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mHealth Technology: Towards a New Persuasive Mobile Application for Caregivers That Addresses Motivation and Usability

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MHEALTH TECHNOLOGY: TOWARDS A NEW PERSUASIVE MOBILE APPLICATION FOR CAREGIVERS THAT ADDRESSES MOTIVATION AND USABILITY

by

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ABSTRACT

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With the increasing use of mobile technologies and smartphones, new methods of promoting personal health have been developed. For example, there is now software for recording and tracking one's exercise activity or blood pressure. Even though there are already many of these services, the mobile health field still presents many opportunities for new research.

One apparent area of need would be software to support the efforts of caregivers for the elderly, especially those who suffer from multiple chronic conditions, such as cognitive impairment, chronic heart failure or diabetes. Very few mobile applications (apps) have been created that target caregivers of the elderly and most seem to be limited to a single condition or to creating generic to-do lists or tracking medications. None seem to address the complex tracking of multiple chronic conditions, nor one of the key difficulties found with written checklists for this population, namely that caregivers quit recording health information regularly as time passes.

This dissertation will explore methods for improving the consistency of usage of health tracking software for the caregivers of the elderly with multiple chronic conditions by creating designs that explicitly address the context and motivations of caregivers.

This work will assess a number of existing approaches and provide a design and a prototype for a new motivating application to help the caregivers of patients with multiple chronic conditions. It will assess how well the tool seems to address factors associated with intrinsic motivation (e.g. autonomy, competence, relatedness, and feedback). The overall usability of the software application will also be addressed, following guidelines from ISO standards and Nielsen's theories.

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LIST OF ACRONYMS AND ABBREVIATIONS

mHealth	Mobile Health
ELMCC	Elderly Living with Multiple Chronic Condition
APP	Application
ISO	International Organization for Standarization
SDT	Self Determination Theory
UCD	User-Centered Design
PSD	Persuasive System Design
ITUEM	IT Usability Evaluation Model
MCC	Multiple Chronic Conditions
HD	Huntington Disease
SMS	Short Message Service
BP	Blood Pressure
GPS	Global Positioning System
IRB	Intitutional Review Board
UWM	University Of Wisconsin Milwaukee
BG	Blood Glucose
HDL	High-density lipoprotein
LDL	Low-density lipoprotein
TSH	Thyroid-Stimulating Hormone
DOB	Date of Birth
CZ	CareZone
CBG	CaringBridge
SUS	System Usability Scale
HM	Health Management

LIST OF PAPERS

Paper1 Alkhushayni, S., (2016, April). Improving mHealth Apps for the Caregivers while Addressing Motivation and Software Usability. In Proceedings of the 6th International Conference on Digital Health Conference. ACM.

Paper2 Alkhushayni, S., & McRoy, S. (2016, April). mHealth Technology: Towards a New Mobile Application for Caregivers of the Elderly Living with Multiple Chronic Conditions (ELMCC). In Proceedings of the 6th International Conference on Digital Health Conference (pp. 11-15). ACM.

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Chapter 1

Introduction

1.1 Problem Statement and Motivation

Current software designs do not appear to be a good fit for supporting caregivers; very few of them claim to be targeted to caregivers as discussed below in the "Preliminary survey of software" in section 2.4 of this thesis. Among their shortcomings are that the designs of these systems poorly match the needs and context of the caregivers and also fail to address their motivation. For example, while existing mHealth caregiving apps are helping caregivers to monitor a single chronic condition, there is a need to track people who are suffering from multiple chronic conditions. Moreover, Caregivers often quit recording health information regularly as time passes. The role of caregivers is increasing and thus it would be valuable to support caregivers with better software. Also, since more consistent caregiving may allow them to detect signs of deteriorates health among the people they care for, expanding the use of such tools could have significant health benefits.

A major reason to investigate personal health management tools for informal caregivers is the critical need to improve the care of the large and increasing number of elderly adults with multiple chronic conditions without increasing health care costs significantly.

The leading chronic conditions among people ages 65 and older are: hypertension (51 percent), arthritis (37 percent), heart disease (29 percent), and eye disorders (25 percent). Two in

three people age 65 and older have multiple chronic conditions, and among people age 80 and older, 73 percent have two or more chronic conditions – multiple chronic conditions (MCC) [21,45,46].

Caring for the MCC elderly is also becoming more costly as a growing body of evidence reveals that, for home healthcare patients, older age, diminished cognitive function, and coexisting chronic health conditions such as chronic heart failure, consistently have been found to be significantly related to repeated hospitalization [6].

Thirty percent of home healthcare patients are re-admitted to an acute care hospital within 60 days from discharge, which costs roughly 20% ($17.4 of $102.6 billion) of Medicare's annual budget [22]. Overall health care savings associated with personal health management technologies is estimated to be over $197 billion over the next 25 years [23].

To make an impact, mHealth app developers must take measures to assure that their mHealth app will be accepted by caregivers, patients, healthcare professionals and other end-users who use it. Developers, before developing an application, must determine what functionality is necessary to engage users to keep using the app. To address motivation, they can try to capture relevant aspects of existing theories in the field of motivation and persuasion such as Self-determination theory [1], Fogg's functional role triad [2], and Persuasive system design (PSD) [3,4,5]. These existing theories might potentially be useful, but would need to be synthesized and the principles would need to be realized in terms of actual software designs.

1.2 Research Objectives and Questions

The main objectives of this research can be summarize as follows:

1) Identify the main limitations of existing systems for the target population, caregivers for the elderly with multiple chronic conditions (ELMCC).

2) Identify design features that will better address caregivers' tasks and motivation

3) Implement a mobile application that captures these design features and assess its impact on caregiving tasks

In this thesis, we discuss a new framework for characterizing apps and some formative studies that have been performed to identify the needs of caregivers and to see how they relate to the new framework.

This study will attempt to answer the following questions:

1) What might motivate users to remain engaged with mobile applications? And what methods can be used for that purpose?

Motivation: This research question was proposed to provide recommendations for the developers of mHealth applications to include new design features in order to engage users to keep using the mHealth apps.

2) How can designs explicitly address the context and motivations of caregivers?

Motivation: This research question was proposed to provide recommendations to mHealth developers.

3) How well do the design approaches address factors associated with intrinsic motivation (e.g. autonomy, competence, relatedness)?

Motivation: This research question was intended to improve the motivational aspects of mHealth apps and create a mechanism for assessment. We will assess factors related to intrinsic motivation, as these would seem to be necessary to encourage consistency of usage over time.

