time-based and the agenda for each visit depends on the gestation week that the mother is in. To organize these visits, the estimated date of delivery (EDD) should be calculated either by determination of the last menstrual period (LMP) or by early ultrasonography which is more accurate than LMP (Kirkham, Harris, & Grzybowski, 2005).

At each visit blood pressure, uterine size, urine dipping for protein and glucose, and fetal heart rate should be recorded. The mother's weight gain may also be assessed and further investigations such as ultrasound, receiving Rh immune globulin at 28 weeks gestation, a 50 gram oral glucose challenge test at 24 to 28 weeks gestation, and a Group B Streptococcus test at 35 to 37 weeks should be administered, depending on the mother's condition at that time (Schuurmans et al., 1998).

In some cases pregnancy-related visits start with preconception visits. Preconception visits try to upgrade a woman and her partner's health and well-being (Frey, 2002). The goal of these visits is to address social and medical conditions that can be risky for both mother and fetus (Gregory & Davidson, 1999). According to SOGC's clinical practice guidelines, in preconception visits, care providers talk to women about their medical history, present medication, lifestyle issues, past obstetrical history, the need for taking folic acid, and required immunizations such as rubella (Schuurmans et al., 1998).

2.3. Communication and Establishing Relationship with Pregnant Women

There is an increasing demand from pregnant women to have more choice and control over their care throughout pregnancy and labour periods (*Changing Childbirth*, 1993). Homer et al. (1999) argued that giving women access to their antenatal records empowers them and gives them more sense of control over their care during pregnancy and labour. She also argued that those women who have unlimited access to their records are not made more anxious by the additional information. Besides, women who had access to their pregnancy notes found it easier to talk about antenatal issues with their doctors and midwives (Elbourne, Richardson, Chalmers, Waterhouse, & Holt, 1987).

In addition to its positive emotional effects, involving expectant mothers in record keeping also has administrative and economic benefits. Losing pregnancy records – which was one of the consequences of having poor infrastructure and limited funds in low income countries – led to the development of 'Road to Health' cards (Donald & Hesseling, 1984). Positive results from this study were confirmed in a study done at St. George Hospital, New South Wales, Australia. The rate that pregnancy records were lost by pregnant women themselves in this study was lower than the rate they were lost by the hospital (Homer et al., 1999).

The 'Road to Health' program has been reported to be popular among healthcare providers. But because of pregnant women's limited understanding of the Road to Health card and the obscurity of some of its concepts, both healthcare personnel and pregnant women wanted to replace it with a more detailed and easy to understand framework (Harrison, Heese, Harker, & Mann, 1998). In the St. George Hospital study, there was also a high interest in reusing the system for future pregnancies (Homer et al., 1999).

Beside its benefits, some problems have also been realized from giving pregnant women full access to their records or giving them responsibility to keep and maintain their pregnancy records. If women lose their records or forget to bring them to prenatal visits, it can affect the quality of care provision, and in this case it is not of benefit to replace traditional hospital kept records with incomplete or inadequate woman-carried case notes (Brown & Smith, 2004). In 2006-2007, 400 women – in a RCT with two groups equally divided between women with Universal Serial Bus (USB) devices and control groups who did not have maternity notes – participated in a study to evaluate the use and acceptability of woman-held maternity notes on USB devices. This study confirmed that having access to such notes was a major advance in patient empowerment, satisfaction and safety (Wäckerle et al., 2010).

In Canada, the SOGC recommends that pregnant women have regular communication with their healthcare providers to gain a deeper understanding of their pregnancy and its aspects, which is necessary to make informed decisions and to be prepared for

upcoming labour and birth needs. The main topics that should be covered in these

communications include (Schuurmans et al., 1998):

- the role of the baby's father,

- pregnant woman's support network,

- prenatal classes or educational literature,

- exercise and diet,

- sexual intercourse during pregnancy,

- birth plans of the woman and the views of the delivering physician,

- the philosophy regarding breastfeeding,

- and physician enquiries about possible physical or sexual abuse and being

  attentive to indications of such abuse that may not be directly expressed by the

  woman.

To understand effective communications, knowledge about the channel and players is

very important. According to the Pew Research Center's recent report (Pew Research

Center, 2013c):

- 70% of U.S. adults get information, care, or support from a doctor or other

  health care professional.

- 60% get information or support from friends and family.

- 24% get information or support from others who have the same health

  condition.

To facilitate communication and to promote healthy choices in pregnancy care, the SGOC suggests the preparation of a prenatal care plan, a "record of pregnancy" patient diary, a birth plan, and specific information pamphlets or books (Schuurmans et al., 1998)

2.4. Pregnancy-Specific Health Records

This section is based on a review of several papers on antenatal records and a pregnancy PHR. SOGC's guidelines on prenatal records have been considered as a main reference. Pregnancy-specific health record is a very comprehensive and broad topic area and involves works far beyond the scope of a Masters' thesis. Therefore in research for this thesis and the related development of an app for pregnant women, only a portion of pregnancy specific health records has been covered, and only limited functionalities have been developed and tested for the app.

In a study at the University of North Carolina (Oh, Sheble, & Choemprayong, 2006), five facets were proposed to handle pregnancy health records:

- Appointments

  An expectant mother has several prenatal visits and tests during her pregnancy. For these visits and tests she needs to know the requirements involved and the date, time, location and results. Social events and classes related to the pregnancy can also be categorized as appointments.

- Diary

Women are encouraged to keep records of their daily pregnancy experiences and events. In this daily record they may log health information, emotional concerns, and feelings. The diary can be linked to an appointment system to help women to remember important issues they need to talk about with their healthcare provider during prenatal visits.

- Finance

Financial record includes cost of medicines, visits, tests, hospitalization, devices, payments, insurance coverage, taxes, etc.

- Health Data

Recording health data involves a set of tools to organize time-based objectives such as test results, vital signs, and standard health measurements, as well as comparisons to previous pregnancies or averages.

- Resources

Resources include published pregnancy-related materials in text or multimedia form, which can be made available for presentation based on gestation age or in a time independent way.

2.5. Ease of Use and Usefulness

The speed of technological development appears to be much higher than the speed of individual user adoption and use of new technologies (Karahanna & Straub, 1999). As a result, understanding why individuals accept or reject information technology has

been one of the most challenging issues and central concerns in recent information

system research (Karahanna & Straub, 1999; Swanson, 1988).
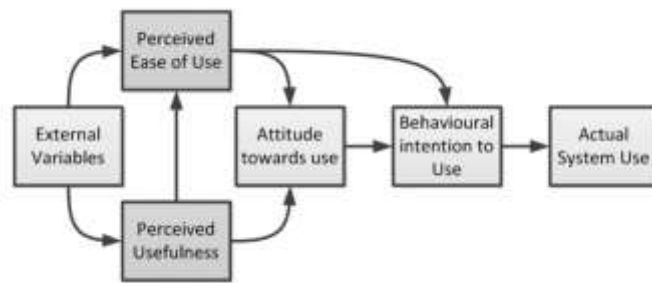
Figure 4 Technology Acceptance Model (adapted from Davis 1989)

Defining *perceived usefulness* as "the degree to which a person believes that using a

particular system would enhance his or her job performance" and *perceived ease of use*

as "the degree to which a person believes that using a particular system would be free

of effort", Davis (1989) suggested that these are the two major factors affecting user

willingness to adopt an information system. For the purpose of this thesis only three

constructs will be evaluated (Figure 5): the effect of perceived ease of use and

perceived usefulness on user intention to use the technology.
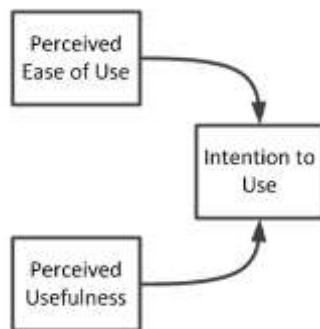
Figure 5. The Model Used in This Study

Studying 152 users and four application programs, Davis (1989) developed and validated new scales for perceived usefulness and perceived ease of use. He refined and reorganized the results into two six-item scales with very high (0.98 for usefulness and 0.94 for ease of use) reliabilities.

Davis's model and its related scales have been tested and retested many times, always showing similar results for the model and the reliability of its scales (Hendrickson, Massey, & Cronan, 1993). Holden and Karsh applied TAM on 16 datasets analyzed in over 20 studies of clinicians using health information technology for patient care and found that certain relationships in TAM are significant and TAM considerably predicts user acceptance in health information technology (2010). Several studies have suggested that to evaluate applications, compare user groups, and predict usage, these instruments could be useful within or across organizations (Adams, Nelson, & Todd, 1992; Davis, 1989; Subramanian, 1994). In the refinement of his scales Davis (1989) suggested certain dimensions for each of his two main constructs (see Table 1).

