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Title of Thesis: MHEALTH APPLICATIONS: PROBLEMS, CHALLENGES, AND FUTURE DIRECTIONS

Name of Candidate: Sirina Sucklal
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Thesis and Abstract Approved: ________________________________

Dr. Dongsong Zhang
Professor
Department of Information Systems

Date Approved: ________________

Abstract

Title of Document:	MHEALTH APPLICATIONS: PROBLEMS, CHALLENGES, AND FUTURE DIRECTIONS.
	Sirina Sucklal, Masters in Science, 2017
Directed By:	Dr. Dongsong Zhang, Information Systems

This thesis analyzes the problems and barriers encountered by users of mHealth applications for overall wellness, disease management or intervention. There has been an increase in the utilization of mHealth applications to analyze data collected from users to help them manage their disease and improve health outcomes. The data collected assist the development and modification of mHealth applications so that the general public can benefit from those applications. Problems and barriers, such as language and behavioral barriers, unfamiliarity with mobile technology and technical difficulties that have been encountered by users, have not been addressed by current studies. The aim of this thesis research is to identify and better understand those problems and barriers, and propose future research and practical directions. The results of this research suggest that studies should focus on the problems and barriers that are faced by users to improve the benefits of the disease management/intervention.

Keywords: mHealth applications, patients, disease management, problems, data.

TITLE PAGE

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By

Sirina Sucklal, Masters in Information Systems, 2016

Directed by: Dr. Dongsong Zhang, Department of Information Systems

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CHAPTER 1

1.0 Introduction

MHealth (mobile health) is the use of mobile and wearable devices (such as personal digital assistants, smart phones, fitbits, and smartphones) to enhance the delivery of health care services and the outcome health care (Medical Dictionary, © 2009 Farlex and Partners). The mHealth field is remarkably dynamic, and the range of applications being designed is constantly expanding. MHealth applications (apps) assist consumers with self-management of overall wellness, disease prevention and disease management (IMS Institute for Healthcare Informatics 2015). Currently, over 165,000 mHealth apps are available, the majority of which focus on wellness, diet and exercise. As users become more aware of the important role of mHealth apps in their own healthcare, there is an opportunity to leverage these apps in innovative ways (IMS Institute for Healthcare Informatics 2015).

MHealth apps for users can be divided into two categories including apps that facilitate overall wellness (diet & exercise) and apps that focus on disease management and intervention. MHealth apps for wellness make up two-thirds of all the apps (IMS Institute for Healthcare Informatics 2015). A quarter of mHealth apps target disease and treatment management including a small amount of mHealth apps that are geared towards specific diseases (IMS Institute for Healthcare Informatics 2015).

While mHealth programs continue to increase across regions because of the features and potential capabilities of various apps, there are problems and barriers that have been encountered by users, which need to be addressed. Many of the current studies focus on interventions, outcomes and development of mHealth applications to manage certain diseases, instead of problems and barriers. Research is necessary to find out and understand the problems and barriers encountered by users as there is a need to develop solutions to alleviate or address them in order to improve patient adoption of mHealth apps and satisfaction.

MHealth apps have the ability to change the way healthcare is provided globally. The objectives of this thesis are:

1. To identify the problems and barriers with current mHealth apps encountered by users via research;
2. To discuss how to address these problems and barrier;
3. To discuss how increased awareness and utilization of mHealth apps can reduce the cost of healthcare

1.1 Background

According to the IMS Institute for Healthcare Informatics, there is an expanding body of evidence showing that the use of mHealth apps can improve health outcomes. Within the past few years, progress has been made across the key components necessary for driving greater adoption of mHealth apps as some health care providers have begun to prescribe mHealth apps as a practice. (IMS Institute for Healthcare Informatics 2015).

Table 1 presents the positive impact that mHealth apps have on patient compliance, success rates for diet and fitness interventions as well as the ability to assist with reaching vulnerable and remote populations. Additionally, there is also evidence of the positive impact of mHealth interventions on chronic disease management (IMS Institute for Healthcare Informatics 2015).

Table 1 Positive impact of mHealth apps.

• Nutrition: Increased adherence to diet monitoring and decreased effort to continue diet without app. (e.g. Mattila et al. (2008), Rodrigues et al. (2013))
• Wellness: Results of healthy lifestyle indicators demonstrate the positive impact of using web-based app interventions. (e.g. Takenga et al. (2014))
• Mental Health: Rapid improvements in work and social functioning with participants who had middle to moderate depression, anxiety and/or stress. (e.g. Kerssens et al. (2015), Ben-Zeev et al. (2013))
• Perioperative care: App used effectively in patients undergoing routine cardiac procedures to ensure 100% compliance with instructions along with excellent patient satisfaction scores. (e.g. Zan et al. (2015), Park et al. (2014))

Currently, there are over 165,000 mHealth applications, 65% of them facilitate wellness management (fitness apps, lifestyle & stress, diet & nutrition), 24% target disease & treatment management (healthcare providers/insurance, medication reminders & information, women's health & pregnancy, disease specific) and 11% is focused on other (IMS Institute for Healthcare Informatics 2015).

Table 2. MHealth Apps by Category

Disease & Treatment Management	**Other**	**Wellness Management**
Healthcare Providers/ Insurance – 2% (e.g.	11% (e.g. Donnelley et al. 2010)	Fitness – 36% (e.g. Rodrigues et al. 2013)

Phillips et al. 2014)		
Medication Reminders & Information – 6% (e.g. Sidney et al. 2012)		Lifestyle & Stress -17% (Piette et al. 2012)
Women's Health & Pregnancy – 7% (e.g. Schwartz et al. 2015)		Diet & Nutrition – 12% (e.g. Rodrigues et al. 2013)
Disease Specific – 9% ((Smillie et. al. 2014, Kim et al. 2015)		

The mHealth apps designed for wellness management such as lifestyle and stress, monitor the blood pressure of users and provide feedback to them. An example of such apps is the electronic home blood pressure BP monitor app. The study by Piette et al. (2012) focused on monitoring the blood pressure of hypertensive users. This intervention had two components, automated self-care support telephone calls and home blood pressure (BP) monitoring. The users were satisfied with the program as it helped them to manage their hypertension.

The disease specific apps that are geared towards self-management of chronic conditions such as diabetes, blood pressure, and mental health conditions are more common. In the study by Takenga et al. (2014), the patients used the Mobil Diab to manage their diabetes by monitoring their blood sugar trend over an extended period of time. The users found the system helpful in monitoring their blood sugar trend and were motivated to use it for regular glycemic control.

Mental health apps total a third of disease specific mHealth apps, with the most commonly addressed conditions being autism, anxiety, depression, Attention Deficit Hyperactivity (ADHD) Disorder and Alzheimer's. (IMS Institute for Healthcare Informatics 2015). MHealth apps for Alzheimer's are able to facilitate disease management strategies and support. The study by Kerssens et al. (2015) utilized the Companion, a touch screen device to deliver psychosocial interventions to users at their homes using rich audio visual programs combining images, music, and messages, from trusted individuals important to the user for meaningful and positive engagement. Caregiver/care recipient dyads were recruited from a network of organizations and institutions. A Companion was personalized for each of the seven (7) households based on the determination of barriers, use of facilitators, usefulness of the device to persons with dementia and their primary family caregivers through structured observations, interviews and assessments. The study found that most of the users had a positive experience with the intervention and that people could be motivated and prompted to accomplish important health and wellness routines.

1.2 Statement of the Problem

This research will answer the following two questions through an analytical review of the literature:

a. What are the common problems and barriers encountered by users of mHealth applications?
b. Can the problems and barriers be overcome? If so how?

This thesis is focused on investigating the problems and barriers encountered by users of mHealth applications. The testing of these apps through empirical studies is focused on the impact of the interventions on care outcomes rather than problems and/or barriers faced by users while using mHealth apps. Those problems and barriers often influence the effectiveness and usability of an mHealth app for the targeted population.

After an examination of the problems and barriers encountered by users of mHealth applications, solutions and guidelines will be proposed to help overcome these problems and barriers.

1.3 Significance of the Study

The significance of the study is to highlight the problems and barriers experienced by users of mHealth applications and to make some suggestions to address these problems and barriers. MHealth apps can play an important role in building on the demand for new and effective ways to increase and improve self-care management. They can improve awareness of the symptoms of diseases and triggers as well as provide adherence treatment and increase management of symptoms. Increasing user involvement can facilitate symptom assessment and communication between user and provider.

Although mHealth apps appear to have many benefits, users encounter problems and barriers that prevent them from utilizing these apps. Understanding and addressing users' requirements are the main prerequisites for developing useful and effective technology based intervention. The studies indicated that users were receptive to using technology to manage their symptoms and related pain despite fear and inexperience with technology.

Similar studies by Anderson et al. (2016) and Rothstein et al. (2016) have shown that problems and barriers prevent successful integration of mHealth apps. Anderson et al., conducted semi-structured interviews that provided information about the usage, benefits and challenges of health monitoring using apps. Rothstein et al. assessed the feasibility, usability and acceptability of a mHealth app and found that there were numerous barriers (ex. software and device challenges) to successful integration.

1.4Thesis Outline

The rest of this thesis is organized into four (4) chapters. Chapter 2 discusses the literature from which the problems and barriers are extrapolated. Chapter 3 discusses the results of the analysis. Chapter 4 provides an analytical discussion of mHealth applications and presents the limitations of the prior studies. The thesis concludes with an overall assessment of the problems and barriers encountered by users of mHealth applications.