1.3 Research approach

To provide recommendations for the developers of mHealth applications to help them select more appropriate design features and keep their users engaged we will review relevant literature, including Self Determination theory, User-centered design strategies, Fogg's Triad Role model and Persuasive Design. Secondly, we will conduct new studies with human subjects, to gain empirical confirmation of the proposed principles. These studies will involve software usability tests, discussions with focus groups, interviews with elderly people and caregivers who are experienced in using the mHealth applications. Third, we will apply an adaption of the ITUEM model to see how well it aligns with these empirical assessments of usability of existing caregivers' mHealth apps.

Fourth, a new framework will be designed for guiding the developers of persuasive mHealth apps. Finally, a new mobile app informed by the new framework and human subjects research, will be implemented and evaluated with some target users.

1.3.1 Rationale for the Research Approach

The research aims to apply both theoretical and empirical approaches. For the theoretical approaches we will draw on well accepted theories from social science and engineering. Specifically, Self-determination theory (SDT) will be considered as an approach for motivation to adopt a change over the long-term, User Centered Design (UCD) will be used to assess the current software designs and to develop a new one.

Several focus groups will be conducted during the study. This method was chosen because they provide qualitative data and the group's dynamic helps to give more natural data and it helps the participants to focus on the subject [24].

Collecting quantitative data can be obtained from questionnaires. The data obtained from the questionnaires will provide an overview of strengths and weakness of the mHealth application [25]. The data gathered through the questionnaire will be analyzed through statistical analysis.

Chapter 2

Background

Research Background on Changing Behavior Design and caregivers

This study draws on the disciplines of software engineering and user centered design. For the sake of the problem domain, this work must also address background of the motivation, self-determination theory, and behavioral changing.

2.1 Caregivers Background

This work aims to support informal caregivers, both paid and unpaid. According to the U.S. Bureau of Labor Statistics, over 800,000 personal care aides and home health were working in people's homes in 2012 and the number is expecting to increase by at least 50% by 2022 [27]. Among paid informal caregivers, 34% of personal care aides and 55% of home health aides were working in a patient's home [26,27].

In addition, in the United States, 21% of the adult population provides some form of unpaid care for an adult relative who is aged or otherwise unable to care for him or herself [28]. Research indicates unpaid caregivers are predominately female, with some college education, working full or part-time, and struggling to balance the care they provide to a loved one (on average 20 hours per week) with their own family responsibilities [28]. As such, these caregivers often cite higher levels of perceived stress, social isolation, difficult finding time to care for one's self, and lack of work-life balance, resulting in a negative impact to emotional well-being [29]. Without proper

support and strategies to manage chronic stress, unpaid informal caregivers may compromise their own health and reduce their lifespan by as many as 10 years [29].

Although most caregivers are older adults [30], children are also often caregivers. One recent study considered children who care for family elderly with Huntington disease (HD) [16] and their experience in caregiving. The study focused on caregiver's wellbeing. The study found that the majority of children caregivers experienced conflict with parents (92%) and school problems (60%) concurrent with poor psychological wellbeing. According to the author although the study included around 80 kids, none of them was using any app [personal communication 2015] [31]. So having such apps could also help these younger caregivers.

2.2 The Potential for Benefits from Increased use of Information Technology

For many consumer health management tasks with different populations, software or web based interventions are known to have been widely adopted. One study found using a computerized touch screen assessment tool makes diabetic patients more active in the consultation and helps improve diabetes care [36]. There is also evidence that a mobile based intervention might be effective, especially for younger patients [34,33,32,35]. The advantages of adopting the technology include: a) providing disease-specific information in a range of formats, including text, photo and video, b) providing alerts to remind patients to take their treatment, c) capturing user-entered data for potentially providing instant guidance or treatment advice to encourage positive health-related behaviors, d) enhancing communication links between health care professionals and patients, and e) providing links to "approved" specific social networks [37].

There is evidence that a mobile-based intervention might be effective in improving communication between patients/caregivers and providers and for promoting adherence to

recommended care of chronic disease, especially for younger patients/caregivers [34,37,32]. MHealth usage is growing rapidly in the United States. A national survey conducted by the Pew Internet and American Life Project of 3,014 adults living in the United States found that more people used apps to track or manage their health in 2012 (37 percent) than in 2010 (17 percent) [38].

2.3 Previous Work on Software for Consumers for Promoting or Monitoring their Health

There are many applications designed for health promotion and for health behavior change. In this section some of these existing applications will be presented. Authors in reference [10] examined factors that might influence the potential success of applications to support health promotion. Their target population was young adults. They explored their opinions and behaviors towards applications that support health behavior change. The target for young adults' feedback was around the usage of the application. Authors found that there are many factors that could affect the usage such as the legality of the app, the security, the immediate effect and the required effort when using the app. From this research [10], authors gathered and summarized some recommended features that could be used in designing health promoting applications. Some of these features can be related to persuasive design principles.

The recommended features from [10] are listed below:

1- Requires low effort and is pleasant to use.

2- Sustain interest over long periods of time.

3- Has low cost and effort; free to download and set up.

4- Developed by legitimate experts and the developer's credentials made explicit.

5- Includes features to help users track health-related behavior, including setting and monitoring goals.

6- Provides feedback and advice that guide people in how they can change behavior.

7- Generates positively framed alerts and reminders that are relevant and timely but not too frequent.

8- Easily turned off or disabled (Certain settings and the entire app).

9- Provides accurate and reliable information and tracking functions.

10- Access is discrete and has adequate privacy settings.

11- Use of the app does not negatively impact or restrict any other uses of the smartphone.

12- There is clarity about what app will do; no surprise.

By looking at the features above, the most valuable features specific to health tracking are the points about including settings and monitoring goals (point #5), generating infrequently alerts and reminder (point#7) and giving feedback on how the behavior could be changed (point # 6).

According to [11] there are seven principles or guidelines proposed by authors for the design of health promoting applications. They made a case study of technology designed to help users to improve their health, a system called HealthyEdge. The most valuable guideline that we learned from this work is to enhance the user experience by allowing the user to set goals or to obtain social support [11].

The effectiveness of mHealth applications that support chronic disease management of diabetes, cardiovascular disease and chronic lung disease has been discussed in a systematic literature review conducted by [18]. Results showed that there is difficulty often in using mobile applications, such as problems with inputting the values, errors etc., which eventually leads users to quit using the apps.

In a design study with elderly people above 65 years old conducted by [21], results have identified the health metrics such as activities of stress release, tracking of rest, that designers usually do not consider.

2.4 Preliminary Software Survey

Tracking apps allow the user to record, track, set goals, create custom tags to store and access measurements anywhere and anytime using personal health websites, analyze the progress using intuitive graphs and statistics, and share information using email or SMS or social media.