Usefulness	Ease of Use
- Work More Quickly - Job Performance - Increase Productivity - Effectiveness - Makes Job Easier	- Easy to Learn - Controllable - Clear & Understandable - Flexible - Easy to Become Skillful

• Useful	• Easy to Use

Table 1. Elements of Perceived Usefulness and Perceived Ease of Use (adapted from Davis 1989)

Davis showed that each construct's dimensions have a high correlation with the construct in which it appears and very low correlation with the other construct. In another study Venkatesh & Davis (2000) developed and tested a theoretical extension of the Technology Acceptance Model, TAM2. Adopting the scale from this study, a 15-item questionnaire was developed for the current research to measure the effect of perceived usefulness and perceived ease of use on user intention to use (adopt) the pregnancy PHR tool (See Table 2 in Section 3.4).

3. METHODS

This chapter explains how this study was planned and the related app designed, and discusses in detail the procedures by which the app was developed.

3.1. Previous Works

Although there are a plenty of pregnancy apps in app store and google play, based on authors best knowledge there is no pregnancy specific PHR tethered to health-care provider EMR in Canada. Current apps are designed to educate mothers about their pregnancy specific issues, increase their knowledge about changes they may

experience as well as baby's growth. The developed module is going to be connected to a PHR platform which can be tethered to healthcare provider's EMR. Also the module has capability to adopt COGS guidelines which is followed in maternity centers all around the country.

3.2. Planning

While it is argued that the approaches used by developers in order to design computer applications are mainly based on personal intuition and experience (Plass, 1998), from the early stages of planning, the main objective of this app design was to facilitate human-computer device interaction by adopting a user-centered approach. According to the literature, the user interface of an app can be conceptualized as a communication channel between its user and the functional modules of the device (Barfield & Furness III, 1995; Marchionini, 1991; Waterworth, 1992).

The interface, however is influenced by the structure and characteristics of the system which is supporting it. According to Norman (1990), the limited structural capabilities of certain operating systems in the past have resulted in *computer/application-centered* approaches to user interface design, and text-based communication methods that required certain levels of training and learning from potential users in order for them to be able to use commands and syntaxes. Advances in operating systems have gradually enabled more *user-centered* approaches to app development which focus on the way users process and store information rather than on how computers do related tasks. This reduces the amount of training and learning required in order for the users to be able to effectively use the apps once they are developed. However, the initial

design of any app is still mostly based on developer perceptions and understanding of what type of interface is easy to use and preferred by users. As a result, even with the intention of being *user-centered,* apps are still created in a more *designer-centered* approach. It is therefore through preliminary test-runs that developers gain a more realistic perspective on how the app can be tailored to user preferences.

3.3. Design

3.3.1. Functionalities

As pregnancy lasts over a 41-week time-span, one of the main features of any pregnancy related app is how provided or required information and functionalities are distributed and displayed, based on the pregnancy time schedule. In order to gain a broad perspective and understanding of the preferences of users in this regard, related literature on designing apps for pregnant women was reviewed. In one of the pioneer studies in how pregnant women use PHR systems, Oh et al. (2006) reviewed the main prototypes of Calendar View and two Timeline Views (Figure 6, Figure 7, and Figure 8). They reported the pros and cons of each of these approaches for facilitating decision making based on the type of the service the designer is intending to provide through a PHR. For example, a calendar view can enhance the possibility of integrating heath information with other personal information. However, this feature reduces the visibility of pregnancy-specific data. On the other hand, despite the difficulties of the timeline view with regards to user familiarity, it can provide easy access to important information and also highlight the continuity of time throughout pregnancy. Based on

this result the timeline view was chosen for the design of the app in this research. However, the risk of user unfamiliarity with a timeline interface is acknowledged and considered to be a limitation of this design. In addition to the published literature, pregnancy and other similar apps in the market have been reviewed to better understand the industry's approaches to user interfaces. For example, successful websites like babycenter.com also use weekly timeline approaches.

Figure 6 Calendar Interface: Monthly Records Display, (adapted from Oh et al. 2006)
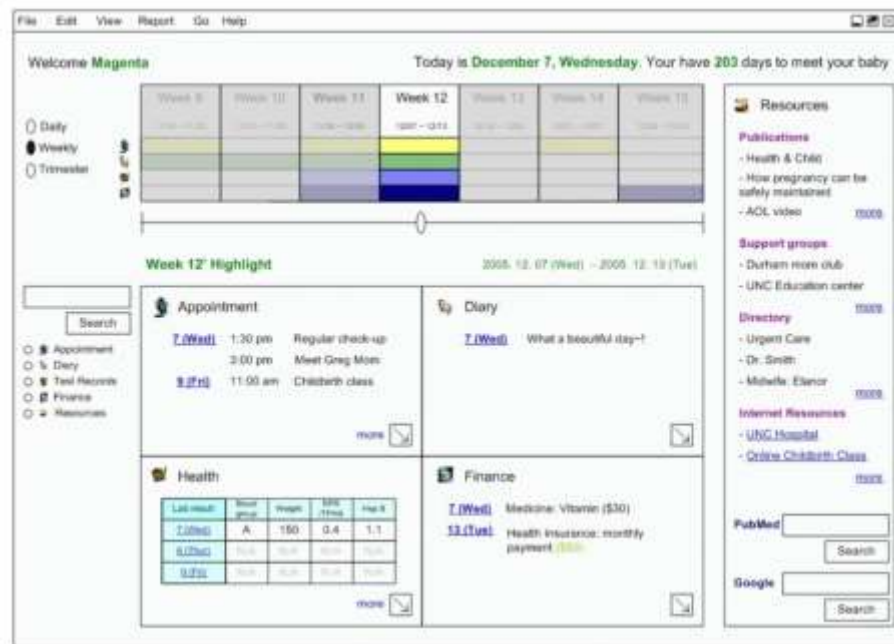
Figure 7 Timeline Interface I: Weekly Records Display, (adapted from Oh et al. 2006)

Figure 8 Timeline Interface II: Weekly Records Display, (adapted from Oh et al. 2006)

As with any other app, one of the important decisions was to choose the different functionalities to be included. Based on the four general categories of PHR functions (information collection, information sharing, information exchange and information self-management) in the study by Kaelber et al.(2008) and five prospective functions of PHRs (personal medical information access, summarizing personal medical information for the use of healthcare provider, patient-specific consumer-level health information portal support, access to lab and diagnostic study results in understandable language, and health self-management), identified by Kim and Johnson(2002), a preliminary list of functions was developed. Considering the fact that the app that was developed is designed to be a module of a larger PHR platform, some of the main PHR functionalities expected of similar apps, such as user registration and sign up, health-related data entry including blood pressure, sugar levels, etc., and demographic information are not included in this app's design. Clearly, many of these functionalities would also raise privacy and ethical concerns, but for the purpose and scope of this Master's thesis I have decided to exclude them from app functionalities. For the purpose of clearly understanding the needs of users, I consulted experts on the subject and some pregnant women. The following three resources provided valuable input to the choice of functionalities for the PHR pregnancy module.

1) I contacted Mari Teitelbaum, the director of BORN Ontario. BORN Ontario is an authoritative source of accurate and trusted pregnancy related information in Ontario and shares this information with different parties involved in pregnancy and related

care-giving services. In a preliminary meeting, the thesis and preliminary design of the module were presented to participants: the director (Mari Teitelbaum) of BORN Ontario, the director (Tracy Carr) of OSCAR EMR (Open Source Clinical Application and Resources Electronic Medical Record), and Thesis supervisor (Dr. Norm Archer).

In the meeting, Ms. Teitelbaum highlighted the importance of motivating pregnant women to keep entering data, the memory bias and its effect on how women forget less recent events but more important information in their prenatal visits. She suggested developing a real-time electronic pregnancy diary in order to diminish memory limitations effects and also to enable creating a better pregnancy agenda for prenatal visits. This electronic diary can act like a pregnancy journal and the woman can use it in following pregnancy to remember previous pregnancy experiences and the causes and effects of such changes during that time.

Ms. Teitelbaum also mentioned how healthcare providers are not funded to maintain electronic communication with patients and therefore providing an app which allows healthcare providers to have more accurate information about pregnant women can be very useful. She also said that a possible functionality of such an app should be to provide pregnancy related information to women and increase awareness of the latest evidence-based knowledge. She introduced SOGC resources for providing the evidence-based knowledge to pregnant women.

At the end of the meeting possible methods of connecting the modules to MyOSCAR and its benefits from healthcare and technical point of view were also discussed.

2) Through a convenience sample, I consulted three pregnant women in different stages of pregnancy. They agreed that an electronic diary would be helpful to them. They also pointed out that they would benefit from having a reminder of pregnancy related appointments.