CHAPTER 2 Literature Review

This section reviews literature on mHealth applications and the problems and barriers faced by users. A literature search was conducted on the use of mHealth apps in studies by users for overall wellness, disease management or intervention through four phases: *identification*, in which articles were identified primarily through an exhaustive database search; *screening*, in which the found articles were evaluated based on their abstracts and other metadata; *eligibility*, in which the screened articles were evaluated through full text analysis; and *inclusion*, in which final articles were identified for review. The following databases were searched: (1) UMBC Digital Collections, (2) IEEE Xplore, (3) ACM Digital Library, (4) AOK Article One Search, (5) EBSCO and (6) Proquest.

Only articles published within the past 10 years were selected and reviewed based on the following inclusion criteria:

a. MHealth application for self-management of health, overall wellness, prevention, disease management or intervention
b. MHealth application used in a study for self-management of health, overall wellness, prevention, disease management or intervention
c. Results of the utilization of the mHealth app by users were included in the study
d. Inclusion of user feedback on the mHealth applications used in the study

The keywords used were:

1. Self-management
2. MHealth applications

3. Intervention
4. Disease prevention
5. Overall wellness
6. Users
7. Feedback
8. Problems
9. Data

Full text review of the articles included analyses of populations, interventions, and outcomes:

- Populations: All populations were considered.
- Interventions: Required interventions were mHealth apps that were accessible to the populations using them in different parts of the world.
- Outcomes: Studies were required to have a quantitative measure of user feedback.

The inclusion criteria and search yielded 50 articles. An in-depth review of those articles revealed numerous problems and barriers encountered by users of the mHealth apps referenced in the studies. These problems and barriers were identified from the feedback of the users. The feedback of the users included opinions such as whether they liked the app or not, the ease of use, technical challenges, and language barriers.

Listed below are studies of mHealth applications that were reviewed for this thesis.

Table 3. Diseases and the mHealth Applications Used

DISEASE TARGETED BY STUDIES	TYPE OF MHEALTH APPROACH USED BY THE APPLICATION	MAJOR FINDINGS OF THE STUDY
Diabetes	Mobil Diab - enables diabetes patients to share and store their data leading to a reduction in physical consultations with a physician. (Takenga et al. 2014)	It can be utilized in developed countries and underserved communities as it is able to overcome distance and time barriers.
Diabetes	Diabetes Notepad - is a self-management system that records data. The application includes diabetes education material and a cardiovascular risk calculator. (Kim et al. 2015).	The application can be a useful tool leading to positive changes in diabetes self-care. This study demonstrates changes in the clinical course of diabetes.
Diabetes	NICHE - remote wireless intervention interactive informational feedback system used to provide feedback and reminders to patients. (Faridi et al. 2008)	Technology appears feasible but must be made more user friendly
Diabetes Self-Care	Mobile Diabetes Self-Care System - has a self-knowledge base, is an interactive system with an active and responsive consultation base. (Guo et al. 2015).	Effective in improving patients' self-care knowledge.
Chronic Obstructive Pulmonary Disease	Edge - intervention focused on simplicity of use (touch screen, no keyboard) and consisted of a symptom diary, remote self-monitoring and multimedia educational and self-management materials. (William et al. 2014).	Patients were able to use the mHealth application, interpret clinical data and use them within their self-management approach regardless of previous knowledge.
Pain Coping Skills	MPCST - delivered pain coping skills (PCST) via live videoconferencing. MPCST focused on enhancing efficacy through technologies to address social cognitive factors influencing patient's confidence. (Somers et al. 2015).	Cognitive behavioral approaches to pain management have shown efficacy but persistent patient access limit their routine use.
Soldier Reintegration	MCare - is bidirectional where providers send patients secure mobile messages and patients responded to specific messages utilizing an interface designed to be intuitive. (Poropatich et al. 2014).	The project demonstrated the feasibility and administrative effectiveness of a scalable mHealth using secure mobile messaging.
Wellness Management	Wellness Diary - enables the user to record self-observations and receive feedback as needed. (Mattila et al. 2008).	Some patients believed that the diary complicated their regular calendar use.

Coronary Heart Disease	Personalized programsText4Heart - A 2 part parallel randomized trial was conducted. Some patients were used as control and others received personalized programs via SMS and a supporting website. (Dale et a. 2015)	Lifestyle behavioral changes occurred in 3 months but a larger study is needed to determine size of the effect in the long term as well as reduction in cardiovascular events.
Dementia	Companion - touch screen technology delivering psychosocial nondrug intervention. (Kerssens et al. 2015).	Companion helped to mitigate symptoms and addressed needs
HIV Care	HAART - cellphone based intervention using texts and phone calls to pregnant women with HIV. (Schwartz et al. 2015)	Intervention was feasible and highly acceptable
Cancer	WHOMS - allows patients to submit answers to structured questionnaires about their health. (Bielli et al. 2004).	Patients who lack familiarity with mobile phone refused to participate
Sickle Cell Disease	SMART - User is prompted twice per day through reminders for medication and pain assessment. (Shah et al. 2014)	Sickle cell specific application was built. Patients were receptive to using technology to managing their symptoms and related pain
Cancer	ASyMS - temperature and other data is entered after taking electronic symptom questionnaire to determine toxicity levels. (McCann et al. 2009)	Application has the potential to improve management of symptoms
Chronic Obstructive Pulmonary Disease	mHealth - consists of a smartphone for communication and computations, sensors to obtain objective information on patient's health status (transmitted wirelessly), questionnaire data collected from patients on smartphones, web based system schedules tasks and collects patient data centrally. (Van der Heijden et al. 2013)	Initial testing shows applying system that uses probabilistic reasoning is technically feasible and patients are willing to use the system.
Sickle Cell Disease	Web-based e-Diary - used to input patients' data while remotely monitoring pain and symptoms. (Jacob et al. 2013)	The web based diary can remotely monitor pain and symptoms
Parkinson's Disease	Telehealth - the study used videophone and telephone to evaluate the usefulness and usability of the intervention. (Fincher et al. 2009)	Visualization by videophone was better at addressing the self-management counseling.
Sickle Cell Disease	SMART - patients recorded intensity of pain using a paper visual analog (VAS) and then again via an electronic VAS. (Jonassaint et al. 2015)	System usable and feasible but compliance greater among those with larger devices.

Hypertension	Tele-monitoring support system - monitors blood pressure and transmit readings automatically to central data repository. Clinical rules engine notifies physician of abnormal readings. (Piette et al. 2012)	Technology is applicable to a variety of diseases and builds on the demand for new and effective ways to improve chronic disease management.
Diabetes	MAMS - electronic medication blister monitor patient's adherence of medication intake. If necessary loophole interactions can be closed to improve adherence. (Brath et al. 2013)	Electronic blisters can be used but must be carefully designed for daily application.
Cancer	Connect Mobile App - patients can report, monitor symptoms and health problems for predefined categories and receive individually tailored self-management support. (Mirkovic et al. 2013)	Understanding and addressing users' requirements are the main prerequisites for developing useful and effective technology based interventions.
Coronary Heart Disease	MEMS - text messaging was used to improve adherence to antiplatelet and statin medications among patients. (Park et al. 2014)	Mobile health interventions show promise in promoting medication adherence.
HIV/AIDS-infected	HIVAS - warning system based on SMS used to increase adherence of medication. (Martini da Costa et al. 2012)	SMS messages have a distinct advantage in reducing intrusions in a patient's life and is low cost compared to voice communications.
Heart Failure	iGetBetter - instructs patients to take their measurements and log their information through an interactive voice response (IVR) telephone system. (Zan et al. 2015)	Low intensive remote monitoring program is feasible to augment care for ambulatory patients with heart failure
Cardiovascular Disease	mHealth healthy eating CR Program - targeted four sources of influence: mastery experience, vicarious learning, social persuasion, and somatic and emotional states. (Dale et al. 2014)	Text is a simple and acceptable way to deliver healthy eating and behavior change strategies and can be integrated as a part of a wider mHealth comprehensive CR program.
Asthma	Mobile phone - used to transmit symptoms and peak flow information with immediate feedback and support. (Pinnock et al. 2007)	Mobile phone based monitoring system can facilitate self-management
Schizophrenia	FOCUS - a mobile self-management intervention system. (Ben-Zeev et al. 2013)	Innovative technology can play a role in self-management of illness
Outpatient Care	MessageMedia - intervention is administered via a web-based text messaging software. (McInnes et al. 2014)	Reduced appointments and no shows. Text messaging is a feasible method of contacting patients.

Asthma	Peak Flow Meter - handheld electronic peak flow meter connected to a mobile phone transmit recordings to mobile phone's software. (Ryan et al. 2005)	Server based peak flow asthma telemedicine system analyzing peak flow values and sending feedback to the patient is useful in enhancing self-management.
Prostate Cancer	ICT-Platform - symptoms assessed by patients via a server connected to a web interface which sends alerts to nurses. (Sundberg et al. 2015)	Increased patient involvement, which facilitated symptom assessment and communication between patient and their provider.
Macular Degeneration	HMT - patients use device to test their retinal visual function. Patients receive reminders to do visual tests. (Kaiser et al. 2013)	Elderly patients can with appropriate training and guidance use hand held devices to self-test retinal visual function.
Cancer	Mobile Phone Toxicity Monitoring - patients input medical information into the application. Medication reminders are sent out to patients. (Weaver et al. 2014)	Possible to optimize medication and manage chemotherapy side effects in real time via mobile phone
Depression	Telehealth monitor - used to measure medical indicators of patient's primary illness. (Sheeran et al. 2011)	Feasibility of using homecare to provide collaborative care for geriatric depression
Radiotherapy	Symptom reporting application - patients report symptoms on a mobile phone once daily during treatment. Clinicians reviewed patients' reported symptoms during visits. (Falchook et al. 2016)	Substantial symptom reporting is possible using mobile device technology.
Chronic Otitis Media	Multimedia messages - used to try and increase clinic attendance and ear health. (Phillips et al. 2014)	Mobile phone based interventions to promote health outcomes are acceptable
Cystic Fibrosis	ICT application - electronic self-reporting of daily symptoms and access to feedback for comparison. (Cummings et al. 2011)	Results highlight challenges in stimulating self-management behaviors particularly among adolescents.
HIV	Videos on apple phones - mobile media devices were used to present peer health messages to patients. (Winstead-Derlega et al. 2012)	It is feasible and acceptable to use mobile media technology to deliver peer health messages.
Palliative Care	ASyMSp - system monitored and managed symptoms while providing programmed self-care advice relevant to the severity of the symptoms. (McCall et al. 2008)	Positive experiences were reported by patients despite fear and inexperience with technology.