To get a better picture of what informal caregivers might find if they sought software to support their care giving, we conducted an informal study that attempted to simulate the users typical experience. First, we visited a popular website for personal health management tools (Microsoft's HealthVault "www.healthvault.com") and looked for tools that listed blood pressure management as one of their supported functions. We limited the search to Android-based tools, as that is one of the most common types because of their lower cost. We searched using the term "blood pressure" and then repeated the search using android as a constraint. On 6/1/2015 using the search term "blood pressure "yielded 25 results. When we further restricted this search to apps that work with Android, we got 15 results.

Within this set, we found that many were purely educational in nature (rather than for tracking) and some are meant to be used only with specific devices or providers. The educational apps provide the user with information about the disease, like the disease's symptoms, medications, disease complications and prevention, without allowing him/her to record information or set alarms. Some apps tell the user about the company services, service locations and try to encourage users to use their services.

Of the 15 results, we found five apps that a caregiver might find potentially useful for health tracking. For the second round of our study we downloaded the five most promising apps from the first evaluation and looked for features related to usability. We downloaded each of these apps and installed them on two different Android devices (two models of smart phones). For an initial survey, we examined four binary features (ease of use; ease of installation; reminders; communication via email/SMS). Table 2.1 below includes a summary of the results of our preliminary survey.

App's Name	Easy to learn	Easy to install	Reminder /Alert	Email/Text MSG	Other Functions
myFitnessCompanion Version 4.0.6 Updated: 3/21/15	No	No	Yes	No	Yes; As mentioned in the app description: diabetes insulin injection use, weight, asthma, blood pressure, dietary intake, blood glucose, HbA1c, cholesterol, oxygen (sp02), body temperature, respiration, bowel movement or your heart rate
Smart Blood Pressure Version 1.4.4. Updated 1/23/15	Yes	Yes	Yes	No	
HoMedics Version 2.3.0.4 Updated: 4/27/15	Yes	Yes	No	No	
iTriage Version:5.60 Updated:5/14/15	No	Yes	No	No	Yes

Wellness Connected App Version 1.5.0 Updated: 6/24/14	Yes	Yes	Yes	No	Yes (Blood Pressure, temperature, weight)

Table 2.1: Preliminary Survey of Software (HealthVault, Android only)

We found that none of the apps supported communication (outside Health Vault). Half were easy to use and install, although these apps were also found to have the most limited functionality. Several other potential difficulties we noted included a lack of documentation (e.g. a user guide or manual) for most apps, and that many of the apps had a different appearance when installed on different Android devices.

Perhaps the best exemplar of a current, easy to use app we found is "Wellness Connected", but it did not provide reminders, as shown below in Figure 2.1:

Figure 2.1: Easy Health Tracking Example

Smart Blood Pressure (not shown) is also simple and provides reminders, but only tracks blood pressure. Other apps that support tracking and reminders (myFitnessCompanion), were found to have interfaces that appear cluttered and confusing and were also deemed difficult to install and learn to use. (See Figure 2.2). We did several, broader, web based searches.

Figure 2.2: Harder to use example: myFitnessCompanion.

After the study, we did find a media announcement for another app specifically for caregivers called “Careticker”. The tool supports care tracking for informal caregivers. It also supports the scheduling and recording of consumer health data. The report mentioned that the winner of the “Audience” award for Health Innovation@50+ LivePitch event was Careticker. According to other descriptions of it that we found, it seems to be “the world’s first web/mobile platform that helps and support unpaid, family caregivers track and gain rewards for the care provided to their loved ones” [HealthInnovations@50 LivePitch, 2014]. (The app was briefly available on Google play, but was uninstalled in July 2014.)

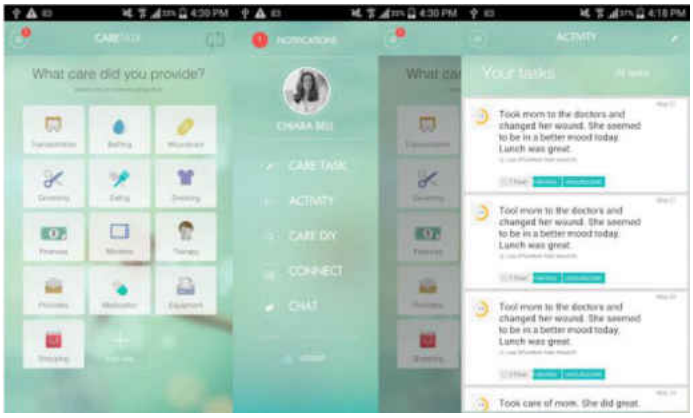

Figure 2.3: A Newly Available System for Informal Caregivers: Careticker

We note that this new app appears to include several features related to intrinsic motivation, although does not seem to include others (such as a way to create reminders or lists of tasks or to track health data).

On June 1st 2015, we used a Google search engine to find examples of software specifically for caregivers of the elderly including support for tracking multiple chronic conditions. We used the keywords **"**caregiver apps", apps for caregivers, app for caring for elderly. We also restricted the results to android. Table 2.2 below summarizes the most relevant Android apps we found after a closer inspection of their web pages. The results for this search yielded many other potentially relevant results, but a closer examination revealed just five that met our minimal criteria of supporting health tracking for multiple chronic conditions.

App's Name	Features	Pros/Cons
Carezone Version:4.1.1 Updated: 5/22/15	1-A care profile to log all pertinent information about loved one who is receiving care 2-Invite friends and families to join you and become "helpers" 3-File storage service so that you can share files with loved ones about elder's care 4-What's called a "CareZone broadcast" that allows you to "send a recorded voice message to up to 100 recipients." Those features are mentioned in the app description webpage.	The app did not track medication schedules or send reminders
MyMedSchedule Version: 1.01 Updated: 6/13/11	Set personal goals and compare them to your actual results	No alarms supported

CaringBridge Version: 6.0.1 Updated: 7/9/14	1-It offers a place for multiple caregivers and family members to share pertinent information, such as updates, encouragement, and arranging care 2- There's a guest book offering a place for journal entries, medical updates, photos, stories, and tributes	1- Can't update profiles 2- Search function pretty much is useless 3- No tracking, No alarms 4- App can't be uninstalled from your device

Table 2.2: Preliminary Survey of Software from Google Search Engine (Android Only)

2.5 Theoretical Approaches

In this section we consider past theoretical work related to the aims of this dissertation.

2.5.1 Self Determination Theory (SDT)

SDT is a social scientific approach that one can use for predicting how well current designs of technology support motivation and what potential changes to designs might be most effective. SDT purports intrinsic motivation is critical to long-term maintenance of behavior modification. According to SDT, there are three needs that must be satisfied for intrinsic motivation to be high: Autonomy, competence, and relatedness [1,39].