3) I also received valuable insight from Ms. Claudia Steffler, the unit director - Maternity Centre of Hamilton- Dept. of Family Medicine, McMaster University. She provided an information booklet[2] which is mainly distributed to pregnant women during their first prenatal visit. She recommended including the information in the app in order to provide online accessibility to this information.

Throughout pregnancy, particularly when it is the mother's first experience, it is often important to understand individual information seeking behaviors. McKenzie (2003) argued that information seeking for pregnant women is considered as a part of preparing for motherhood. Research indicates that social ties are beneficial for one's health and wellbeing (Eisenberg, 1979). Establishing a network of pregnant women that share the same experiences and encounter similar life events increases the homogeneity of such a network. It can also enhance the quality of such a social interaction and in turn increase its benefits by providing support for emotional

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[2] A Healthy Start for Baby and Me, Ontario's easy-to-read book about pregnancy and birth by *best start health nexus*

concerns, information, and self-appraisal (Berkman, 1984). The goal of incorporating this feature in the module is to increase a sense of belonging or social integration amongst users, enabling them to share concerns that they face because of similar situations and similar objectives of others in the network.

By reviewing similar applications, I also decided to include a 'Baby needs' functionality for pregnant women that would work as a shopping list, suggesting certain items that a mother would need to purchase before the birth of her child. It is expected that this aspect of the module would in particular be helpful to first time mothers. Similar to other apps, a 'Help' functionality was also included that would give general instructions on how the module could be used. The following table summarizes the main functions of the module and a brief description of the intended benefits each function would provide.

Function	Intended benefits
Diary	- Diminishing the limitations of one's memory in remembering pregnancy related concerns and experiences. - Improving the effectiveness of agendas prepared for prenatal appointments. - Keeping treasured memories of a life-changing experience.
Appointments	- Reducing the number of missed appointments.

Resources	- Providing easy-to-access and easy-to-read pregnancy related information. - Distributing scientifically supported and authoritative health related information.
Baby needs	- Prioritizing pregnancy related purchase needs and budgeting
Forum	- Increasing a sense of belonging and social integration. - Improving general health and wellbeing by decreased stress. - Self-evaluation
Settings	- Changing password - Setting up the timeline according to the due date
Help	- User manual and general instructions required for using the app.

3.3.2. Interface Design Guidelines

The importance of cosmetic and aesthetic appeals of an app cannot be overstated. Initially, as per popular industry trends, the module was intended to provide users the ability to change the color palette and theme of the interface according to personal preferences and the gender of the baby. However, considering time limitations and in order to simplify the features of the module, a single color option was selected with light green, white, and tan as gender-neutral colors.

The icons included in the interface were based on the functionalities defined in the previous section. Therefore, the main page includes the minimum number of six icons. The main page's design was inspired from the icon-based design of Apple iOS on its smart devices. The images for each icon were selected based on the theme of the app and were all pregnancy related (Figure 9).

Figure 9. Module's Main Screen

In order to be visually appealing and user-friendly the first page includes large pictures. The size of the pictures and content of each page is adjusted in a manner that the user needs to make minimum use of the scroll feature unless less frequently used functionalities such as setup and forum are required. The most- frequently used functionalities were selected according to the recommendations made by the field experts on the project. The help link is available on all the pages on the app in order to

provide guidelines to the users when required. Special attention was given to the fact that different smart devices have various display sizes. The module adjusts itself automatically and therefore the overall display fits the screen of desktop computers, tablets, and smart phones. The module was tested on three different (Android, iOS, and Windows) platforms using four main web browsers: Chrome, Firefox, Safari, and Internet Explorer. On all combinations the module worked without any difficulty.

3.3.3. Clinical Content

The clinical content of this module was of utmost importance as the intended users were pregnant women and the accuracy and validity of the included information were critical. For this purpose SOGC and 'Health Nexus' were contacted as industry leaders in health promotion for pregnancy in Ontario. Health Nexus, with over 25 years of experience, is a bilingual organization and provides its services both in English and French, which would be of benefit if the opportunities for expansion and commercialization arise. Moreover Health Nexus offers both electronic and print health promotion resources which would be convenient for the purpose of app development in order to transfer the contents into the app environment[3]. A leading authority on reproductive health care, the SOGC has produced national clinical guidelines for both public and medical education on important women's health issues since 1944.[4]

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[3] http://en.healthnexus.ca/about-us
[4] http://sogc.org/about-sogc/
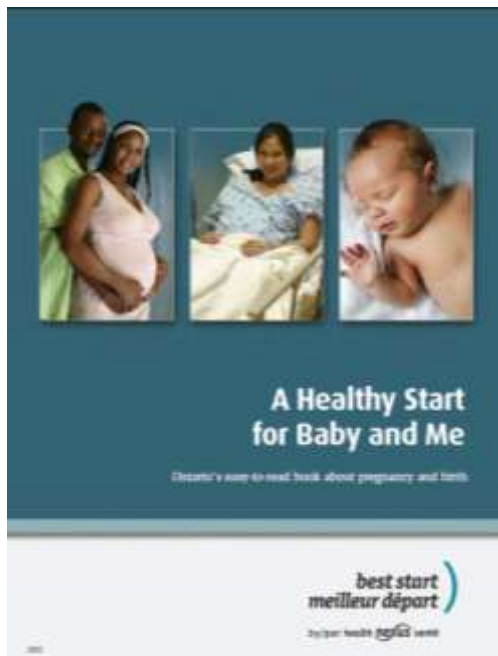
Figure 10. A Healthy Start for Baby and Me,
(adapted from www.beststart.org)

'Best Start', a program of Health Nexus, agreed to provide resources for free for the academic purposes of this research. 'Best Start' is funded through the Government of Ontario and offers resources on reproductive health. For the purpose of this app and in order to provide users with easy to read and easy to comprehend content, the 2012 revision of 'A Healthy Start for Baby and Me'[5] was selected. Permission to use the entire content of this resource and the Best Start logo was obtained and a related agreement signed by both parties. The agreement states that at this stage the app will not be commercialized without further permission. After the app was developed a demo of how the app works was presented to Health Nexus, through which they confirmed the accuracy of the content.

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[5] http://www.beststart.org/resources/rep_health/pdf/low_lit_book_fnl_LR.pdf

'A Healthy Start for Baby and Me' (Figure 10) is an easy to read health promotional book that does not require special training and skills for comprehension and is particularly suitable for women who have difficulty reading, due to poor literacy or lack of English language skills. The book only contains information for healthy and normal pregnancies and does not provide advice for women who have health issues or are pregnant with more than one baby. This resource contains information on when to get help and advice on how to choose a healthcare provider and support group. It provides pregnant women with tips on healthy eating, essential nutrients, and food safety issues. Furthermore it touches on common health issues related to pregnancy including physical activity, stress, work, drugs, smoking, medicines, etc. This book adopts a timeline perspective to pregnancy and covers the 9 months of pregnancy, based on three trimesters in which it describes how the baby is growing, what changes the mother may feel and how she can keep her baby and herself safe throughout these time spans. Finally it provides insight into the labour and birth process itself and what to expect after the baby is born.

3.4. Module Development

In order to identify the right technologies for the module and to use these in the most relevant way to end users and to provide a smooth user experience, developers need to understand the current status of smart-device-based m-health services at the application level. Therefore, the very first step is recognizing m-health key

components: mobile devices, software platform (providing basic services such as networking and database), and m-health applications. (Liu et al., 2011)
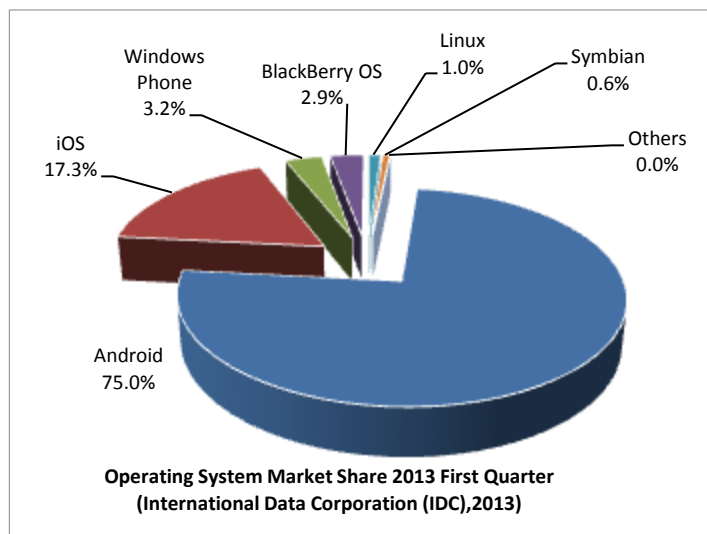
Figure 11. Operating System Market Share 2013 First Quarter (adapted from IDC 2013)

As described in Chapter One, smart mobile devices are converging to a set of similar features such as touch screen technology, network connections, GPS, blue tooth, built-in camera, etc. which makes it very easy and convenient to use them regularly. What makes a difference in using these smart mobile devices are the different platforms used to run services on them. Currently, there are six major platform – operating systems and development tools – providers (Figure 11) that dominate the mobile platform market (Holzer & Ondrus, 2011):

- Google (Android OS)

- Apple (iOS)

- Nokia (Symbian OS)

- RIM (Blackberry OS)

- Microsoft (Windows Mobility OS family)

- LiMo Foundation (Linux Mobile OS).