Mobile Medication Management	MyMedRec, DrugHub, Pillboxie, PocketPharmacist - applications used to add, prescribe, schedule reminders, read and scan drug information, email profiles and record dosage. (Grindrod et al. 2014)	Initial frustration of participants highlight the benefits of linear navigation when designing for older users.
HIV Adherence and Retention	WelTel BC1 - text message support via an automated text messaging platform. (Smillie et al. 2014)	Maintaining engagement was a challenge due to the number of barriers ex. Drug use, depression, unstable housing.
Chronic Pain	iCanCope -needs assessment conducted for the development of an online chronic self-management program. (Stinson et al. 2014)	Exploring perception of youth with chronic pain was crucial in laying foundation for development of the self-management intervention.
Patient Adherence to Antiretroviral	SMS Reminder - intervention used interactive voice response and non-interactive neutral pictorial image using short message service (SMS) to report adherence to treatment. (Sydney et al. 2012)	Due to widespread use of mobile phones, there is tremendous potential in healthcare for the designing of appropriate interventions using mobile phone.
Obesity Control	SapoFit - daily data on food, exercise, weight, age and height are input on the user's personal health record which is then used to determine user's health status. (Rodrigues et al. 2013)	SapoFit helps to control weight, caloric intake and physical activity. It is universally accessible.
Chronic Disease	BP monitor - patients used blood pressure monitors to measure their BP several times and keep a written record of the results. (Trudel et al. 2007)	Automated telephone care management plus BP monitors can improve outcomes in low/ middle income countries.

MHealth apps for users can be broken down into four categories, diet, exercise, disease management and intervention.

Diet Applications

Diet applications focus on making changes for a healthy lifestyle. The general objectives of diet mHealth apps are weight management and basic wellness management.

One of the mHealth apps used by users in a study was the Wellness Diary (Mattila et al. 2008). The study focused on the usage, usability and acceptance of the Wellness

Diary and its implementation. The Wellness Diary (WD) was developed for personal wellness management and is based on Cognitive Behavioral Therapy (CBT), a commonly applied psychological approach that is aimed at individual behavioral changes. CBT is a combination of cognitive and behavioral procedures to help the individual identify and change the problem-maintaining mechanisms. The key features of WD were mobility (moving about freely and easily), recording of wellness related self-observations and feedback automatically generated based on the observations. Mobility enabled the user to record self-observations and receive feedback whenever and wherever needed, making wellness monitoring a pervasive and everyday part of life. The concept was aimed at supporting a user's own recognition and decision making process in managing behavioral problems.

There were two different implementations of WD, one for weight management and the other for general wellness management. The difference between these two implementations were the selection of variables (food and drinks, weight, steps, exercise, feelings, fat %, blood pressure, stress, illness, doctor visits, treatments) offered to the user. The primary goal in selecting the implementations for different variables was the support long term self-monitoring. The outcome measures utilized in the study were:

a. The objective of study I was to study the usage, usability and acceptance of the weight management implementation of the WD.
b. The objective of study II was to study a different implementation of the concept in a predominantly female, older and less technically skilled group.

In study I, the subjects appreciated the simplicity and low maintenance approach of the Cognitive Behavioral Therapy philosophy, and that the WD acknowledged and supported the user's own responsibility in making weight management decisions. While most of the users also liked the personal and private aspect of the weight management approach, some users would have preferred to have a peer group to discuss and compare results. A couple of users indicated that the WD complicated their regular calendar use, mostly due to wellness related entries that appeared in the calendar day view along with the regular entries and crowded the day view. Nevertheless, the usage rate of the application was high and did not significantly decrease during the study, which shows that WD was suitable for daily use over long periods of time. (Mattila et al. 2008)

In study II, most users found it easy to learn to use the WD as well as making entries into it. All users considered using the mobile phone for entering information as easy and some found it easy to send data from the application. Study II users made more entries in the WD than study I users. Additionally, the usage rate was maintained at a high level throughout the study as in study I. In light of the positive responses to the usability questionnaire and the high and sustained usage of the WD, it can be concluded that WD was well accepted by this user group. Thus, the results indicate that the WD application is suitable for people of different ages and backgrounds, and not only technically oriented young people. One of the challenges in developing ICT-assisted wellness tools was to make them acceptable to different user groups and to provide a feel of a personal tool. (Mattila et al. 2008).

Exercise Applications

Exercise applications focus on daily exercise, dietetic monitoring and assessment. The objective of this mHealth app is to maintain a daily personal health record of the user's food intake and daily exercise. The objective of the study by Rodrigues et al. (2013) was designing, constructing and validating a mobile health system for dietetic monitoring and assessment, called SapoFit. SapoFit is a mobile system that required several daily inputs from users, mainly food and exercise, and other inputs such as weight, age and height. These data are updated on the user personal health record (PHR) through a web service for easy and immediate access. The user profile utilized the PHR for determination of the user's nutritional status. This status included the user's body mass index (BMI), the user daily caloric intake and energetic needs. SapoFit had to keep a user well motivated not only to use the application but also to lose weight.

The application controlled the user's weight, and alerted the user whenever necessary, in accordance with the customization specified for the user. The majority of users felt that the platform had an attractive design, was easy to use, helpful for meal control, the environment was user friendly and intuitive, navigation options are clear and consistent, and text blocks are written in minimalist style, fonts were easy to read on the screen and the application helped in understanding the problem of obesity. However, half of the users were unhappy with the application response time, because the server connection was still a prototype version and its performance was worse than the exploration server.

SapoFit was a tool that offered to control weight, caloric intake and physical activity of the users. An important aspect of this system was the usability and inbuilt universal accessibility. There was a lack of geo-referential technologies and algorithms to provide context and location-aware services. These services would enable collaboration and cooperation among real users, socialization and helping each other to reach pre-defined thresholds.

Disease management

Disease management focuses on the use of mHealth apps to self-manage diseases. The objective of the mHealth app is to enable the user to monitor their own health. Studies for disease management evaluated the feasibility of utilizing applications to empower users to monitor their health. Zan et al. (2015) evaluated the feasibility of using the iGetBetter system for disease self-management by users with a heart failure. The iGetBetter system offered an opportunity to leverage the increasing accessibility of mobile technologies and consumer facing digital devices to empower users in monitoring their own health outside of the hospital setting.

This was a single arm study where 21 ambulatory, adult heart failure users utilized the mHealth app. The questionnaire used in the study captured baseline technology use and social health. Users were provided with a step-by-step reference guide, and instructed to take their measurements and log their care plan activities daily through the user portal and/or interactive voice response (IVR) telephone system. Users took their weight, blood pressure, and heart rate measurements each morning using a WS-30 Bluetooth weight scale, a self-inflating blood pressure cuff, and an iPad Mini tablet computer connected to the Internet for them to view. If a user did not complete one or more steps, they would receive a reminder phone call from the IVR system prompting them to log their care activities and/or manually enter in their measurements using their phone keypad. The outcomes assessed were:

(a) Usability and satisfaction

(b) Engagement with the intervention

(c) Hospital resource utilization

(d) Heart failure related quality of life.

All 20 study participants were satisfied with the intervention. 95% were comfortable using the intervention and would recommend the intervention to friends and family members. Most of the participants agreed that the system was easy to learn and to carry out their home care activities using the system. This pilot study indicated the feasibility of a low-intensive remote monitoring program leveraging commonly used mobile and portable consumer devices in augmenting care for a fairly young population of ambulatory patients with heart failure. (Zan et al. 2015).

Overall, patients reported high acceptability of the iGetBetter system and found the intervention highly feasible and applicable to their care. The intervention encouraged patients to take their vitals which were automatically transferred to a centralized Web portal, however, patients were offered the option of using an IVR telephone system to report data to the Web platform and set automated daily reminder calls for their care plan items.

The portability and convenience offered by the consumer facing digital devices provided as part of the remote monitoring system, likely contributed to patient satisfaction and high engagement levels, while dissatisfaction with the IVR system and technical difficulties likely affected adoption and engagement in certain parties. Additional studies with a larger sample size and a more diverse patient population was deemed necessary to determine the effect of mobile based remote monitoring programs on clinical outcomes in heart failure. As a result of the low intensity of the remote monitoring component, the current system may not be suitable for patients with more severe disease. (Zan et al. 2015).

In another disease management app, Ben-Zeev et al. (2013) showed that mHealth approaches can support the rehabilitation of users with psychiatric conditions. The purpose of this study was to show that mHealth approaches can support the rehabilitation of users with psychiatric conditions. The research was conducted with users and practitioners at a community-based rehabilitation agency. All stages of the project were conducted with users receiving care and practitioners at a large psychiatric rehabilitation agency.