Autonomy is the individual's belief they have the power and authority to make a change. The more perceived autonomy, the greater the intrinsic motivation [1,39]. Competence is knowledge, skills, and ability needed to make the change or achieve the desired result; the higher the perceived competency, the greater the intrinsic motivation. Last, relatedness or relationships with others are needed to enhance intrinsic motivation and support long-term behavior

modification. When autonomy, competence, and relatedness are satisfied and supported, intrinsic motivation will be high [1,39]. Extrinsic Motivation, such as praise or rewards, might also help change behavior.

Functions related to motivation can be implemented in software, but multiple functions may be needed. For example, software that uses points or badges addresses only some aspects (e.g. rewards and feedback), but does nothing to enhance autonomy, competence or relatedness. Autonomy might be addressed by software by allowing users to choose a subset of tasks from a broader set or to be able to change the schedule of reminders once they have been set. Competence could be addressed by providing training on how to use an app and by making sure that the functionality and usability of the software fits the technology capability of the care giver.

Relatedness might be addressed by supporting communication with others (such as family members, other caregivers, or providers) or a larger community of users.

To understand more about how the intrinsic motivation is typically incorporated, we can consider the developer's description of Careticker (mentioned earlier). According to the Google Play description, this mobile app will allow one to do the following functions:

1) "Track all of caregiving activities." which satisfies the need of Feedback.
2) "Ask for advice from expert caregivers. "Which satisfies the need of Relatedness.
3) "Learn and interact from other caregivers." Which also satisfies the need of Relatedness.
4) "Measure and improve your caregiving ability." will satisfy the need of Feedback.
5) "Increase your care score and get incentivized for the care you provide to loved ones." will satisfy of Rewards.
6) "Follow other Caregivers and build your own community network." will satisfy the need of Relatedness.

Thus, while the app addresses motivation, by helping to track care, it would not address competence, because it does not allow one to track health values in any structured way or to review the history of health data over time.

2.5.2 User-Centered Design

From software engineering, one approach to creating more acceptable software designs is to focus on the user's perspective.

The main purpose of User-Centered Design is to include the user in the development process in a structural way. ISO provides a framework for User-Centered Design [18,19,25], These six Principles are as follows:

- The design is based upon an explicit understanding of users, tasks and environments.
- Users are involved throughout design and development.
- The design is driven and refined by user-centered evaluation.
- The process is iterative.
- The design addresses the whole user experience.
- The design team includes multidisciplinary skills and perspectives.

As described in the principles, essential design steps include identifying the users who will use the product, their goals, what they will use it for, and under what conditions they will use it. Design evaluation should include usability testing with actual users. The user-centered design approach is iterative. In an iterative design process, the specifications and prototypes are revised and redesigned based on the knowledge gathered with the repeated steps. In this thesis, the application prototype development process is iterative. [40]

2.5.3 The Functional Triad

The Functional Triad [5] of Fogg's is a conceptual framework that illustrates the different roles of computers from the perspectives of the users. It was suggested by Fogg in 1998 as a "functional view" to computers. The framework was then described in more detail in his book [2,3,4]. It establishes different perspectives and theories of persuasion. The Functional Triad states that computers function in three different ways: as tools, as media, and as social actors (see Figure 2.4 below). According to Fogg [2,3,4]., the Functional Triad helps to influence and analyze the persuasiveness of technology, because persuasion strategies vary depending on the role that the computer has.

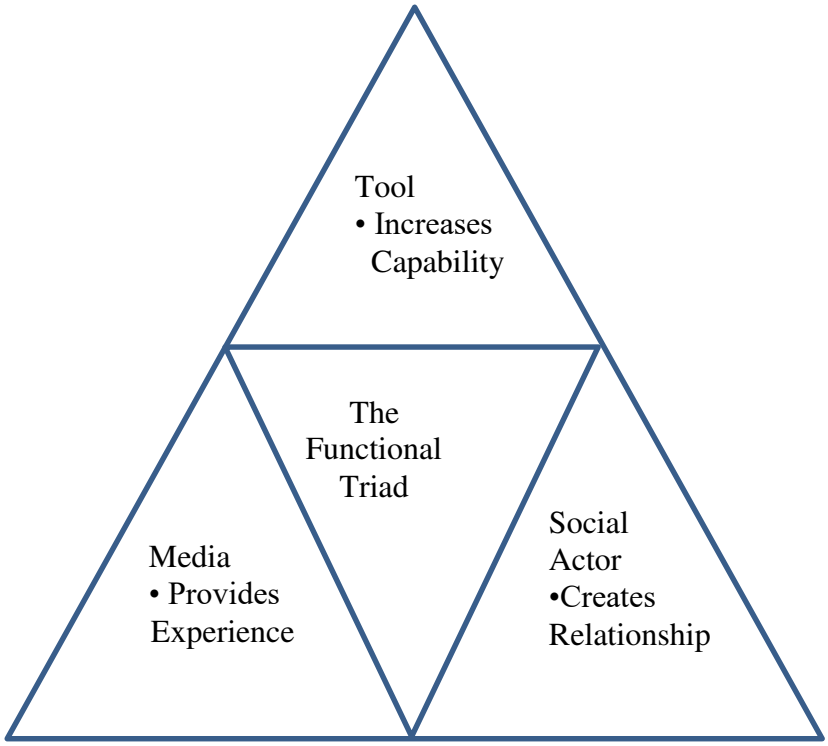

Figure 2.4: Fogg's Functional Triad

In addition to the three categories of the Functional triad, [2,3,4] highlights credibility, mobility and connectivity as being also significant for persuasion. Credibility can be defined as believability and its key dimensions are trustworthiness and expertise.

2.5.3.1 Computers as Tools

When computers serve as tools, they aim to enhance capability and make activities easier to do, guiding people through a process that motivates. Seven attributes of persuasive technology tools were identified by Fogg: reduction, tunneling, tailoring, suggestion, self-monitoring, surveillance, and conditioning [2,3,4]. Tunneling technologies lead users through a predefined sequence of actions or events. Reduction technologies make target behaviors easier by reducing a complex activity to a few simple steps. Suggestion technologies suggest a behavior at the most convenient moment. Tailoring technologies provide information that is highly related to the individuals and filter less relevant information. Self-monitoring technologies allow people to monitor themselves so as to change their behaviors. Surveillance technology allows one party to monitor the behavior of another to change behavior in a particular way. Conditioning technology is based on operant conditioning to change behaviors [2,3,4]. According to [2,3,4]), these technologies are based on various theories. For instance, reduction technologies are based on psychological and economic theories that propose that humans look for minimize costs and maximize gains.