To be able to cover all platforms Hyper Text Markup Language version 5 (HTML5) was chosen as the interface development language. HTML5 is a technology with cross browser support. Popular browsers such as Chrome, Firefox, Safari, Internet Explorer 9 and Opera can read and execute HTML5 codes. Because of the limited scope and timeline of this thesis, testing the final product was limited to platforms with more market share (Google Android and Apple iOS) (International Data Corporation (IDC), 2013).

In the early stages of design and development of this module MyOSCAR[6] was chosen to be the PHR platform to host the module. For database management MySQL – which is MyOSCAR's database management system as well – was selected. It is an open source and robust Database Management System (DBMS) which is secure and fast, and includes encryption capability. In consultation with the MyOSCAR development team, PHP was selected as the scripting language because of its ability to connect to the host using web services. All the requirements and limitations of the project led to choosing a web-based architecture for the module which operates through Internet connectivity.

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[6] My OSCAR is the PHR platform developed by OSCAR McMaster and its architecture allows independent apps to have access to data that has been entered by other ones.

For initial testing, I asked three friends of mine (two of whom were pregnant at the time I designed the module and one had a pregnancy two years before) to use it on my computer (my development site) and let me know what they think about the module over all. I also presented a live demo to Ms. Hiltrud Dawson, a health promotion consultant in Health Nexus, and I also presented an online demo to the 'Best Start' team.

The main page (Figure 9) was developed in three sections:

- The top menu bar, which contains the module logo, search functionality and options drop down menu.
- The main icon-based module launcher which runs the Diary, Medical care (appointments), Information (resources), Baby Needs, Forum, and Settings functionalities.
- The week navigator.

The 'Resources' section is one of the two (besides the 'Baby Needs' section) that are time independent functionalities. In this section, all texts in 'A Healthy Start for Baby and Me' PDF file[7] were extracted from the source file and converted into html text format, all images transformed into PNG format with no background to keep files small, and all references linked to corresponding resources by converting them to hypertext format. Commenting capability was added to resources, making it possible

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[7] http://www.beststart.org/resources/rep_health/pdf/low_lit_book_fnl_LR.pdf

for users to discuss various topics. Views of this section and others in the module can be seen in the User Manual described in Appendix A. Participants have been provided by a paper-based user manual. They also had access to online user manual in the module.

The 'Visits' and 'Diary' sections are based on weekly events leading up to the pregnancy due date. The first thing a user needs to do, after first logging in, is to set the pregnancy due date she has been told by her primary healthcare provider. 'Forum' is a section in which a user decides to share some of her diary entries. 'Forum' is a partially time dependent section. The user still sees her diary entry in her module's 'Diary' section on a weekly timeline basis, but others who share their diary entries will see it in their 'Forum' section which is organized on a daily timeline.

Due to the Hamilton Integrated Research Ethics Board (HIREB) requirement that Canadian health records should be stored on Canadian servers, a Canadian domain registrar and Canadian host service provider were selected and the module was uploaded to its web hosting space. The domain name 'pregrec.com' was purchased and assigned as the module's URL.

3.5. Experimental Design

The objective of this thesis was to assess the perceived ease of use and usefulness of the designed app and to determine user intentions to persist in utilizing the app. For this purpose, and based on the model described in the previous chapter, an ethics

application was submitted to HIREB explaining the study design and the purpose of the project. Because of the nature of the app the target participants had to be pregnant at the time they used the app and completed in the related survey. For ethical concerns and in order to protect participant privacy, it was decided not to contact them directly but to use an indirect recruitment method. After obtaining ethics approval, participants were recruited through the Hamilton Maternity Centre. Two nurse practitioners volunteered to help with participant recruitment and data collection. They were briefed on the study design, the app, and its proposed benefits. Then they were asked to present the app and its manual to their clients and ask them to use the app for the period of 4 weeks. Participants were told that information they enter will not be shared with their physicians. After this period, participants were asked to fill out a questionnaire containing 15 questions that were intended to measure the main variables: perceived ease of use, usefulness, and intention to use and attitude to use. Furthermore basic demographic information such as the age of the participant and their number of previous pregnancies were collected. The questionnaire is presented in Table 22.

Table 2. Participant Questionnaire

Patient Number: - - - - - -   Number of previous pregnancy(ies): - - - - -   Age: - - - - - -years

1. I frequently look for pregnancy related information on the Internet. (ATT1)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
2. I like to be in a forum and anonymously discuss my worries with other pregnant women. (ATT2)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
3. I need to know that my care provider can see my diary every day. (ATT3)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
4. I enjoy keeping the record of every moment I have with my baby. (ATT4)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
5. Using pregnancy app I can manage my pregnancy record more quickly. (PU1)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
6. Using PREGREC enable me to keep my pregnancy record and find related resources more quickly. (PU2)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
7. Using PREGREC would improve my performance in manage my pregnancy. (PU3)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
8. I would find PREGREC useful in managing my pregnancy. (PU4)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
9. Learning to use PREGREC is easy for me. (PEOU1)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
10. It would be easy for me to become skillful at using PREGREC (PEOU2)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
11. My interactions with the PREGREC are clear and understandable. (PEOU3)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
12. I would find PREGREC easy to use in managing my pregnancy. (PEOU4)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
13. I will keep using PREGREC on a regular basis for the rest of my pregnancy. (IU1)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
14. I will use PREGREC from the very beginning in my future pregnancies. (IU2)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree
15. I will strongly recommend others to use PREGREC. (IU3)				
☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree

Do you have any other feedback or suggestions about PREGREC's ease of use and usefulness?

In order to compensate participants for their time, and to motivate them to fill out the survey, free continuous use of the app was offered to them for their current and future pregnancies. Participants were eligible for inclusion if they were pregnant, 18 years of age of older, and had access to a smart device with network connections and mobile Internet coverage. Initially the intention was to recruit 15-20 participants.

3.5.1. Objectives

As described in chapter one, the objectives of this thesis are to develop a PHR module to support personal pregnancy health records and functionalities for pregnant women and to evaluate the perceived usefulness and perceived ease of use of the developed module and its effect on user intention to use.

3.5.2. Data Collection

As described in the study design an indirect recruitment method was adopted in order to present the app to pregnant women. Each participant was assigned an identification number and a username and password in order to be able to access the app. Their user names were predefined as 'user0(IDno)' and their passwords were randomly generated. The app itself did not collect any user data for the purpose of the study. However it was possible to monitor time logs and frequency of use in order to ensure that the participants were in fact using the app as intended. After a 4 week period of using the app, the participants were asked to fill out one page paper surveys (see Table 2) that took less than 5 minutes on average to complete.

4. RESULTS

30 pregnant women undertook to use the pregnancy app. Out of these 30 participants, 18 returned completed questionnaires, a 60 percent response rate. Besides the data gathered through questionnaires, a set of data was collected using a log-recording feature developed for the module. This feature records the code of the function coupled with the user's code in the database but does not record any user diary or comment entries.

4.1. Participant Profiles

Because of privacy issues, it was decided not to collect personal information from participants. Recruitment and data collection was also done indirectly by nurse practitioners in the Hamilton Maternity Centre. Nurse practitioners were asked to recruit English speaking women with access to Internet via any smart mobile device. The only demographic questions that participants were asked were their age and number of previous pregnancies. However most of the participants chose not to answer these questions. Therefore no demographic interpretation of the data can be made.

4.2. Module's Log File

4.2.1. Log File data

To monitor the frequency of use of the module's different components, a log recording query was added to query was added to the module.

Table 3 shows function usage frequency by each user; for example user021 logged into the system 10 times, read 39 different resources, selected 73 items in the shopping list and deselected 15. The number in the heading for each table is the total number of times that function was accessed.