The outcome measures were done in three stages:

a. Stage 1: Direct service staff surveyed more than half of the users receiving care at the time, in the context of an initiative to explore mHealth options for treatment provision in community settings. Users answered questions about their ownership and use of mobile technologies, payment methods, and interest in future services. Survey information was combined with data from the electronic medical record including demographic and historical self-report, DSM-IV diagnosis determined by agency clinical staff, and ongoing status (e.g. annual income, hospitalizations).

b. Stage 2: A multidisciplinary team incorporated user and practitioner input and employed design principles for the development of e-resources for people and schizophrenia to produce a mHealth intervention. They developed a smartphone based intervention system to minimize potential technical and functional points of failure:

   i. Smartphones are easily carried, socially acceptable and concealable.

   ii. Smartphones functions (call, text, video, camera, music, and gaming capabilities) increase the likelihood that the device will hold some appeal beyond solely serving as a therapeutic instrument and will be carried regularly.

   iii. Recent research suggests that when given the option, people with schizophrenia prefer to use smartphones for self-monitoring and find them easier to use.

   iv. A smartphone application was designed that could be installed on the device itself rather than a web-based application that would require the phone's Internet connectivity functions or intervention messages sent from a remote server.

c. Stage 3: 12 consumers participated in laboratory usability sessions. They performed tasks involved in operating the new system, and provided "think aloud" commentary and post-session usability ratings. First, users provided demographic information and reported on their experience with mobile technology. Next, they performed a series of tasks involving the operation of the smartphone and the intervention system, in the presence of research staff.

> Two facilitators were present for each usability session: one administered the session and the other transcribed. Usability sessions were concluded in two cycles. The first was completed with seven patients/users utilizing a web-version of FOCUS. The second cycle was conducted with five users utilizing the native application installed on the smartphone.

Many users indicated that they would be interested in receiving mHealth services delivered via their mobile device, including reminders about taking their medications or appointments, regular check-ins with practitioners, and psychoeducation and information about treatments and services. The majority of users were satisfied with how easy it was to use and viewed the system as helpful. Several users engaged in the system suggested coping strategies while in the room (e.g., relaxation) during the usability session. The study concluded that innovative technologies could play an important role in supporting self-management of illness, well beyond the confines and limitations of the physical clinic or treatment center. For behavioral intervention technologies to be viable, they need to be developed with the needs, characteristics, and preferences of their intended treatment populations in mind. Only at the end of a comprehensive user-centered development process were the study authors able to produce a mHealth system that was more likely to be used successfully by people with schizophrenia that was ready for testing real-world conditions. (Ben-Zeev et al. 2013).

Intervention

The idea behind mHealth intervention apps is the ability to monitor users via a mobile device. The objective of the intervention app is to provide clinical support through the use of technology. Some of the studies on intervention evaluated the feasibility of monitoring users via mobile devices during treatments, examining symptoms and pain characteristics, pain medications and nonpharmacological strategies used for pain, thoughts and feelings, and healthcare visits or the receptiveness of users with disease to technology and a mHealth application designed for their disease such as PCST.

Somers et al. (2015) examined the feasibility and acceptability of a brief PCST intervention delivered to users in their homes using mobile health (mHealth) technology. Pre to post intervention changes in pain, physical functioning, physical symptoms, psychological distress, self-efficacy for pain management, and pain catastrophizing also were examined.

Users with a diagnosis of breast, lung, prostate, or colorectal cancer who reported persistent pain (N=25) participated in a four session intervention delivered using mHealth technology (videoconferencing on a tablet computer). Users completed measures of pain, physical functioning, physical symptoms, psychological distress, self-efficacy for pain management, and pain catastrophizing. User satisfaction was also assessed.

PCST (pain coping skills training) was designed to help users with persistent pain acquire mastery skills that could enhance their pain management. This novel study intervention was delivered in users' homes through live videoconferencing (i.e., Skype) with a therapist using a tablet. MPCST (mobile PCST) focused on enhancing the efficacy of PCST by using technologies to address social cognitive factors that may influence users' confidence to manage their pain (i.e., mastery, vicarious learning, verbal encouragement, negative responses to skills). MPCST allowed the user to acquire, practice and master pain coping skills in their natural environment. The therapist models skills and explain skills use by others (i.e., vicarious learning). As the user practiced skills in their home, the therapist provided real time feedback and problem solving (i.e., verbal encouragement, addressed negative responses) (Somers et al. 2015).

MPCST comprised of 30-45 minutes sessions delivered via videoconferencing (i.e. Skype) to the user at their home. The protocol skills were designed to enhance users' self-efficacy to:

1. Use attention diversion techniques to decrease pain
2. Manage their pain to engage in activities that will decrease their pain, disability, and distress
3. Use cognitive restructuring to decrease pain catastrophizing, which can result in decreased pain, disability and distress

Participants were given an iPad to take home to complete the intervention. The post treatment assessment was completed approximately one week after intervention completion. (Somers et al. 2015).

User self-report measures were collected with a secure Web-based assessment Web site. Users completed measures of:

(a) Pain

(b) Physical functioning

(c) Physical symptoms

(d) Psychological distress

(e) Self-efficacy for pain management

(f) Pain catastrophizing.

Users reported that the program was of excellent quality and met their needs. Significant pre intervention to post intervention differences were found in pain, physical symptoms, psychological distress, and pain catastrophizing. Cognitive behavioral approaches to pain management, including PCST, have shown efficacy, yet persistent user access barriers limited their routine use. The study intervention was designed to be a highly accessible and efficacious behavioral cancer pain intervention. The use of mHealth technology was a feasible and acceptable option for delivery of PCST for users with cancer. This delivery mode is likely to dramatically increase intervention access for cancer users with pain compared to traditional in person delivery (Somers et al. 2015).

Another intervention app designed by Poropatich et al. (2014) focused on determining if a secure mobile health (mHealth) intervention provided to geographically dispersed users would improve contact rates and positively impact a military healthcare system. There was high acceptability of the application. The mHealth intervention included appointment reminders, health and wellness tips, announcements, and other relevant information.

The mCare system designed to operate on a user’s personal phone, was bidirectional. Providers sent users secure mobile messages ranging from wellness tips and administrative unit announcements, and users responded to specific messages utilizing an interface designed to be intuitive, utilizing one click or character responses (to address the capabilities of users with reduced cognitive abilities). The primary outcome measures of the effort were to validate the ease of use and clinical utility of the mCare application across a diverse geographic region and among varied users. The goal of the mCare pilot was to enroll 100 volunteers in the performance improvement project, but because of user enthusiasm actual enrollment was five times higher. User acceptance was perceived to be high in the pilot effort. MCare user retention remained high over the course of the user's assignment. (Poropatich et al. 2014).

Over 70% of users demonstrated routine use up to 6 months after initial download, surpassing industry reports for apps in the general marketplace. User self-reported usage also indicated that over 70% of soldiers used mCare multiple times per week, and 78% believed that using mCare improved their overall experience.

User feedback surveys indicated that approximately 85% of respondents (n=90) reported appointment reminders as being the most helpful feature in mCare. Two primary factors were key to generating positive user impressions: ease-of-use and content relevancy. The mCare pilot project demonstrated the feasibility and administrative effectiveness of a scalable mHealth application using secure mobile messaging and information exchanges, including personalized patient education.

In a number of the studies users did not report any problems or barriers. Other studies, however, found numerous problems and barriers encountered by users which are reflected in the table below.

Table 4. Problems and Barriers Encountered by Patients in Studies

Problems and Barriers Encountered by Patients in Studies		
Problems and Barriers	**Description**	**Studies**
Technological	Inability to use device independently	Kerssens et al. (2015)
		Donnelly et al. (2010)
	Inability to navigate menus, upload data, use software	Faridi et al. (2008)
		Cobern et al. (2005)
		Bielli et al. (2004)
		Dhukaram et al. (2012)
		Kim et al. (2015)
		Kaiser et al. (2013)
	Software problems, screen freezing	Fincher et al. (2009)
	Bad or lack of Internet connection, not receiving messages, poor response time	Jonassaint et al. (2015)
		Rodrigues et al. (2013)
		Park et al. (2014)
		Sheeran et al. (2011)
Language	Literacy problems, inability to understand the language of the app	Smillie et al. (2014)
		Schwartz et al. (2015)
		Sidney et al. (2012)
Behavioral	Ignoring information, skepticism about the app, lack of responsibility for condition	Pinnock et al. (2007)

	Failing to provide feedback due to stigma	Sheeran et al. (2011)
	Ignoring information on how to self-manage pain	Stinson et al. (2014)
	Feeling that the app is a waste of time, dependence of professional supervision	Williams et al. (2014)
	Perception of stupid questions	McCall et al. (2008)
	Belief that helping researchers and not themselves	Cummings et al. (2011)
Other	Lack of mobile phone ownership	Phillips et al. (2014)
	Equipment is uncomfortable and inconvenient	Faridi et al. (2008)
	Lack of local products (drugs and food) in database	Takenga et al. (2014)
	Short battery life of device	Faridi et al. (2008)
		Sheeran et al. (2011)
	Truthfulness of medication adherence documentation	Brath et al. (2013)
	Dependence on users to maintain medication record without errors	Grindrod et al. (2014)
	Problems receiving and responding to phone calls	Piette et al. (2012)
	Too much time needed	Dale et al. (2015)
	Some users found the Internet/ application easier to use	Cobern et al. (2005)
	Narrow/ single functionality of the app	Winstead-Derlega et al. (2012)
	Narrow/ single functionality of the app	Da Costa et al. (2012)
	Cost of Internet service, time educate on using the app	Takenga et al. (2014)

*Some items in the list may overlap due to their meanings.