Making a behavior easier to achieve increases a person's motivation to participate in this behavior more frequently. Use of these different tools might also increase the person's belief in their ability to perform a specific behavior. This can assist a person to develop more positive attitudes about the behavior and try to perform it more frequently. The effectiveness of tunneling technologies is based on commitment and consistency. When people once commit to an idea, most people tend to stick with it. Tailoring technologies are based on several empirical studies that have

shown proof that tailored information is more efficient than generic information in behavior change. [2,3,4] also builds on experimental psychological studies and proposes some ways to recognize suitable moments. Self-monitoring technologies make it easier for users to realize how well they are performing the target behavior. They are based on different theories suggesting that people are more likely to do things that are easy to do. In addition, they support the natural human drive for self-understanding [2,3,4]. Surveillance technologies are widely used: when people realize they are being monitored, they behave differently [2,3,4]. Surveillance technologies differ from the other types of persuasive technologies, because interaction between the user and the technology is indirect.

2.5.3.2 Computers as Media

When computers function as media, their goal is to supply experiences by allowing people to explore cause-and-effect relationships, providing people with vicarious experiences that motivate, and helping people rehearse a behavior. Fogg has identified three types of simulations that are relevant for persuasive technologies:

Firstly, there are simulated cause and effect scenarios, simulated environments, and simulated objects. [2,3,4]. Cause and effect scenarios can help people to observe directly the link between cause and effect. Second, Simulated environments in which people can rehearse a behavior can help them to change their attitudes and behaviors in the real world. Finally, simulated objects bring the virtual objects into the real world to be available in everyday activities. According to Fogg [2,3,4], the three different types of simulations are based on psychology. The power of cause and effect scenarios comes from the ability to figure out cause-and-effect relationships without waiting for a long time to check the results. They are also able to transfer the effects in credible ways. Computer simulations are used widely in learning. Simulated environments have

been adopted from education and game design. By bringing the virtual objects into the real world, simulated objects will be available in daily routines. Thus, they can fit into the context of a person's daily life, they are less dependent on imagination [2,3,4].

2.5.3.3 Computers as Social Actors

Computers as social actors can persuade people by using the same persuasion principles that people use in daily communication with each other. When computers serve as social actors, their aim is to create a relationship and be persuasive by rewarding people with positive feedback and providing social support. Fogg has identified five primary types of social cues, namely physical, psychological, language, social dynamics, and social roles. He has also identified five persuasion principles of persuasive technology functioning as social actor: attractiveness, similarity, praise, reciprocity, and authority. [2,3,4]

2.5.4 Persuasive Design

For many, using a health tracking tool represents a change of behavior. Persuasive design is a method for building systems and constructing products that have persuasive features to change default behavior or attitudes. One of the most important researchers in field of persuasive technology is B.J. Fogg who gave a definition of persuasive technologies as "interactive computing systems designed to change people's attitudes and behaviors" [2]. He also defined the term Captology as "the study of computers as persuasive technologies. This includes the design, research, and analysis of interactive computing products (computers, mobile phones, websites, wireless technologies, mobile applications, video games, etc.) created for the purpose of changing people's attitudes or behaviors" [2]. In his definition, it is important to differentiate between persuasion and coercion, which should be avoided [2].

Captology differentiates between unintended behavior and intended behavior change. It focuses on the intended changes that the designer wants to achieve. Based on Captology there are different factors affect the persuasion including the timing and the context of persuasion, for example defining the right moment of persuasion can increase the efficiency of the persuasion goal.

Persuasive System design (PSD) was proposed by [2,3,4]. It includes a method for designing a persuasive system to capture the design principles and persuasion features. It proposes three major design stages: Analyzing major aspects of persuasive systems; Understanding the persuasion context; Designing system qualities [2,3,4].

While dealing with persuasive design there are many rules that relate to promoting and simulating the user and providing rewards for the user when he earns them. Gamification denotes to the implication of games elements in a non-gaming environment and also it includes creating a player experience in health promoting applications. The rewards bring out joy and engagement by using the virtual trophies or points which can be applicable for this study domain. Gamification will not be used in this thesis since the focus will be more on persuasive and intrinsic motivation theories [2,3,4,1].

2.5.4.1 Understanding Persuasive Context

What is most unique to Persuasive design as proposed in [2,3,4], is the second phase, which involves determining the intent and the event and the strategy [2,3,4]. The intent is what the designer wants the users to do. The event represents the user or the technology, and the strategy represent the message or the route of persuasion. The model also divides design principles into four criteria: Primary Task Support, Dialogue Support, System Credibility Support, and Social Support [2,3,4].

The authors of [2,3,4] also suggest that their PSD model can be used for persuasiveness evaluation. It can be used either: as a framework for user based methods, or for inspection-based methods, such as heuristic evaluation by an expert. We will be integrating aspects of this model into our framework for the evaluation of current systems.

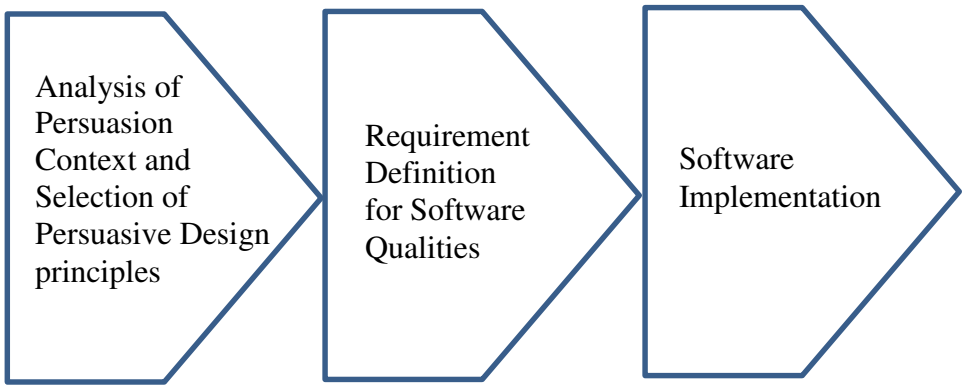

Figure 2.5: Phases in Persuasive Systems Development.

2.5.4.2 Designs System Qualities

In the third phase of [2,3,4], the authors propose 28 design principles for persuasive system content and functionality. In addition, they describe example software requirements and implementations, within the four categories mentioned above (primary task, dialogue, system credibility, and social support). The design principles in the primary task support category assist the performing of the user's primary task. The task can be defined as the action performed by the user in turning input into output (1). All design principles in this category are based on the work of Fogg [2,4].

The authors also turn to think that users act more or less reasonably in the way in which they format and modify attitudes on the basis of beliefs instead of performing behavior as a result

of conditioning. The design principles in this category are Fogg's principles of reduction, tunneling, tailoring, personalization, self-monitoring, simulation, and rehearsal.