Login	30
user001	1
user004	3
user005	1
user006	1
user007	1
user008	1
user012	1
user015	1
user016	1
user018	2
user021	10
user024	1
user025	1
user027	1
user029	1
user030	3

Read Resource	57
user004	7
user007	1
user016	2
user018	2
user021	39
user024	2
user025	2
user027	1
user030	1

Change Password	13
user004	3
user005	1
user015	1
user016	1
user018	2
user021	1
user029	3
user030	1

Pregnancy Settings	12
user004	1
user005	1
user008	1
user015	1
user016	1
user018	1
user021	4
user024	1
user025	1

Add Diary	3
user005	1
user015	1
user025	1

Edit Visit	1
user016	1

Baby Needs off	17
user021	15
user027	2

Add Visit	10
user012	2
user016	1
user018	2
user024	3
user025	2

Baby Needs on	75
user016	1
user021	73
user027	2

Table 3 Function Usage Frequency per User

4.2.2. Log File Data Analysis

In analysing log file data, ignoring user roles in generating usage frequency and focusing on the actual times focusing on the actual times each function has been used, seems misleading. For example, in using the example, in using the shopping list, user021 generated more than 95% of the accesses. Therefore I decided Therefore I decided to determine 'the number of times a function was used' with 'the number of users who number of users who accessed that function' (

Table 4).

Functions	Number of times used	Number of users
Login	30	16
Diaries	3	3
Visits	11	6
Resources	57	9
Shopping	93	5
Password change	13	8
Pregnancy Settings	12	9

Table 4 Function Usage Frequency and Number of Users

Log file analysis shows that almost all the users (16 of 18 who completed the questionnaire) logged in to the module and used it at least once. Based on the results of the log file data, reading pregnancy resources was the most popular function among users. The second most popular function was managing visits and appointments; using the shopping list was the third most frequently used. Unexpectedly participants did not use the diary entry function as much as expected.

4.3. Questionnaire Data Analysis

4.3.1. Data Screening

Prior to data analysis, the accuracy of data entered and missing values in questionnaires were examined. The size of the sample was less than what was expected but due to the limitations of this thesis and time constraints I decided to proceed with analysis.

In the screening phase of the data gathered by questionnaires 6 responses were eliminated due to incomplete questionnaire and missing data. However some of these cases had filled out the open ended comment section and explained their reasons for not completing the questionnaires. Because of the importance of these comments in understanding the users' perceived ease of use and usefulness of the app, these comments will be discussed later in this chapter. The remaining set of 12 completed questionnaire responses were transferred to an electronic format and data entry was double checked by a colleague. It should also be pointed out that only three participants had completed the demographic questions about their age and number of previous pregnancies. Therefore these two variables will be excluded from the analysis. After omitting the missing cases a frequency analysis was conducted. The results are presented in Table 5.

Table 5. Frequency Analysis

Questionnaire Statistics

	ATT1	ATT2	ATT3	ATT4	PU1	PU2	PU3	PU4	PEOU 1	PEOU 2	PEOU 3	PEOU 4	IU1	IU2	IU3
N Valid	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	4.25	2.92	2.67	3.42	3.50	3.25	3.25	3.50	3.50	3.33	3.25	3.33	2.58	2.58	3.33
Median	4.00	3.00	3.00	3.50	4.00	3.50	3.50	4.00	4.00	4.00	3.00	3.50	3.00	2.50	3.00
Std. Deviation	.622	1.165	.888	1.165	1.168	1.288	1.055	1.000	.905	.888	.965	.985	1.165	1.311	1.073
Minimum	3	1	1	1	1	1	2	2	2	2	2	2	1	1	2
Maximum	5	5	4	5	5	5	5	5	5	4	5	5	4	5	5

4.3.2. Reliability Analysis

In order to determine the reliability of the items selected for measurement a reliability analysis was conducted for each variable separately. Perceived usefulness was measured through 4 items derived from Venkatesh & Davis (2000). These items are as follows:

PU1. Using the pregnancy app I can manage my pregnancy record more quickly.

PU2. Using PREGREC enables me to keep my pregnancy record and find related resources more quickly.

PU3. Using PREGREC would improve my performance in managing my pregnancy.

PU4. I find PREGREC useful in managing my pregnancy.

The reliability analysis of this scale yielded a Cronbach alpha of 0.93 which suggests that the measurement is reliable.

Perceived ease of use was measured through 4 items derived from Venkatesh & Davis (2000). The following items were used in this study:

PEOU1.   Learning to use PREGREC is easy for me.

PEOU2.   It would be easy for me to become skillful at using PREGREC.

PEOU3.   My interactions with PREGREC are clear and understandable.

PEOU4.   I find REGREC easy to use in managing my pregnancy.

The reliability analysis of this scale showed a Cronbach alpha of 0.94 which again shows that the scale is reliable.

Intention to use was measured through the following three items, two of which are derived from Venkatesh & Davis (2000) and the third one was added to check if intention to use has any correlation with recommendation (for future studies):

IU1. I will keep using PREGREC on a regular basis for the rest of my pregnancy.

IU2. I will use PREGREC from the very beginning in my future pregnancies.

IU3. I will strongly recommend others to use PREGREC.

The reliability analysis concluded that this measurement was reliable as well (Cronbach alpha= 0.90).

To understand user methods of handling worry using information technology, based on Cohen and Lazarus (1979) two items were selected to measure information seeking and social support method and two items were chosen to measure user willingness to maintain pregnancy records and be open to monitoring by their healthcare provider (This construct were not proven reliable based on the responses received.):

     ATT1.   I frequently look for pregnancy related information on the Internet.

     ATT2.   I like to be in a forum and anonymously discuss my worries with other

           pregnant women.

     ATT3.   I need to know that my care provider can see my diary every day.

     ATT4.   I enjoy keeping the records of every moment I have with my baby.

These items were intended to be used as control variables to measure their effect on user perceptions of usefulness and intention to use the module in future. At this stage, due to the small sample size it was not possible to derive a significant correlation between these items and the other constructs.

4.3.3. Correlations and Regression Analysis

In order to proceed with the analysis a standard multiple regression was performed between user perceived ease of use and perceived usefulness of the app as independent variables, and intention to use the app in the future as dependent variable. In order to conduct this analysis SPSS REGRESSION was used. The correlations between the variables are presented in Table 6.

Table 6. Correlations between Variables

Correlations

		PU	PEOU	IU
Perceived Usefulness	Pearson Correlation	1	.610*	.791**
	Sig. (2-tailed)		.035	.002
	N	12	12	12
Perceived Ease of Use	Pearson Correlation	.610*	1	.481
	Sig. (2-tailed)	.035		.114
	N	12	12	12
Intention to Use	Pearson Correlation	.791**	.481	1
	Sig. (2-tailed)	.002	.114	
	N	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

In Table 7, R for the regression analysis was significantly different from zero. The adjusted R^2 value of 0.63 indicates that more than 60 percent of the variability in user intention to use can be predicted by perceived usefulness and perceived ease of use of the app. In the regression analysis only perceived usefulness differed significantly from zero. 95% confidence limits were calculated (0.222 to 1.451). This confirms that perceived usefulness of the module significantly contributes to user intention to use the app in future. Based on the obtained results from participants, hypothesis i (Pregnant women are more likely to adopt a pregnancy specific PHR module when they find it useful) is supported but hypothesis ii (Pregnant women are more likely to adopt a pregnancy specific PHR module when they find it easy to use) is not supported.

Table 7 Multiple Regression Analysis Model

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.791[a]	.626	.542	.73532

a. Predictors: (Constant),), Perceived Ease of Use, Perceived Usefulness

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.134	2	4.067	7.522	.012[b]
	Residual	4.866	9	.541		
	Total	13.000	11			

a. Dependent Variable: Intention to Use

b. Predictors: (Constant), Perceived Ease of Use, Perceived Usefulness

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.024	.923		.027	.979	-2.064	2.113
	Perceived Usefulness	.836	.272	.793	3.080	.013	.222	1.451
	Perceived Ease of Use	-.004	.325	-.003	-.013	.990	-.738	.730

a. Dependent Variable: Intention to Use

4.3.4. User Suggestions

At the end of the questionnaire, participants were asked to make suggestions about the ease of use and usefulness of the app. The suggestions are listed in Table 8. It is insightful to point out that out of the 6 questionnaires that were incomplete, 5 had not used the app at all. They listed reasons such as difficulty in downloading the app or incompatibility with their smart phones as reasons for not using the app. Of course in order to use the app, users need to have access to data on their smart devices.

Table 8. User Suggestions

1. Seemed like more of a journal, than an info site.

2. A little hard to understand and navigate around compared to other pregnancy apps.

3. Great app! I just didn't use it too much myself, especially since it was only introduced to me in later pregnancy. Perhaps I would have used it more regularly if I had it from the first trimester.

4. I found it hard to get to the page showing how many weeks along I am. I had to click through every week instead of skipping ahead or searching it. I personally don't want to keep a log of everything I eat/do. So I didn't continue using it. However, I know some women find this interesting to do so.