Technological barriers

Inability or fear of using a mobile device or Internet, software and equipment issues were some of the problems/barriers faced by users in the studies. Bielli et al. (2004) developed for transmitting users' self-reported outcomes using mobile devices or the Internet, as well as testing whether users could and would use the system via a mobile device. 42% of the users refused to participate mostly due to their lack of familiarity with mobile phone use. Similarly, in the study by Dhukaram et al. (2012), a user-centric vision for cardio vascular disease (CVD) management and treatment, was used to treat patients with a sound solution for continuous and remote monitoring and real time prevention of malignant events. Barriers to adoption of the application included: inability to use the device independently, the need for assistance with the instruction manual, and training. Some users did not feel that the technology made them feel in touch as they would when visiting the hospital/physician for procedures. There were also barriers reported in the Jonassaint et al. (2015)'s study that focused on the usability of a mHealth tool called SMART for the assessment of pain symptoms and its feasibility as an intervention for improving user self-management in sickle cell disease care. A number of users reported feeling comfortable using SMART, however, other users experienced some difficulty, including poor Internet connection at home and technical difficulties with the app (frequent crashing, repeated notification, over alerting, deletion of the app when a new iOS update was installed) and short battery life.

Behavioral barriers

Some barriers were more behavioral. Pinnock et al. (2007) explored the opinions and concerns of users with asthma and primary care clinicians on the potential role of phone monitoring technology supporting asthma self-management. Some users expressed skepticism as to whether the electronic system could change behavior of those who ignored information and did not take responsibility for their condition.

Others reflected the perception that regularly submitting peak flow or symptom that might encourage dependence on professional supervision.

In Sheeran et al. (2011), lack of truthfulness was reported to be a barrier. The study tested the feasibility, acceptability and preliminary, clinical outcomes of a method to leverage existing home healthcare telemonitoring technology to deliver depression care management (DCM) to both Spanish and English speaking elderly homebound recipients of homecare services. A number of users reported that they would be more honest reporting their symptoms with the telemonitor than to an individual due to the stigma of having depression.

Behavioral barriers rose to another level in the McCall et al. (2008) study that tested the feasibility of using mobile phone-based technology, Advanced Symptom Management System in Palliative Care (ASyMSp) to monitor and manage symptoms reported by users living at home in the advanced stages of their illness. Some users reported feeling comfortable using the handset as it allowed easier communication of these symptoms to their health professionals. Other patients/users found the questions asked, stupid.

Language barriers

Other barriers were based on language. The aim of the cross sectional study by Sidney et al. (2012) was the assessment of the perceived usefulness and acceptability of mobile phone reminders to support adherence to ART treatment among HIV infected users. The intervention consisted of two components: (1) an interactive voice response (IVR) and (2) a non-interactive neutral pictorial image using short message service (SMS). The IVR was received once a week at a pre-arranged time in a language selected by each patient. A neutral pictorial SMS (an image comprised of basic characters found on all phones to accommodate the most basic handsets) was designed for the study and delivered once a week, three days after the call. A month after receiving the intervention, patients were administered a structured questionnaire to ascertain receipt of the perceived usefulness of the intervention. A large number of patients stated a preference for the IVR (interactive voice response) over the SMS (short message service).

The Smillie et al. (2014)'s study reported a language barrier. The study focused on understanding the attitudes of users living with HIV who faced multiple barriers to engagement in HIV care, and their experiences using the WelTel intervention as a tool to help manage their care. The WelTel BC1 intervention involved a weekly SMS text message support using an automated text messaging platform. Users who indicated a problem or question were either texted or called. Some of the ESL (English as a Second Language) users found communicating in English via messaging challenging. A few users were frustrated with the process of learning text.

Other barriers

The availability and overload of technology also posed a significant problem. Phillips et al. (2014) focused on whether phone multimedia messages (MMS) would increase clinic attendance, improve ear health and provide a culturally appropriate method of health promotion. Users preferred simple text messages with a specific time and date in comparison to video messages which they found unclear and confusing. There was

low clinic attendance, low phone ownership, and long waiting lines. Sharing phones may have prevented the user who needed to see the messages from seeing them.
Takenga et al. (2014) proposed and validated an innovative mobile health application, Mobile Diab. It managed a secure collection, processing, storage and sharing of diabetes related data and reduced the frequency of physical consultations to the treating physician. The system was aimed at empowering users to manage their diabetes by monitoring their blood sugar trends over an extended period of time and draw some actionable conclusions. Barriers included cost of Internet connection, time needed to acclimate to the application, and the failure of the drug list and meal database to include local food and applied drugs.

The Cummings study highlighted a problem faced by researchers and not users. Cummings et al. (2011) evaluated the benefits of a health mentoring program supported with a web and mobile phone based self-monitoring application for enhancing self-efficacy for self-management skills and quality of life for users with Cystic Fibrosis (CF). Users stated that the application assisted them in thinking about their symptoms but they indicated that they were engaged in helping the researchers instead of themselves. This clearly highlights one challenge faced in engaging users in self-management through clinical trials.

Insights from Paper Analysis

The analysis of the selected papers provide the following insights:

1. Problems and barriers encountered by users of mHealth applications are not being studied by designers/authors of studies.

2. Problems and barriers encountered by users affect the outcome of studies of mHealth applications.

3. Based on the feedback from users' problems and barriers will likely influence future use of mHealth applications.

4. Based on the feedback issues such as access to the Internet, literacy/language, issues, technical issues/inability to use mobile technology, cost, time, behavior, veracity of responses and documentation submitted by users, mobile phone ownership, and narrow/single functionality of the applications, impacted and affected the outcome of the studies.

CHAPTER 3 Results of Analysis

An analysis was conducted of the selected studies on mHealth from three perspectives: functions, interface and design and the strengths and weaknesses of each of these three perspectives discussed in this chapter.

The functions of an application have numerous dimensions. Dimensions of application functionality indicates, that there is a multi-functionality aspect of mHealth apps, even though they continue to have narrow functionality such as providing a user with information or instructing how to test blood glucose. (IMS Institute for Healthcare Informatics 2015). There are seven (7) dimensions of application functionality:

Table 5. Dimensions of Application Functionality
(Adopted from (IMS Institute for Healthcare Informatics

Inform: information about the application is given to the user in various formats, text, photo or video.
Instruct: the user is instructed on how to do a test (e.g. a blood glucose test).
Record: the user is able to input data via manual, active or automatic passive upload.
Display: the application has the capability to show the data that has been entered by the user graphically.
Guide: the application has the capability to guide the user based on the information that has been entered, and may offer a diagnosis or recommend that the user seek a doctor for treatment.
Remind/ Alert: reminds the user of the application to do things such as take a pill, do a blood glucose test.
Communicate: has the capability to provide communication between healthcare providers and the

user of the application through connectivity and integration.

In designing future mHealth intervention programs, the multi-functionality capabilities of mHealth apps should be utilized when considering:

1. Location of the study – is the study in a developed country or undeveloped country, rural or urban area, high income or low income area.
2. Users – who are the users of the application (educated or uneducated, older or younger, male or female).
3. Availability of the Internet – do the intended users have access to the Internet, if they do not how can the application be made accessible to them
4. Cost of Internet services and phone – what is the cost of Internet services and mobile phone to the intended users, can the application be accessible without Internet service.
5. Language/literacy of those being studied – do the users speak the language of the application, can be application be written in the local language and made as simple as possible for those who are considered illiterate.
6. Creation a local database at the specific location – based on location of the users can a local database be created with the drugs and food in that specific location.

If applications are designed without the appropriate functionalities then it will be reflected in the results. Piette et al. (2012) conducted a randomized trial of automated telephone monitoring and behavior change calls plus home BP monitoring among hypertensive patients in Honduras and Mexico. Weekly hypertensive support calls were delivered to users' telephones using voice over Internet protocol. Although users were overall satisfied with the program and felt that the program helped them to manage their hypertension, some of the barriers encountered included problems receiving phone calls, problems responding to phone calls and problems taking blood pressure.

Likewise, Kim et al. (2015) designed an application for diabetes self-management, to obtain basic data on whether diabetes self-management activities improved and to what extent. Although most respondents found the application easy to use and indicated that they would continue using it as well as recommend its use to others, male users found the application easier to use than women.

The interface of an application is also important. The type of interface used for the application can make it easier for a user to use the application. Faridi et al. (2008) examined the feasibility of utilizing technology to assist with diabetes self-care in a clinic population as well as its impact on clinical outcomes. Intervention patients participated in a brief intervention and received tailored daily messages via cellphone prompting them to enhance their diabetic self-care behavior. Users reported that there were too many menus to navigate on the cellphone when uploading data, buttons were too small, and commands changed too frequently.

The interface and functions are part of a larger design process. In conceptualizing a design of a mHealth application, several factors have to be taken into consideration. The first of which is the ease of use. If the application is hard to navigate and use, then users may become frustrated with the intervention and not be inclined to use the application. The second factor is designing the application with the target population in mind while taking into consideration factors such as age, and knowledge of technology. If the intended target is too old or too young then they may have to rely on a third party to use the intervention for them if they do not know how to use the mobile phone and the mHealth application.

The third factor is satisfaction. Designing a mHealth application for use by a targeted population means having to look at features of the application that would entice a user to use the application. If the user is not engaged while using the application and becomes frustrated with the mHealth application then the end result will likely reflect that dissatisfaction. A review of the articles used for the thesis indicated that users became bored and/or frustrated when they were unable to utilize the mobile phone and its application. It is therefore important to teach the users how to use the technology in addition to making the application simple and functional as many people may not use technology on a daily basis.

The fourth factor is efficiency of the mHealth application. A number of the applications had technical difficulties in addition to other problems such as poor or limited Internet service, faulty mobile devices, inability to reload applications. These issues affected whether the users deemed the applications to be efficient and useful.