The design principles in the dialogue support category are related to human computer interaction or user feedback. The design principles in this category are slightly based on Fogg (2003) and particularly to the social actor category (attractiveness, similarity, and praise) and media category (virtual rewards). Reminders and social role are proposed as novel design principles, while Fogg's principle of reciprocity was excluded from this framework because it was seen as a characteristic of a user rather than a system feature. The design principles in this category include praise, rewards, reminders, suggestion, similarity, liking, and social role.

The design principles in the system credibility support category describe how to design a system so that it is more credible and thus more persuasive. The design principles in this category have been adopted and modified from Fogg [2,3,4]. The design principles in this category include trustworthiness, expertise, surface credibility, real-world feel, authority, third-party endorsements, and verifiability. The design principles in the social support category describe how to design the system so that it motivates users by enhancing social influence. These principles have been adopted from [2,3,4] principles on mobility and connectivity. The design principles in this category include social facilitation, social comparison, normative influence, social learning, cooperation, competition, and recognition.

2.5.4.3 Selection of the Design Principles from PSD Model

In this study, based on the data gathered from the background literature, appropriate design principles were selected. These principles were also formatted in the form of general functional requirements. Two of the most important principles would be the principles of self-monitoring and liking. Liking states that a visually appealing system is more persuasive so the prototype should

be fun and visually engaging. Self-monitoring will be the focus of the prototype. The PSD framework has 28 design principles describing the functionality of the persuasive system. The suggested persuasive system principles by [3,4] are Primary task, dialogue, system credibility, and social support. In the following section the persuasive principles will be listed in Tables 2.3 and 2.4, the chosen ones are listed first with the needed requirement and the excluded ones are listed next.

Most of the principles that were not selected, were excluded because we felt that they were outside the scope of this study.

Principle	Requirement
Personalization A system that offers personalized content or services has a greater Capability for persuasion.	The system has to adjust to the Patients' needs.
Self-monitoring A system that keeps track of one' sown performance or status supports the user in achieving goals.	The system should make it possible for users to follow their status. For example, caregivers track their MCC elderly patients' status.
Simulation Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.	System should make it possible for Caregiver to watch and eventually change the patient behavior in Some points.
Praise By offering praise, a system can make users more open to persuasion.	User should be praised and commended where Appropriate.
Rewards Systems that reward target behaviors may have great persuasive powers.	The system should give the users virtual rewards for completing tasks.
Reminders	

If a system reminds users of their target behavior, the users will more likely achieve their goals.	The system should use reminders to keep the caregivers committed to the MCC elderly.
Liking A system that is visually attractive for its users is likely to be more persuasive.	The system should be visually appealing and attractive to be a motivating app.
Similarity People are more readily persuaded through systems that remind them of themselves in some meaningful way.	The apps will be used by the caregiver and by the elderly patient.
Trustworthiness A system that is viewed as trustworthy will have increased powers of persuasion.	The system should offer adequate information for the caregivers properly.
Expertise A system that is viewed as incorporating expertise will have increased powers of persuasion.	The system should offer adequate information showing knowledge and Competence.
Surface credibility People make initial assessments of the system credibility based on a first hand inspection.	The system should look credible.
Social role If a system adopts a social role, users will more likely use it for persuasive purposes.	The system should support communication. For example, social media connections.
Tailoring Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group.	The system should have short profiling to provide tailored information.
Tunneling Using the system to guide users through a process or experience provides opportunities to persuade along the way.	The user himself has to be in charge of the process. In our scope the app will be used by the caregiver to track the elderly MCC elderly patient's health. But this feature can

	be considered if our app will have a part to help the caregiver wellbeing.
Rehearsal A system providing means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world.	We need to help users in effective process and then stretch to it because of our goal to support motivation through autonomy.
Reduction A system that reduces complex behavior into simple tasks helps users perform the target behavior, and it may increase the benefit/cost ratio of a behavior	Primary task support
Suggestion Systems offering fitting suggestions will have greater persuasive powers	It can be included in the system later by offering some partial solution and in that case it will be included.

Table 2.3: Selected Persuasive Design principles [3,2,4]

Principle	Requirement	Reason for Exclusion
Authority A system that leverages roles of authority will have enhanced powers of persuasion.	System Credibility Support	The study focuses on competence and autonomy.
Verifiability Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.	System Credibility Support	System prototype focuses on the content the user input but verifying is difficult. hence, verifying could include later.

Real-world feel A system that highlights people or organization behind its content or services will have more credibility	System Credibility Support	"No natural real-world analog" Or the system could include a day planner
Social facilitation System users are more likely to perform target behavior if they discern via the system that others are performing the behavior along with them.	Dialogue Support	Not necessary for our system.

Table 2.4: Excluded Persuasive Design principles [3,2,4]

Some principles were excluded because they are not applicable in this work's scope. Some of these principles, such as social facilitation might be included in the future, if it determined that the selected principles are insufficient to support long-term engagement. In the following chapter, two preliminary studies will be discussed; later chapters will discuss the new system and its evaluation.

2.6 Methods for Usability Evaluation

We will take multiple approaches to evaluation, including the evaluation of overall usability. The International Organization for Standardization (ISO) standard ISO- 9241, has defined usability as "the effectiveness, efficiency and satisfaction with which a specified user can achieve the specified goals in a particular environment" [27,28]. Usability is a primary factor in mHealth applications, particularly for elderly people who may find it hard to interact with smartphones.

Several researchers, including Nielsen and Shneiderman have suggested ways to assess usability. According to Jacob Nielsen, there are five quality components that define usability [29], they include: Learnability, Efficiency, Memorability, Low error rate, Satisfaction.

Similarly, Shneiderman [41], suggests performance speed, time to learn, time taken to recover from errors, error rate by the users and satisfaction are the key usability attributes [30]. Table 2.5 below provides a high-level comparative overview of the usability quality components suggested according to Schneider, Nielsen, and ISO 9241-11.

Nielsen 1993	Shneiderman 1998	ISO 9241-11
• **Efficiency** • **Learnability**	• Speed of performance • Time to learn	• Efficiency
• **Memorability** • **Error**	• Retention over time • Error rate	• Effectiveness
• **Satisfaction**	• Satisfaction	• Satisfaction

Table 2.5: Usability Quality Components [31]

This thesis will use the heuristic evaluation method during the design phase [see appendix 1]. Other forms of evaluation can be achieved by including the users in the testing process [20]. For example, in observational studies the think aloud method can be used. In this method, while conducting the test, the participant is encouraged to talk aloud what he or she is thinking [21]. Designers and test conductors can also measure the mistakes or other problems the users might encounter in the system [20]. Observational studies can be done effectively with a small number of participants. Nielsen [14] found that 75% of usability problems could be uncovered by having just four to five test users.