5. I will not use the app from the very beginning in future pregnancies only because it is online and I pay for data☹.

6. I found it easy to use, but I am not one to write everything down.

7. The only reason why I could not answer all questions because I found the app confusing from the start. It did not have certain things in there and it was unorganized. Instead of drop down menu, I would like to see icon items and more color.

8. Was unable to use the app and could not put it on my phone.

9. I have not used the app yet.

10. I chose not to use the app.

11. I have not downloaded the PREGREC app.

12. I previously had a pregnancy app prior to this information. Pregnancy apps are fantastic tools and in the future I hope to try yours

5. DISCUSSION

5.1. Contributions

The importance of information and its accuracy when provided to pregnant women led to the development in this thesis of a pilot pregnancy app based on credible and trusted pregnancy information. The main contribution of this study is demonstrating the usefulness of a pregnancy application that influences user intention to use.

Moreover, this study uncovered user preferences with regards to the user interface and architecture of such an app Based on participant feedback, offline access to the app is one of the most important issues which should be addressed in future

implementations. Users who had no access or not-for-free access to data on their smart devices had difficulties using the module. Navigation through gestation weeks was another ease-of-use issue that has been recognized by users. Lack of proper training and/or tutorial videos also affected the ease-of-use. 'Less color options' was also brought up by some participants and 'providing more option for module customization' was recommended for future implementations. The log file data showed that shopping list is an interesting feature in the module that might ease the creation and expansion of a pregnancy social network.

5.2. Limitations

The main limitation in this study was the timeframe needed to prepare for the study, and the relative length of pregnancy. This study took a total of eight months for module design and development, study design, getting research ethics board permission, testing the module, and data collection. Compared to the nine months of pregnancy and the time limitations of the study it was not possible to ask participants to use the module for the full pregnancy period in order to gain advantage of full module functionalities.

The other limitation of this study was the extra workload that was imposed on healthcare providers if additional functionalities were added to the app. The Maternity Centre did not have enough resources to support 'monitoring patients 24/7'. In the first phase not enough time and resources were available to develop the important

provider side of the module, so this component was canceled. Clearly it would be of great advantage to the patient that her healthcare provider has access to whatever she enters into the module. Thus it was still necessary, if something unusual happened she would need to call her healthcare provider. Although some of the provider side functionalities were actually developed, they had to be excluded from the study, thus making the module less attractive to patients.

Privacy issues also caused some restrictions in the study. Lack of direct contact with participants made the training process less effective. For example, in two cases two participants (number 11 and 26) were not aware of the module's (no need to download and install) web-based nature. Participant 11 wrote in the questionnaire's feed-back section: "Cannot complete the questionnaire because I have not download the PREGREC app" and participant 26 wrote: "was unable to use app, could not put it on my phone"

Participant number 12 disagreed with using PREGREC for future pregnancies and as a reason wrote: "Only because it's online! I pay for data☹". It seems that the module's online nature may be a barrier to its adoption and acceptance for some women.

5.3. Recommendations for Future Research

Based on the findings of this study, more conclusive research is needed on the content and scope of the functionalities required for the pregnancy app. It was supposed that

diary will be the most popular sub-module, but resource provision was more popular than diary. The reason could be the difficulty of typing by smart-phones' virtual keyboards compared to the ease of reading texts and watching pictures on the wide screens these devices have. Researches could be done on how important are each function or feature for pregnant women. It is also important to acknowledge the role of primary health care providers in making these apps more functional and useful. The preferred architectural design (e.g. online vs. offline, stand-alone vs. tethered) of such an app needs to be further explored.

5.4.   Conclusion

Smart devices are popular in seeking, sharing, and recording health information. The objectives of this study were to develop a pregnancy specific PHR module and to evaluate the role of perceived usefulness and perceived ease of use in user intentions to use the module. This study showed that using evidence-based prenatal care and practice guidelines, a pregnancy specific PHR module can be developed, and it also showed that if pregnant women find the app useful they will continue to use it. However, for this particular design, the study did not support the role of perceived ease of use on user future intention to use the pregnancy module. This may be due to the increased digital proficiency of users nowadays, particularly those in developed countries and the increasingly user friendly features available in various architectural designs. The study did not reveal significant variance in respondents' perceived ease of use. The study also revealed that the functionality most often used by the participants

was reading clinical resources provided to them through the app. Further studies are needed to determine the level of detail of functionalities and health information that is needed when incorporating these in a pregnancy specific PHR module.

REFERENCES

Adams, D. A., Nelson, R. R., & Todd, P. A. (1992). Perceived usefulness, ease of use, and usage of information technology: a replication. *MIS Quarterly*, 227–247.

AHIMA. (2013). Defining the Personal Health Record. Retrieved October 22, 2013, from http://library.ahima.org/xpedio/groups/public/documents/ahima/bok1_0273 51.hcsp?dDocName=bok1_027351

Archer, N., Fevrier-Thomas, U., Lokker, C., McKibbon, K. A., & Straus, S. E. (2011). Personal health records: a scoping review. *Journal of the American Medical Informatics Association*, *18*(4), 515–522.

Ball, M. J., & Lillis, J. (2001). E-health: transforming the physician/patient relationship. *International Journal of Medical Informatics*, *61*(1), 1–10.

Barfield, W. E., & Furness III, T. A. (1995). *Virtual environments and advanced interface design.* Oxford University Press. Retrieved from http://psycnet.apa.org.libaccess.lib.mcmaster.ca/psycinfo/1995-98783-000

Belsey, J., & Snell, T. (1997). *What is evidence-based medicine?* Hayward Medical Communications. Retrieved from http://www.medicine.ox.ac.uk.libaccess.lib.mcmaster.ca/bandolier/painres/download/whatis/ebm.pdf

Berkman, L. F. (1984). Assessing the physical health effects of social networks and

social support. *Annual Review of Public Health*, *5*(1), 413–432.

doi:10.1146/annurev.pu.05.050184.002213

Bibring, G. L. (1959). Some considerations of the psychological processes in pregnancy.

The Psychoanalytic Study of the Child. Retrieved from

http://psycnet.apa.org.libaccess.lib.mcmaster.ca/psycinfo/1960-07446-001

Brown, H. C., & Smith, H. J. (2004). Giving women their own case notes to carry during

pregnancy. *Cochrane Database Syst Rev*, *2*. Retrieved from

http://onlinelibrary.wiley.com.libaccess.lib.mcmaster.ca/doi/10.1002/146518

58.CD002856.pub2/pdf/standard

Changing Childbirth: Report of the Expert Maternity Group. (1993). HM Stationery

Office.

Cohen, F., & Lazarus, R. S. (1979). Coping with the stresses of illness. *Health Psychology:

A Handbook*, 217–254.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of

information technology. *MIS Quarterly*, 319–340.

Davis Jr, F. D. (1986). *A technology acceptance model for empirically testing new end-

user information systems: Theory and results*. Massachusetts Institute of

Technology. Retrieved from

http://www.researchgate.net/publication/35465050_A_technology_acceptance

_model_for_empirically_testing_new_end-

user_information_systems__theory_and_results_/file/9c960519fbaddf3ba7.pdf

Delone, W. H. (2003). The DeLone and McLean model of information systems success:

a ten-year update. *Journal of Management Information Systems*, *19*(4), 9–30.

Donald, P., & Hesseling, P. (1984). The 'Road to Health' card - a cornerstone of

preventative and promotive paediatrics. *South African Medical Journal*, *65*, 423–

5.

Eisenberg, L. (1979). A friend, not an apple, a day will help keep the doctor away. *The*

American Journal of Medicine, *66*(4), 551–553.

Elbourne, D., Richardson, M., Chalmers, I., Waterhouse, I., & Holt, E. (1987). The

Newbury Maternity Care Study: a randomized controlled trial to assess a policy

of women holding their own obstetric records. *BJOG: An International Journal of*

Obstetrics & Gynaecology, *94*(7), 612–619.

Eysenbach, G. (2001). What is e-health? *Journal of Medical Internet Research*, *3*(2).

Retrieved from

http://www.ncbi.nlm.nih.gov.libaccess.lib.mcmaster.ca/pmc/articles/PMC176

1894/

Frey, K. A. (2002). Preconception care by the nonobstetrical provider. *Mayo Clinic*

Proceedings, *77*(5), 469–473.

Frost, J. H., & Massagli, M. P. (2008). Social uses of personal health information within PatientsLikeMe, an online patient community: what can happen when patients have access to one another's data. *Journal of Medical Internet Research*, *10*(3). Retrieved from http://www.ncbi.nlm.nih.gov.libaccess.lib.mcmaster.ca/pmc/articles/pmc2553 248/

Glazer, G. (1980). Anxiety levels and concerns among pregnant women. *Research in Nursing & Health*, *3*(3), 107–113.