In analyzing the problems and barriers faced by users, a solution is being proffered as an alternative to the regular mobile phone used to support the mHealth applications. A lot of these mHealth applications were tested in different parts of the world that do not have ready access to hospitals, high mobile phone ownership, cost effective Internet service, high literacy rate and technological knowledge. In 2005, One Laptop per Child (OLPC), a non-profit initiative created software and content for laptops that were powered by the sun. In piggybacking off this concept, I propose the designing of a mobile phone that would use the power of the sun to operate with the appropriate software and content so that mHealth applications and data can be pre-installed for use by users.

If a phone could be created like the laptop and be available at a reduced cost, then it is possible that mHealth applications could be used by more users to self-manage their diseases especially in areas where there is limited or no medical access. Additionally, the programs and mHealth applications could be simplified and pictures used to supplement the intervention in the regional language where the study is taking place. This would further address the literacy and language issue as the local people could better relate to the mHealth application as it addresses their immediate needs.

The design specifications used by One LapTop were based on the parts of the world where their product (s) would be used. The organization that designed the One LapTop based its development on the following:

a. Use of an ARM processor to reduce power consumption
b. Ability to weather extreme environmental conditions
c. Support easy field repair
d. Local language support
e. Support 2GB RAM and up to 8GB internal solid state storage
f. Bluetooth capability
g. Size of a textbook but lighter than a lunchbox
h. Constant connectivity
i. Transformer hinge to assume several configurations

j. Uses LiFePO4 batteries
k. Ability to use alternate power source
l. No hard drive to prevent the One LapTop from crashing
m. Only two (2) internal cables
n. Wireless antennae which outperforms the typical laptop

The proposed design for this mobile phone is based on a similar but not exact concept so as not to violate trademarks and copyrights. First, the phone should be thin and flat for ease of use and transportation. Next, the phone should operate off solar (the sun) energy while allowing it to use batteries or to be plugged into an outlet if feasible. The keyboard should be traditional and the type of material used to make the phone should be durable for long lasting and harsh weather conditions. The wireless capability should be greater than that use by typical phones, the software should be easy to understand, navigate and limited to the barebones of what is necessary to have a functional mobile phone. The mHealth applications should be done in local languages, be easy to navigate and use, pictures should be used whenever possible to reinforce the interventions and use of technology training should be simplified to the lowest literacy levels of the target populations. If these suggestions are implemented then some of the problems and barriers faced by users may be minimized or eliminated and the studies may achieved a higher response level and greater feedback which in turn would allow better modifications to the mHealth applications ultimately leading to greater expansion and use among the target population.

Figure 1. Picture of One LapTop
(https://en.wikipedia.org/wiki/One_Laptop_per_Child

This is a rugged, low power inexpensive laptop that uses flash memory. The wireless networking has a greater range than the typical consumer laptop and it last longer.

Figure 2. Upright view of One Laptop (http://one.laptop.org/about/hardware)

Figure 3. Solar powered phones with a traditional screen.
https://www.bing.com/images/search?q=picture+of+a+solar+panel+on+a+phone&view=detailv2&id=D5998718EE7CD375A22C5591F53DD1D1AFAC&selectedindex=10&ccid=1nQhZNOZ&simid=608017914009748304&thid=OIP.Md6742164d3997ccf571c8ff8f7e45aa5H0&mode=overlay&first=1

This is a solar power phone has a full solar panel on its back which can generate enough power to charge it. The phone is small enough to fit into a pocket.

CHAPTER 4 Discussion

Major Findings

An analysis of a few of the studies indicated that some users were satisfied with the technologies that they used as well as their efficiency. In breaking down the responses to those studies indicating satisfaction and efficiency, a number of reasons were observed:

a. A mHealth system was simple and easy to us.
b. Texting intervention were easy to use.
c. System was easy to carry/transport.
d. Preference for voice response among those with literacy/language issues.

Most of the studies reflected that users often face problems and barriers that impact or prevent their use of these technologies. One of the more prominent problem is access to the Internet which can lead to other issues such as cost of service and phone, availability of the Internet, mobile phone ownership and knowledge of how to use/navigate the phone and Internet service to access the mHealth application.

In a number of the studies that were reviewed for this thesis, the mHealth applications which were designed and used by researchers were tested on people in different parts of the world. Access to the Internet for the users of a number of studies was not readily available or if available was very costly. As such, it is unlikely that the targeted population within that region for the mHealth application would be able to afford the phone and Internet service in order to utilize the mHealth application to manage their disease.

Design of the applications was also a problem. In some studies, the users complained about being able to navigate the menu, some users needed help to use the application as they found it difficult to use, utilizing the technology in an efficient manner, among other issues. One of the reasons given in studies where there were no complaints, was the relative ease of use. An application should be easy to use and simple. It should not be difficult to navigate. It should be user friendly and intuitive. Another barrier was language. A number of the studies were conducted in a number of countries around the world. Everyone does not speak the same language, therefore an application should be designed so that it can adapt easily to the local language of the user.

Investigating the problems and barriers encountered by users is beneficial to the development and use of mHealth apps. Successfully addressing these problems and barriers can expand public awareness and use of mHealth apps. Awareness of the important role that mHealth apps can play in healthcare provides an opportunity to leverage these apps in innovative ways. The opportunity to leverage mHealth apps in innovative ways include:

a. Providing outreach and information to sections of the society that has been traditionally underserved (e.g., elderly, vulnerable, poor, and rural).
b. Addressing the health needs of people living in developing countries.
c. Utilizing features that have various capabilities to expand outreach to the targeted populations. For example, short message service (SMS) is a cost effective, efficient and a scalable method of providing outreach services for numerous health issues.

d. Making the technology more user friendly.
e. Simplifying and educating on the use of the technology to increase its usage.
f. Users are receptive to using technology to manage their symptoms and pain as long as it is not complex.
g. MHealth apps can be used where there is an absence of clinics, lack of healthcare professionals and limited access to health related information.
h. Understanding and addressing users' requirements are the main prerequisites for developing useful and effective technology based interventions.
i. Increased patient assessment can facilitate symptom assessment and communication between patient and sponsor.
j. Elderly patients can with appropriate training and guidance use hand held devices to administer self-exams.
k. There are challenges in stimulating self-management behaviors in some people including adolescents.
l. When designing technology for older users, linear navigation is important. This means that simpler is better.
m. MHealth apps can help people make informed decisions about their health.
n. Collection of patient health data can be more easily accomplished. Data collection is a crucial component of public health programs and accurate data are necessary to gauge the effectiveness of existing policies and programs and to shape new ones.
o. Remote monitoring mHealth apps enable one or two way communication to monitor patient health conditions, maintain and remind caregivers of

appointments, ensure medication adherence and include in-patient and out-patient services.

p. Multi-functional mHealth apps have a greater capacity to monitor and assist consumers in managing their health than those that have a single function.
q. The interfaces of mHealth applications should be presented in local languages and be easy to navigate and use.
r. Pictures should be used whenever possible to reinforce the interventions.
s. Use of technology training should be simplified to the lowest literacy levels of the target populations.

The solution proposed in this thesis is based on the One Lap Top per Child (OLPC) (http://one.laptop.org/about/hardware). The laptop was specifically created with the following requirements:

a. Use of an ARM processor to reduce power consumption
b. Ability to weather extreme environmental conditions
c. Support easy field repair
d. Local language support
e. Support 2GB RAM and up to 8GB internal solid state storage
f. Bluetooth capability
g. Size of a textbook but lighter than a lunchbox
h. Constant connectivity
i. Transformer hinge to assume several configurations
j. Uses LiFePO4 batteries
k. Ability to use alternate power source

l. No hard drive to prevent the One LapTop from crashing

m. Only two (2) internal cables

n. Wireless antennae that outperforms the typical laptop

An analysis of the requirements suggest that a mobile phone can be designed with similar features like those of the OLPC, to address some of the problems and barriers experienced by the users namely, outreach to the underserved populations and those living in developing countries, utilization of features that can expand outreach such as text messages (SMS), local language support, ease of use and being user friendly, constant Internet connectivity, ease of data collection, simpler linear navigation, remote monitoring and technology training.

The cost of a mobile phone can be prohibitive, especially a phone that requires the Internet or the capability to add and download an application which is not a part of the phone's basic operating system. If a mobile phone is designed with similar requirements of the OLPC, then the cost could be minimal. If the phone is inexpensive, it should be more accessible and available to underserved populations and developing countries with the possibility of increasing outreach. Outreach to underserved populations and those living in developing countries is one of the problems and barriers faced by users found in this research. In the study by Phillips et al. (2014) for example, the mHealth app played a vital role in clinic attendance for ear health in two remote communities in Australia. This app was used to send information to patients about their appointment date and time, thereby increasing clinic attendance. Phillips found that among the targeted population there was not enough phone ownership but for those who did have the phones, their attendance increased as a result of outreach. Another study that also supports the proposed solution is the one by Poropatich et al. (2014), which focused on determining if an mHealth app provided to geographically dispersed patients/users would improve contact rates.

The utilization of features such as text messages (SMS) can further expand outreach. In the study by Schwartz et al. (2015), the users who were pregnant women with HIV on active antiretroviral therapy were case managed through text messages and therefore did not have to go to a clinic to be seen regularly. The women indicated that they were happy with receiving text messages offering emotional support and showing that someone cared for them. Likewise in the study by Martini da Costa et al. (2012) SMS messages were found to have a distinct advantage in reducing intrusions in a patient's life and was of low cost compared to voice communications. As a result the patients did not have to interrupt their daily lives to go to a clinic. Another problem and barrier that often impedes acceptability of a mHealth app and that the proposed solution addresses is language and literacy. If a user cannot understand the language or is not literate then that is a problem. The idea behind the proposed solution is the use of local languages to the area on the mHealth app. Additionally, there is local language support for those who may need it. In the study by Smillie et al. (2014), messages were sent to the participants in English, even though they were French and Canadians. As a result, they had problems reading the text messages. Similarly, in a study by Sydney et al. (2012) the users preferred receiving an interactive voice response in a language they selected rather than text messaging that they had problems with understanding. The proposed solution would alleviate this problem.