There have been some methods designed that try to quantify usability. The System Usability Scale is a simple scale that provides a view on the subjective usability of a system [22],

from the users' perspective, it is good way to compare across studies because it is one of the recommended strategies of US government agencies [44]. We will discuss our use of this method in Chapter 5, as an approach to making our results more comparable to others.

2.6.1 Health ITUEM

The Health IT Usability Evaluation Model (Health-ITUEM) was developed based on the concepts of usability stemming from the ISO 92411-11 and the Technology Acceptance Model (TAM) [42]. It was developed to fill up or complete the missing information that existed in previous usability frameworks and models [42]. The Health ITUEM focuses on the assessment of usability through the following items: error prevention, completeness, memorability, information needs, flexibility/customizability, learnability, performance, competency and other outcomes. In ITUEM model, more detail was added by including positive and negative effects for each of the Health-ITUEM codes. The results of this improvement allowed assessing positive, negative, and neutral responses to the usability of mHealth applications which led to the development of 27 possible coding categories. An adapted Health-ITUEM model was used in this study as a way of assessing the limitations of earlier work. There were a total two codes for each of the six usability coding categories included, for a total of 12 possible codes. Table 2.6 illustrates an overview of the codes and sample quotes.

Information needs	The information content offered by the system for basic task performance, or to improve task performance
+ Information needs	Positive occurrence or response related to Parent Code Information needs
− Information needs	Negative occurrence or response related to Parent Code Information needs
Flexibility/Customizability	System provides more than one way to accomplish tasks, which allows users to operate system as preferred
+ Flexibility/Customizability	Positive occurrence or response related to Parent Code Flexibility/ Customizability
− Flexibility/Customizability	Negative occurrence or response related to Parent Code Flexibility/ Customizability
Learnability	Users are able to easily learn how to operate the system
+ Learnability	Positive occurrence or response related to Parent Code Learnability
− Learnability	Negative occurrence or response related to Parent Code Learnability
Performance speed	Users are able use the system efficiently
+ Performance speed	Positive occurrence or response related to Parent Code Performance speed
− Performance speed	Negative occurrence or response related to Parent Code Performance speed
Competency	Users are confident in their ability to perform tasks using the system
− Competency	Negative occurrence or response related to Parent Code Competency
+ Competency	Positive occurrence or response related to Parent Code Competency
Motivation	Users were motivated to use the application
+ Motivation	Negative occurrence or response related to Parent Code Motivation
- Health	Positive occurrence or response related to Parent Code Motivation

Table 2.6: Health-ITUEM Adapted Codes and Health Impact Code [42]

CHAPTER 3

Preliminary Studies

3.1 Preliminary Study 1

3.1.1 Frameworks for Software Design

To address factors that contribute to long term use of new software for caregivers, our first qualitative study aims to collect and assess data related to motivation or persuasive design in software. We use a new framework that synthesizes aspects of Self-determination theory (SDT) [1], Persuasive system design (PSD) [3,4,5] and Fogg's functional role triad [2] (Table 3.1 provides some examples of how PSD principles might be mapped onto software requirements for a system; Table 3.2 provides an overview of our new framework). According to SDT, there are three needs that must be satisfied for intrinsic motivation to be high: Autonomy, competence, and psychological relatedness. PSD provides the designer with 28 different principles and features to develop a motivated and persuasive system, which fit into four general categories: Primary Task Support, Dialogue Support, System Credibility Support, and Social Support.

Fogg's functional triad for a computing technology model proposes that technologies can function as tools, media, or social actors. As tools, technologies can increase people's ability to perform a behavior by making it easier, for example, to upload measured data for tracking blood pressure status over time. As a medium, technologies can create simulated experiences that support rehearsing a behavior, empathizing, or exploring causal relationships (e.g., helping people create a plan or set a goal to exercise regularly). As social actors, technologies can use social responses

to influence behaviors; for example, video tutorials might describe how to fit regular exercise into daily life and provide rewards to people in the form of positive feedback. In our synthesis, the SDT notions of autonomy, competency, and relatedness, correspond to the user's perspective, and provide the primary structure. We use PSD to represent the designers' perspective and the functional triad of tool, medium, and social actor as a means to link concepts of SDT to the concepts of PSD. Thus the framework helps bridge the gap between the two perspectives. Others have evaluated mobile technology from the design perspective only [17,18]. Below we elaborate on the framework and the information provided in Tables 3.1, 3.2 and 3.3.

3.1.1.1 Autonomy

From the PSD model the most related principles are Reminders, Similarity, Personalization and Tailoring, which could increase autonomy as a tool. To assist a person experience autonomy in their healthcare decision-making, a mobile app can also serve as a social actor to create relationships. Or, a mobile app can be a medium by providing a to-do list; autonomy is achieved when specifying or changing tasks.

3.1.1.2 Competency

A mobile app can serve as a persuasive tool for achieving competence by supporting a person's confidence in his ability to manage health issues. From the PSD model, Expertise, Tunneling and Rehearsal are three principles that can support achieving competence as a tool. A mobile app can also serve as social actor for achieving competence for health management; for example, caregivers can share how they track medications or manage symptoms. In the PSD model, competence as a social actor might be achieved via Social role, Tailoring, or Expertise. A mobile

app might be a medium for managing their loved one's health by providing a to-do list with color codes to show completed health monitoring tasks.

3.1.1.3 Psychological Relatedness

Relatedness can be achieved as a tool by helping to create a sense of attachment to others. A mobile app can do this by supporting communication with others. The PSD principle of simulation would suggest it would be good to use a GPS to show nearby support groups. A mobile app can play the role of a social actor for achieving psychological relatedness by including chat boxes and social networking forums. The PSD model links to achieving the relatedness as social actor, through the principles of Social role and Real world feel. A mobile app can act as a medium for psychological relatedness via the PSD principles of Simulation, Suggestions or Similarity, such as to show caregivers how to connect with others.

3.1.2 Methods

3.1.2.1 Study Design

A qualitative study design and focus group methodology were used as part of a set of user-centered design activities to inform our work [19]. Eligibility criteria included being an adult caregiver (formal or informal), (Recruited participants were ages 26–56 years.) Willingness to provide written informed consent and having the ability to communicate in English were also required. The IRB of University of Wisconsin Milwaukee reviewed and approved the study protocol.

Participants for the focus group sessions were recruited from October 2015 to November 2015 in the city of Milwaukee - Wisconsin. Recruiters participated in the ninth Annual caregivers'

conference event in Milwaukee, entitled “Caring for the Caregivers”. Participants were recruited using written flyers and verbal invitations at the conference and in classroom settings at the researchers' institution. During the recruitment period, potential participants were provided with details of the study and screened over the phone to determine interest and eligibility to participate in the study. Caregivers were allowed to select any one of the sessions, held over several dates, to allow them to pick the one most convenient to them.