Government of Canada, Statistics Canada. (2012). Births, estimates, by province and territory. Retrieved February 4, 2013, from http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/demo04a-eng.htm

Government of Canada, Statistics Canada. (2013). Live births, Canada — Age and parity of mother. Retrieved July 30, 2013, from http://www.statcan.gc.ca/pub/84f0210x/2008000/t008-eng.htm

Gregory, K. D., & Davidson, E. (1999). Prenatal care: Who needs it and why? *Clinical Obstetrics and Gynecology*, *42*(4), 725.

Grossman, J. H., Field, M. J., & Lohr, K. N. (1990). *Clinical practice guidelines: directions for a new program* (Vol. 90). National Academies Press. Retrieved from http://books.google.ca.libaccess.lib.mcmaster.ca/books?hl=en&lr=&id=zVO9na aWqTEC&oi=fnd&pg=PA1&dq=ClinicalPractice+Guidelines:+Directions+for+aN ewProgram&ots=3GyTXs9CnM&sig=KhWB0uUilTc4iEsGuE4VrWGcby8

Hamilton, S. G. (1956). Obstetric record card for use in general practice. *The Practitioner*, *176*(1051), 79.

Harrison, D., Heese, H. D., Harker, H., & Mann, M. D. (1998). An assessment of the'road-to-health'card based on perceptions of clinic staff and mothers. *South African Medical Journal= Suid-Afrikaanse Tydskrif Vir Geneeskunde*, *88*(11), 1424–1428.

Hawley, G., Janamian, T., Jackson, C., & Wilkinson, S. A. (2014). In a maternity shared-care environment, what do we know about the paper hand-held and electronic health record: a systematic literature review. *BMC Pregnancy and Childbirth*, *14*(1), 52.

Hendrickson, A. R., Massey, P. D., & Cronan, T. P. (1993). On the test-retest reliability of perceived usefulness and perceived ease of use scales. *MIS Quarterly*, 227–230.

Hernandez, A. I., Mora, F., Villegas, M., Passariello, G., & Carrault, G. (2001). Real-time ECG transmission via Internet for nonclinical applications. *Information Technology in Biomedicine, IEEE Transactions on*, *5*(3), 253–257.

Hersh, W. R. (1992). Informatics: development and evaluation of information technology in medicine. *JAMA*, *267*(1), 167–170.

Holden, R. J., & Karsh, B.-T. (2010). The technology acceptance model: its past and its future in health care. *Journal of Biomedical Informatics*, *43*(1), 159–172.

Holzer, A., & Ondrus, J. (2011). Mobile application market: a developer's perspective. *Telematics and Informatics*, *28*(1), 22–31.

Homer, C. S. E., Davis, G. K., & Everitt, L. S. (1999). The Introduction of a Woman-Held Record into a Hospital Antenatal Clinic: The Bring Your Own Records Study. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, *39*(1), 54–57.

Hoyt, R. E., Yoshihashi, A., & Bailey, N. (2012). *Health Informatics: Practical guide for healthcare and information technology professionals* (5th ed.).

Huberty, K. E., Lipacis, M., Holt, A., Gelblum, E., Devitt, S., Swinburne, B., … Lu, J. (2011). Tablet demand and disruption: Mobile users come of age. *Morgan Stanley*.

International Data Corporation (IDC). (2013). Smartphone Operating System Market Share. Retrieved August 1, 2013, from http://www.idc.com/getdoc.jsp?containerId=prUS24108913

Istepanian, R., Laxminarayan, S., & Pattichis, C. S. (2006). M-health: emerging mobile health systems. *M-Health: Emerging Mobile Health Systems, Edited by R. Istepanian, S. Laxminarayan, and CS Pattichis. 2006 XXX, 624 P. 182 Illus. 0-387-26558-9. Berlin: Springer, 2006., 1*. Retrieved from http://adsabs.harvard.edu.libaccess.lib.mcmaster.ca/abs/2006mhem.book.....I

Kaelber, D. C., Jha, A. K., Johnston, D., Middleton, B., & Bates, D. W. (2008). A research agenda for personal health records (PHRs). *Journal of the American Medical Informatics Association*, *15*(6), 729–736.

Karahanna, E., & Straub, D. W. (1999). The psychological origins of perceived usefulness and ease-of-use. *Information & Management*, *35*(4), 237–250.

Kim, M. I., & Johnson, K. B. (2002). Personal health records evaluation of functionality and utility. *Journal of the American Medical Informatics Association*, *9*(2), 171–180.

Kirkham, C., Harris, S., & Grzybowski, S. (2005). Evidence-based prenatal care: Part I. General prenatal care and counseling issues. *American Family Physician*, *71*(7), 1307–1316.

Lederman, R. P. (1990). Anxiety and stress in pregnancy: significance and nursing assessment. *NAACOG's Clinical Issues in Perinatal and Women's Health Nursing*, *1*(3), 279.

Light, H. K., & Fenster, C. (1974). Maternal concerns during pregnancy. *American Journal of Obstetrics and Gynecology*, *118*(1), 46.

Liu, C., Zhu, Q., Holroyd, K. A., & Seng, E. K. (2011). Status and trends of mobile-health applications for iOS devices: A developer's perspective. *Journal of Systems and Software*, *84*(11), 2022–2033.

Marchionini, G. (1991). *Psychological Dimenisons of User-computer Interfaces: ERIC Digest*. ERIC Clearinghouse on Information Resources, Syracuse University. Retrieved from http://bern.library.nenu.edu.cn/upload/soft/0-article/016/16041.doc

McKenzie, P. J. (2003). Justifying cognitive authority decisions: Discursive strategies of information seekers. *The Library Quarterly*, *73*(3), 261–288.

McKibbon, K. A. (1998). Evidence-based practice. *Bulletin of the Medical Library Association*, *86*(3), 396.

National Collaborating Centre for Women's and Children's Health. (2008). *Antenatal care: routine care for the healthy pregnant woman*. RCOG press.

National Guideline Clearinghouse | Home. (2013). Retrieved November 25, 2013, from http://www.guideline.gov/index.aspx

Norman, D. A. (1990). *The design of everyday things*. Doubleday (New York). Retrieved from http://www.getcited.org.libaccess.lib.mcmaster.ca/pub/102805792

O'Sullivan, T. A., Billing, N. A., & Stokes, D. (2011). Just what the doctor ordered: Moving forward with electronic health records. *Nutrition & Dietetics*, *68*(3), 179–184.

Oh, S., Sheble, L., & Choemprayong, S. (2006). Personal pregnancy health records (PregHeR): Facets to interface design. *Proceedings of the American Society for Information Science and Technology*, *43*(1), 1–10.

Öhman, S. G., Grunewald, C., & Waldenström, U. (2003). Women's worries during pregnancy: testing the Cambridge Worry Scale on 200 Swedish women. *Scandinavian Journal of Caring Sciences*, *17*(2), 148–152.

Oliveira, M. (2013, January 30). Tablet ownership is growing explosively in Canada, according to a new report on tech trends, which also notes that Netflix continues to sign up new subscribers. *The Toronto Star*. Retrieved from

http://www.thestar.com/life/technology/2013/01/30/tablet_ownership_doub

les_in_canada.html

Pew Research Center. (2012). Mobile Health 2012 | Pew Research Center's Internet &

American Life Project. Retrieved October 21, 2013, from

http://www.pewinternet.org/Reports/2012/Mobile-Health.aspx

Pew Research Center. (2013a). Cell Internet Use 2013 | Pew Research Center's Internet

& American Life Project. Retrieved October 21, 2013, from

http://www.pewinternet.org/Reports/2013/Cell-Internet.aspx

Pew Research Center. (2013b). Device ownership | Pew Research Center's Internet &

American Life Project. Retrieved October 21, 2013, from

http://www.pewinternet.org/Static-Pages/Trend-Data-(Adults)/Device-

Ownership.aspx

Pew Research Center. (2013c). Health Online 2013 | Pew Research Center's Internet &

American Life Project. Retrieved October 21, 2013, from

http://www.pewinternet.org/Reports/2013/Health-online.aspx

Pew Research Center. (2013d). Health Topics | Pew Research Center's Internet &

American Life Project. Retrieved October 21, 2013, from

http://www.pewinternet.org/Reports/2011/HealthTopics.aspx

Pew Research Center. (2013e). How smartphone owners describe their phones | Pew

Research Center's Internet & American Life Project. Retrieved October 24,

2013, from http://pewinternet.org/Infographics/2011/Smartphones.aspx

Pew Research Center. (2013f). Smartphone Adoption and Usage | Pew Research Center's Internet & American Life Project. Retrieved October 21, 2013, from http://www.pewinternet.org/Reports/2011/Smartphones.aspx

Pew Research Center. (2013g). Smartphone ownership way up, Canadians addicted to their phones: Google study | CTV News. Retrieved October 24, 2013, from http://www.ctvnews.ca/sci-tech/google-study-smartphone-ownership-way-up-canadians-addicted-to-their-phones-1.1388185

Pew Research Center. (2013h). Tracking for Health | Pew Research Center's Internet & American Life Project. Retrieved October 21, 2013, from http://www.pewinternet.org/Reports/2013/Tracking-for-Health.aspx

Phipps, H. (2001). Carrying their own medical records: the perspective of pregnant women. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, *41*(4), 398–401.