Two of the main requirements of the proposed solutions, are ease of use (simple, intuitive, basic and easy to understand) and the user friendliness of the app (appropriate font and screen size, simple menu, and easy to navigate). These requirements address the problems and barriers of unfriendly technology, hard to navigate menus, difficult apps and the smallness of the screen, size of the font, etc. These problems and barriers can be seen in the studies of Faridi et al. (2008), Cobern et al. (2005), Bielli et al. (2004) and others. In contrast, when the users did not face these problems and barriers they were more receptive to the application as can be seen in the study by Rodrigues et al. (2013), where the majority of users felt that the app platform was easy to use, intuitive and user friendly. Similarly, in the study by Zan et al (2015), the participants found the app easy to learn. Additionally, the concept of linear navigation ties into ease of use for the elderly, as it focuses on simplicity as demonstrated in the study by Williams et al (2014) where the focus was on simplicity of use, touch screen and no keyboard.

A specific benefit of the proposed solution is remote monitoring. The proposed solution has a wireless antennae that outperforms the typical laptop. Consequently, Internet connection and accessibility will likely not be affected. Therefore, more mHealth apps can be utilized to remotely monitor users successfully. In the study by Jacob et al (2013), a web based e-Diary was used to input patients' data while remotely monitoring pain and symptoms of users. Similarly, Faridi et al. (2008), focused on remote wireless intervention which was an interactive informational system used to provide feedback and reminders to users. Pinnock et al. (2007) also utilized remote monitoring as the study focused on an app that transmitted symptoms and peak flow information with immediate feedback and support. In all these studies users successfully provided feedback and self-managed their conditions.

A derivative benefit of remote monitoring is data collection. Remote monitoring allows the data collection process to be easier with mHealth apps. In studies by Piette et al. (2012), Ryan et al (2005), Cummings et al. (2011), Takenga et al. (2014) and Kim et al. (2015), the user could successfully input data, store it, transmit it for analysis, and receive feedback.

The proposed solution has many advantages and can address some of the problems and barriers encountered by users. It is a simple, cheap, sustainable and feasible option to address the problems and barriers. While the proposed solution may not be able to address all the problems and barriers encountered by users, those that it can address will lead to an increase in mHealth app usage, increased participation in self-monitoring of health conditions, and a reduction of the dependence in the healthcare facilities.

Table 6. Diseases and Target Population.

TARGET POPULATION	DESIGN	PROBLEMS/BARRIERS	STUDIES
Diabetic men and women	Mobile Diab enables diabetic patients to manage their data around the clock using their mobile devices to better manage their diabetes by monitoring their blood sugar trends over an extended period of time.	Patients found the Mobile Diab a helpful tool as it helped them increase their motivation for regular glycemic control.	Takenga et al. (2014)

Diabetic men and women	Diabetes Notepad a self-management system records comorbidities. The app also included diabetes education material and a cardiovascular risk calculator. App allowed access to saved blood glucose history.	Users stated application easy to use and would recommend it to others.	Kim et al. (2015)
Diabetic men and women	Patients participated in a brief intervention and received tailored daily messages via mobile phones prompting them to enhance their diabetic self-care behavior.	1. Too many menus to navigate on mobile phone when uploading data. 2. Buttons were too small and the commands changed too frequently. 3. Pedometers uncomfortable and inconvenient.	Faridi et al. (2008)
Diabetic men and women	Mobile Diabetes Self-Care System, an active and responsive consultation system facilitates patients' self-care ability and practices to manage their behavior.	1. System easy to carry. 2. Convenient access to data for querying and recording. 3. System is flexible to learn and increase self-knowledge.	Guo et al. (2015)
Diabetic men and women	Use of application to support diabetes self-management to increase self-efficacy and participation in self-management behaviors and improved diabetic outcomes.	No problems. Users were positive toward the application.	Hunt et al. (2014)
Chronic obstructive pulmonary middle age to older men and women	Patients completed symptom diary and pulse oximetry daily. Data reviewed at regular intervals by nurse.	Patients viewed the mHealth app to be beneficial to their self-management.	William et al. (2014)
Men and women suffering from pain	PCST intervention delivered to patients in their homes to help develop mastery skills that can enhance their pain management. This intervention was delivered via Skype.	1. No problem. 2. Qualitative feedback was positive.	Somers et al. (2015)

Soldiers	MCare designed to operate on personal phone and was bidirectional. Patients received secure mobile messages and patients responded using an intuitive interface utilizing an intervention interface with one click or character responses with reduced cognitive abilities.	1. Patient felt that appointment reminder most useful feature of mCare. 2. MCare was easy to use.	Poropatich et al. (2014)
Adult men and women	Wellness Diary recorded wellness related self-observations and objective graphical feedback automatically generated based on observations. User able to record self-observations and receive graphical feedback as needed. Two different implementations, weight and wellness management.	1. Most users liked the personal and private aspect of weight management approach. 2. Some users preferred having a peer group to discuss and compare results. 3. Users found it easy to use Wellness Diary.	Mattila et al. (2008)
Men and women who suffer from coronary heart disease	Randomly controlled trial where the intervention group received a personalized 24 week mHeart program framed in social cognitive theory sent via fully automated daily short message service and a supporting website.	Majority of users did not feel the website was a good way to deliver the Text4Heart program.	Dale et al. (2015)
Older people with dementia	Delivery of psychosocial, non-drug interventions to persons with dementia via the Companion, a touch screen technology.	Inability to use device independently 2. Device not being used as intended	Kerssens et al. (2015)
Pregnant women with HIV	Mobile phone based case management intervention targeting HIV-infected pregnant women on antiretroviral.	No problem. Women would recommend to other women.	Schwartz et al. (2015)
Men and women with cancer	Wireless system being used by patients to transmit self-reported outcomes using mobile phones or Internet.	1. Some of the older patients were unfamiliar with new communication technology 2. Some of the older patients were less educated	Bielli et al. (2004)

Adults with sickle cell anemia	Patients in phase 1 evaluated on receptiveness to technology for self-management. In phase 2, patients were given a preprogrammed device with the SMART app which prompted a response from the user twice daily.	Patients were comfortable using mobile devices for healthcare management.	Shah et al. (2014)
Men and women with cancer	Mobile phone based advanced management system for chemotherapy related toxicity in patients with lung, breast or colorectal cancer.	Patients anticipated that the management system would help them to communicate with doctors and nurses as record and manage their symptoms.	McCann et al. (2009)
Patients with chronic obstructive pulmonary disease	Disease management system to predict and detect exacerbations of chronic obstructive pulmonary disease, while helping patients to self-manage their disease.	Patients felt the system was easy to use.	Van der Heijden et al. (2013)
Children and adolescents with sickle cell disease	Pain and symptoms were entered in an electronic e-Diary. Patients used a smartphone to access the web-based e-Diary twice daily.	Patients expressed a wide variety of feelings. The majority indicated that they were happy.	Jacob et al. (2013)
Elderly patients with Parkinson Disease	Patients randomly assigned to three treatment groups (in person, telephone, or videophone). Participant activity level and duration of the disease which influence self-care and self-management were assessed.	1. No problems. 2. Patients found videophone counseling sessions to be more useful than telephone sessions for self-management counseling.	Fincher et al. (2009)
Patients 12 years and older with sickle cell disease	SMART used to assess pain symptoms and feasibility of an intervention for improving patient self-management in sickle cell disease care. Patients used SMART to record clinical symptoms, pain intensity, location, perceived severity and treatment strategies.	1. Patients experienced poor Internet connection at home. 2. Technical difficulties with the app. 3. Some patients did not complete due to experiencing pain. 4. Short battery life of device.	Jonassaint et al. (2015)

Patients 18 years to 80 years old with hypertension	Intervention patients were given an electronic home blood pressure monitor and written step by step instructions for checking their blood pressure at home several times per week and maintaining a written record of the results. Patients also received weekly automated monitoring and behavior change calls.	Patients stated the program helped them manage their hypertension.	Piette et al. (2012)
Diabetic adults	Remote medication adherence measurement system (mAMS) for elderly patients with increased cardiovascular risk being treated for diabetes, high cholesterol and hypertension. MAMS monitored a patient's behavior in taking prescribed medication and to improve adherence by means to close loop interactions.	1. No problems. 2. System easy to use and very reliable.	Brath et al. (2013)
Cancer patients	The Connect System is an online support system for cancer patients to manage health related issues. Patients can access the connect system to report and monitor symptoms, obtain individually tailored information and get access to reliable Internet sources.	1. Patients were insecure about the system and needed training to use. 2. After using the app, patients stated app easy to use.	Mirkovic et al. (2013)
Coronary disease patients	Data was compared from the Medication Event Monitoring System (MEMS) through four different indicators of adherence: total number of doses taken, percentage of prescribed doses taken, percentage of days correct number of doses taken and percentage of doses taken on schedule.	Patients reported high satisfaction with taking their medication and feeling someone cared.	Park et al. (2014)