Plass, J. L. (1998). Design and evaluation of the user interface of foreign language multimedia software: A cognitive approach. *Language Learning & Technology*, *2*(1), 35–45.

Raphael-Leff, J. (2004). *Psychological processes of childbearing*. University of Essex. Retrieved from http://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.397890

Sackett, D. L., Rosenberg, W. M., Gray, J. A., Haynes, R. B., & Richardson, W. S. (1996). Evidence based medicine: what it is and what it isn't. *BMJ: British Medical Journal*, *312*(7023), 71.

Schuurmans, N., Gagné, G.-P., Ezzat, A., Colliton, I., MacKinnon, C. J., Dushinski, B., & Caddick, R. (1998). HEALTHY BEGINNINGS: GUIDELINES FOR CARE DURING PREGNANCY AND CHILDBIRTH. Society of Obstetricians and Gynaecologists of Canada (SOGC).

Sharples, M., & Beale, R. (2003). A technical review of mobile computational devices. *Journal of Computer Assisted Learning*, *19*(3), 392–395.

Shaw, E., Howard, M., Chan, D., Waters, H., Kaczorowski, J., Price, D., & Zazulak, J. (2008). Access to web-based personalized antenatal health records for pregnant women: a randomized controlled trial. *Journal of Obstetrics and Gynaecology Canada: JOGC= Journal D'obstetrique et Gynecologie Du Canada: JOGC*, *30*(1), 38–43.

Shereshefsky, P. M., Yarrow, L. J., & Shereshefsky, P. M. (1973). *Psychological aspects of a first pregnancy and early postnatal adaptation*. Raven Press New York. Retrieved from http://www.ncbi.nlm.nih.gov.libaccess.lib.mcmaster.ca/nlmcatalog/414550

SOGC. (2013). About SOGC | SOGC. Retrieved November 25, 2013, from http://sogc.org/about-sogc/

Statham, H., Green, J. M., & Kafetsios, K. (1997). Who worries that something might be wrong with the baby? A prospective study of 1072 pregnant women. *Birth*, *24*(4), 223–233.

Subramanian, G. H. (1994). A Replication of Perceived Usefulness and Perceived Ease of Use Measurement*. *Decision Sciences*, *25*(5-6), 863–874.

Swanson, E. B. (1988). *Information system implementation: Bridging the gap between design and utilization*. Irwin Homewood, IL. Retrieved from http://www.getcited.org.libaccess.lib.mcmaster.ca/pub/102647982

Tang, P. C., Ash, J. S., Bates, D. W., Overhage, J. M., & Sands, D. Z. (2006). Personal health records: definitions, benefits, and strategies for overcoming barriers to adoption. *Journal of the American Medical Informatics Association*, *13*(2), 121–126.

Timmermans, S., & Mauck, A. (2005). The promises and pitfalls of evidence-based medicine. *Health Affairs*, *24*(1), 18–28.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: four longitudinal field studies. *Management Science*, *46*(2), 186–204.

Wäckerle, A., Blöchlinger-Wegmann, B., Burkhardt, T., Krähenmann, F., Kurmanavicius, J., & Zimmermann, R. (2010). Notes on a stick: use and acceptability of woman-held maternity notes. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *153*(2), 156–159.

Walker, D. S., McCully, L., & Vest, V. (2001). Evidence-based prenatal care visits: When less is more. *Journal of Midwifery & Women's Health*, *46*(3), 146–151.

Waterworth, J. A. (1992). *Multimedia interaction with computers: Human factors issues*.

Ellis Horwood. Retrieved from

http://dl.acm.org.libaccess.lib.mcmaster.ca/citation.cfm?id=132290

Weitzman, E. R., Kaci, L., & Mandl, K. D. (2009). Acceptability of a personally controlled

health record in a community-based setting: implications for policy and design.

Journal of Medical Internet Research, *11*(2). Retrieved from

http://www.ncbi.nlm.nih.gov.libaccess.lib.mcmaster.ca/pmc/articles/PMC276

2802/

Zickuhr, K. (2011). Generations and their gadgets. *Pew Internet & American Life Project*,

20. Retrieved from

http://libraries.pewinternet.com/~/media/Files/Reports/2011/PIP_Generatio

ns_and_Gadgets.pdf

APPENDIX A: User Manual

Login Page

PREGREC is a web app for pregnancy record management. To access this app, go to the link below and enter the username and password you received from your healthcare provider.

In this study and to protect your privacy, usernames are pre-assigned and have no link to your identity.

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https://www.pregrec.com
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Home Page

Home page includes:

- A menu-bar: Logo, Search and Option icons
- Six modules: Diaries, Medical care, Information, Baby's Need, Forum, and Settings. (Left to right and up to down)
- Navigation Buttons: To select and navigate through gestation weeks.

'Diary' and 'Medical Care' modules have notifications about upcoming visits, or comments for selected week. (via Navigation Buttons).

You always can return to your current week by clicking on the middle navigation button.

Settings

You should change your account settings after logging in for the first time. Tap on the setting module icon on the home page and in the setting page you can enter the due date of your pregnancy and the number of previous pregnancies. You also can change your password in settings page.

Add New Diary Entry

Tap on the option icon in the menu-bar and you can select 'Add a new diary entry'. In new diary page, add a title and date for your diary, and then write your entry. You can add an image for your diary, share it with others, make it anonymous and mark the level of importance of the diary.
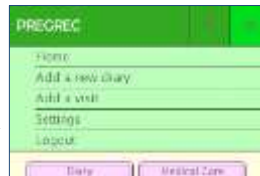
When you share your diary 'with all' you allow other users to see it in the forum page and leave comments for you.

Add New Visit

Select 'add a visit' from the option icon in the menu-bar. In the 'Add a new visit' page add a title, a date and time for your visit, enter your care provider's name, the address and a brief description of what the visit is about or what you should prepare.

Browsing Diaries

By tapping on the Diary icon in the home page, you can preview diary entries. Navigation buttons are available at the bottom of the page to navigate between weeks of gestation.

By tapping on the diary title or 'Leave a comment' link you will be directed to another page in which you can read comments, add new comments and edit the diary.

Navigation Buttons

Navigation through gestation weeks: Diaries, Visits, Summary

Navigation among entries in the active week

Forum

Forum is the list of diary entries that users want to share with others and get their feedback. Only those diary entries which you select to share with others will be displayed in the 'Forum'. The navigation mechanism in forum is date-based. You can select a date and go forward to the next day or backward to the previous one.
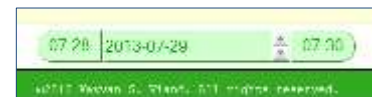
What Baby Needs

This page is a list of baby supplies. As you acquire each item, tap the item to turn red background green.

Be aware that not all items are essential; speak to your care provider if you have a question about these supplies.

Leaving Comments

By tapping on the title or 'leave a comment' link, you can edit or delete contents you developed, see all comments, check unread ones, or leave a new comment.
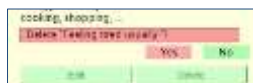
✓ sign on comments means the comment is new and by tapping on the sign you can mark the comment as read.

X sign on comments shows that you can delete the comment. (You can delete comments which either you left on an entry or someone left on the entry generated by you).

To leave a new comment on an entry, tap on the 'leave new comment' link and in 'post a comment' section you can write your comment. Comments can be posted anonymously by checking the 'Make it anonymous' box.

You can also delete or edit visits or diary entries generated by you by tapping on 'Edit' or 'Delete' buttons. The delete function needs confirmation

Diary/Visit Delete Confirmation   *Comment Delete Confirmation*
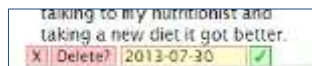
Search

Tap on the search icon in the menu-bar to search for a word in entries (medical care, diaries, or Health Nexus resources).

Based on what and where you search, the app will give you a list of visits, diaries, or resources in which your search term has been mentioned.

Resources

Resources in this app have been adopted from Health Nexus's "A Healthy Start for Baby and Me" booklet.

The booklet is a valuable source of information which will answer most of your questions about pregnancy.

You can select and read any topic by navigating among them. Tap on the 'All Topics' button to see a list of topics. You also can leave a comment for the topic you selected or read the comments others wrote on that topic, and then navigate to the next topic of your choice.

Comments in this page are publicly available for users.