HIV/AIDS patients	A randomly controlled trial where users were followed over a four month period. Some users received SMS messages and those in the control group did not receive messages.	Overall users indicated that messages they received were good.	Martin da Costa et al (2012)
Heart failure adult patients	Self-management of disease by patients with heart failure via mobile technology	No problem. Patients were satisfied and comfortable with the intervention.	Zan et al (2015)
Cardiovascular disease adult patients	The healthy eating program targeted four sources of influence: mastery experience, vicarious learning, social persuasion and somatic and environmental states. The program focused on overcoming barriers to health eating. Users received one text message per day. Users later were contacted by text and email to complete a follow up online survey.	1. Users were pleased with the ease and timing of the text. 2. Users offered ideas on personalizing the text messages.	Dale et al. (2014)
Asthmatic adult patients	Transmission of asthmatic symptoms and peak flows with immediate feedback and reminder of appropriate action	1. Skepticism as to whether the electronic system could change behavior. 2. Dependence on professional support	Pinnock et al (2007)
Schizophrenic middle age men and women	Rehabilitation of individuals with psychiatric condition via a mHealth app.	No problem. Patients/users felt confident utilizing the system.	Ben-Zeev et al. (2013)
Outpatient care to adult men and women	Text messages used with homeless veterans to increase their engagement in care and reduce no-show appointments. Intervention was web-based text messaging software called MessageMedia, which enabled creation, delivery and management of text messages sent to mobile phones via a computer terminal.	1. No problems. 2. Patients found it easy to use texting intervention. 3. Text messages served as helpful reminders and the text message in box served as a record keeping system.	McInnes et al. (2014)

Asthmatic patients 12 years to 55 years old	A handheld electronic peak flow meter was connected to a mobile phone and patients were instructed in the use of the system and advised to complete peak flow readings in the mornings and evenings.	1. Majority of patients felt the phone software was easy to use. 2. The patients liked that there was increased awareness and information, improved ability to monitor/manage condition with availability of feedback screens on mobile phone.	Ryan et al (2005)
Men with prostate cancer	Ten patients diagnosed with prostate cancer and receiving radiotherapy were equipped with a smartphone were asked to submit daily reports for two weeks. The system allowed immediate transmission of patient's data, was interactive and adaptable, connected to a monitoring web interface and offered continuous access to evidence based self-care advice.	1. Most patients found the application acceptable and user friendly. 2. Most patients were older and used a smartphone for the first time.	Sundberg et al. (2015)
Muscular degenerative adult patients	The Health Management Tool (HMT) is a remote monitoring system using hand held devices. The HMT is used to test retinal visual function. Data is entered by the patient and transferred in real time to the HMT database. Clinicians can access the results and compliance information from an Internet based dashboard.	Majority of the patients reported that HMT was easy to use.	Kaiser et al. (2013)
Adult cancer patients	Home monitoring for the management of chemotherapy side effects on patients	No problems. Patients confident with this approach to symptom management.	Weaver et al. (2014)
Elderly homebound patients	Leveraging existing home healthcare telemonitoring technology to deliver depression care management to elderly homebound recipients of homecare services.	No problems. High levels of acceptability and satisfaction.	Sheeran et al. (2011)
Radiotherapy adult patients	Patients reported symptoms using a mobile device daily during treatment or more frequently as needed.	No problems. Patients satisfied with device.	Falchook et al. (2016)

Children suffering from chronic otitis media	Use of multimedia messages to increase clinic attendance, improve ear health and provide a culturally appropriate method of health promotion.	Participants preferred simple text messages.	Phillips et al. (2014)
Children with cystic fibrosis	Health mentoring program with a web and mobile phone based self-monitoring application for enhancing self-efficiency for self-management skills and quality of life for people with Cystic Fibrosis (CF).	1. Patients felt the application helped them to think about their symptoms. 2. Patients felt that they helped researchers instead of themselves.	Cummings et al. (2011)
Adults with HIV	Users viewed short videos of people discussing HIV health topics. Pre and post intervention surveys assessed attitudes related to engagement in care and disease disclosure.	1. No problems. 2. Users reported identifying with the peer health messages.	Winstead-Derlega et al. (2012)
Adults needing palliative care	Advanced Symptom Management System in Palliative Care (ASYMS) used to monitor and manage symptoms reported by patients being cared for at home in the advanced stages of their illness. Programmed self-care advice was available to the patient on the mobile phone upon completion of electronic symptom questionnaire.	1. No problems. 2. Patients were comfortable using mobile phone and found it a helpful tool to monitor symptoms daily to allow easier communication of these symptoms.	McCall et al. (2008)
Medication management for older adult patients	Users given mobile device with four medication management applications and asked to complete a series of application tasks.	1. Users stated medication management application was frustrating, overwhelming and challenge. 2. Users felt adherence strategies require users to maintain a medication administration record was easily fallible.	Grindrod et al. (2014)

Adults with HIV	Weekly SMS text message support using an automated text messaging platform. Mobile phones and phone plan support provided to users without a phone.	1. Some users found communicating in English via messaging to be a challenge. 2. All users stated that they received a timely response from the health care provider. 3. Some users did not have any difficulty receiving and responding to text messages.	Smillie et al. (2014)
Adolescents with chronic pain	A tailored self-management program was designed from a study of adolescents living with and managing chronic pain. Information was recorded at months 0, 6, and 12. Self-adherence to ART was assessed by a standardized questionnaire at each follow up.	1. Most adolescents endorsed the self-management program. 2. A few adolescents stated they were not interested in the self-management program.	Stinson et al. (2014)
Patients taking antiretroviral	Intervention was two part, an interactive voice response (IVR) and a non-interference neutral pictorial image using short message service (SMS). The IVR was sent once a week in a language selected by the users. If there was no response from the user, three additional calls were made over the next 24 hours.	1. Users preferred voice reminders. 2. Users did not want anyone to receive their intervention.	Sydney et al. (2012)
Overweight adults	SapoFit is a mobile system that requires daily input from users on food, exercise, weight, age and height. This data is updated on the user's personal health record through a web service. The application is used to control the user's weight.	1. Most of the users stated that the platform was easy to use. The environment was user friendly and intuitive and the navigation options were clear and consistent. 2. Some of the users were unhappy with the application response time.	Rodrigues et al. (2013)

Men and women with Alzheimer's Disease	Users offered assistive presence in the home environment through frequent memory cues in the form of video reminders delivered via a mobile phone.	1. Physical appearance of device was an issue. 2. Functionality and usability had issues. 3. Users had technical difficulties with the device.	Donnelly et al. (2010)
Cardiovascular Disease adult patients	Patient-centric vision for CVD management and treatment by providing users diagnosed as at risk subjects with a sound solution of continuous and remote monitoring and real time prevention of malignant events. Device embedded in patient's clothing capable of monitoring several clinical parameters to allow timely diagnosis of the patient's conditions with advanced algorithms and data.	1. Users like the idea of consultation through the Internet. 2. Users stated that the technology should not interfere with existing devices (ex. pacemakers) 3. Users felt the technology made them feel in touch.	Dhukaran et al. (2012)
Adult patients with high blood pressure	A user-centric system was developed to ensure high usability and low disruption of lifestyle and workflow. The system monitored blood pressure and transmitted the readings via a mobile phone to a central data repository. A clinical rules engine checked the data and notified patient and physician if readings outside the desired range for a period of time.	Patients liked the self-care aspects and were intrigued by the device for transmission of the blood pressure data.	Trudel et al. (2007)

Limitations

There are several limitations in the analysis of the users' feedback data from the studies included in this thesis. The first limitation is the usability of the application in the individual studies. While there were users who found certain applications easy to use, effective and efficient, there were others who had problems or encountered barriers in using the application. (Donnelly et al. 2010). Problems range from having difficulty (not easy to use) using the mobile application, poor or limited Internet service, and inability to navigate the applications or unfamiliarity with a mobile phone. Users who had difficulty using the mobile phone, were less likely to complete the studies or reacted negatively to the mHealth application. These negative response in turn affected the feedback/ data collection. An extension of this issue is reflected in several studies where the data indicated that some users dropped out of the studies completely, stopped responding or refused to use a mobile phone to complete the study.

The second limitation is the language or type of intervention being used in the mHealth application. Some of the users had literacy and language problems and this influenced their responses within the studies (Sidney et al. 2012) If the intervention is not modified to suit the users who will be utilizing it, then the intervention is of little or no use.

The third limitation is the limitation or lack of access to technology. In order to use the mHealth applications, access to the Internet is absolutely necessary. If there is no access or limited access, feedback from users will be minimal or limited. Problems and barriers encountered by users were not limited to access to technology. Some users had technical problems with the mobile phone as well as the mHealth application. Some of the technical problems included phones with terminal problems, non-working phones, the inability to access/load the disease management/intervention on the mobile phone and other technical problems that the authors of the studies could not resolve (Kerssens et al. 2015)

Additionally, some users were not adept to using even basic technology despite an attempt to familiarize them with it, prior to the beginning of the study. Other technological problems and barriers could also prevent use of disease management/intervention. If users do not have access to a mobile phone or the cost of the Internet services is prohibitive, then their ability to participate/complete the study will be affected.

A fourth limitation is the inability to verify data from the users. Some of the responses and documentation submitted by the users were deemed questionable by the authors of the studies as they could not be independently verified. Additionally truthfulness of medication adherence was also questionable. Several of the authors of the studies did not trust the data presented/entered by users in the study (Phillips et al. 2014).

Conclusion

User feedback data is critical to studies as these comments help to determine the viability of the mHealth applications, whether they will gain any traction in patient use, ease of use, integrating the mHealth applications in a larger population and further development of the mobile applications. Researchers, however, have not focused on the problems and barriers that users faced while using the mHealth applications for disease management. This lack of focus poses a problem in that the failure to address the problems and barriers faced by users does not increase use among the target population. Specifically, if the target population in a study found a mHealth application difficult to navigate and had problems inputting data, then chances are, once the mHealth application is released to the general population, the problem will still exist and will likely impact the number of people who use the application.

While mHealth technology is a feasible and acceptable option for disease management, user surveys should include problems and barriers that are experienced while using the mHealth application for the management of their disease, so that the problems and barriers can be addressed and the mHealth application modified or fixed so that more people can utilize the available technologies to enhance self - management among users.

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