Focus group sessions were led by a facilitator. Focus groups were sometimes attended by one additional researcher who recorded notes and assisted with logistics, such as organizing food, managing consent forms and providing the tokens of appreciation. Focus groups took place in a conference room at the Interfaith Older Adults program and also at the student union at the University of Wisconsin Milwaukee (UWM) campus, lasting approximately 45–70 min. Prior to the start of each focus group, participants were asked to complete surveys that included basic demographics, age, gender, zip code, phone usage, and frequency of use of a mobile phone.

A structured guide that included an introduction and questions was followed by the focus group facilitator. There were five questions: (1) What software have you used either for tracking the health of the person you are caregiving or for your own health? (2) If you have stopped using it, what were some of the reasons? (3) If you have never used any such software, what were some of the reasons? (4) What are some of the reasons that have motivated you to use mobile technology? [17] and (5) If someone were to provide software that met your needs and avoided your concerns, for what tasks do you think the software might be most helpful to you? All focus group sessions were audio-recorded using a digital audio recorder and later transcribed for content analysis.

3.1.2.2 Data Analysis

To analyze the focus group transcripts, a codebook was developed based on our synthesis of three theoretical models: self-determination theory (SDT), the PSD model and Fogg's functional triad, described earlier in this paper. The process of coding involved repeated readings of each transcript using Sound Organizer: 1.6.0.07210. (This is software which came with the digital recorder device.) Upon each reading, concepts were identified and coded if they matched any of elements of the combined SDT, PSD model, and Fogg's functional triad.

Transcripts were repeatedly reviewed and coded until saturation was reached, which occurred when any similar patterns and themes were identified across focus groups and no new information was being identified. Quotations were then grouped according to codes and counted. The data was entered into Qualtrics statistical software (http://www.qualtrics.com/), as installed at the researchers' institution.

Principle	Requirements
Personalization: A system that offers personalized content or services has a greater Capability for persuasion.	The system has to adjust to the ELMCCs' needs
Simulation: Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.	System should make it possible for Caregiver to watch and eventually change the ELMCC behavior in Some points.

Praise: By offering praise, a system can make users more open to persuasion	User should be praised and commended where appropriate.

Table 3.1: Sample of Selected Persuasive Design Principles [2,3,4]

3.1.3 Results

There were 4 focus group sessions. Among the four focus groups conducted with 27 ELMCC, participants' ages ranged from 26 to 59 years or older, with an average age of 42. The majority (83 %) of participants were age 56 and older. The majority of participants were female (67 %). All of the participants were smartphone users. (83%) of participants use their phone for voice calls and texting, (50%) of the participants use their phones for running software apps and (58%) of them use their phones for accessing the internet.

SDT concept	**Fogg's functional role**	**PSD design Principle(s)**	**Mobile app features/ functions**
Autonomy	Tool	Reminders, Similarity, Tailoring	Calendar, Alarm, Medication/appointment reminder
	Social actor	Social role, Social facilitation	Support group connection
	Media	Rewards, Praise, Simulation	Games/Virtual rewards

Competence	Tool	Expertise, Tunneling, rehearsal	Reports, Charts/graphs, lab results over time
	Social actor	Social role, Tailoring, expertise	Tutorials, Personal outreach on how to manage medications
	Media	Tailoring, Simulation	Task creation ability, offering To-do-list, Color coding of tasks
Psychological Relatedness	Tool	Simulation	Tutorials, GPS functionality to locate support groups
	Social actor	Social Role, Real world feel	Chat boxes, Social networking forums
	Media	Suggestion, Similarity, Simulation	Simulation on how to interact and connect with people

Table 3.2: Desired Mobile App Features/Functions Categorized by the SDT, PSD Model and Fogg's Functional Triad

3.1.3.1 Results of Qualitative Analysis

The desired mobile app features/functions were categorized by the SDT, PSD model and Fogg's functional role triad; data is reported here focusing on SDT and Fogg's triad, as shown in Table 3.3. In Table 3.3, while counting the number and the percentage of the comments we referred to Table 3.2 to make sure that each comment fit all dimensional aspects of our synthesized

framework. Participants who mentioned some comments that fit one part of the model (such as autonomy as a tool) but seemed incompatible with the PSD principle for that criteria, were counted as “Other”, for example, one participant mentioned “The software must have a robust but common sense authentication policy. It must reduce at most the login tasks while maximizing user information protection”. Other quotes are discussed, below, as they relate to each of the three SDT concepts.

3.1.3.1.1 Findings of Autonomy

Autonomy in this context was defined as a caregiver’s ability to control their loved one's health care or information. Focus groups participants described the need to support autonomy regarding the organization of medications and appointments. They also identified how the features of a mobile app could be used to inform their treatment decisions and behaviors or to support independent decision making. Calendars and an alarm with reminders for appointments and medications are examples of tools to improve autonomy that were mentioned. For example, one participant discussed the usefulness of having an alarm on her phone: ‘‘One of the reasons that motivate me to keep using CareZone application, it allows me to put reminder of the timings of medicine intake.’’ A participant specifically explained how useful it was to have a calendar as a tool: ‘‘I have an easy to use calendar on my phone. It helps me to keep track the appointments and reminder for annually/monthly checkups for my husband.’’ A number of participants explained that they set an alarm to remind them to take their medications. As one participant said, ‘‘the trackers reminding you to track glucose, etc. are very good. Without the automatic reminders, I would probably always forget to track’’. Another participant said “An app which will remind me to take medication on daily basis and which will remind my monthly/quarterly/yearly medicines

which I need to get from pharmacy. My medical checkup schedule as well. Similar to that body weight, diet and health tracker".

Our analysis also revealed data related to software as a social actor. For example, one ELMCC caregiver's participant suggested that a mobile app could be used as a type of support group "I really did like the community support options, so I would have some functions for community support. Sometimes it's encouraging knowing you aren't alone and there are others nearby who are going through the same thing. It can be used as a type of support group."

We also found evidence of interest in factors related to PSD (such as praise, simulation and rewards). For example, one participant suggested ''I would love if the app can provide me with some virtual rewards every time I achieve the goal for my dad."

3.1.3.1.2 Findings of Competence for Health Management

A mobile app can serve as a tool for achieving competence by supporting a person's confidence in his abilities. Among our participants' comments, we found expressions of desire for tools to enhance competency. For example, one participant explained that he wants to view and track his lab results history without searching into his papers "I like to have the history of my lab results saved into one place, view the results into a graph without walking around with papers."

Some participants also suggested that they would like to be able to have an electronic record of their loved one's status accessible to them on an app so that they can track the status and make informed decisions about their health. "I would like that app would use (the) cloud so the data storage in the local machine would be minimum", "Symptom tracking would be number one. For care of other people, I'd like the ability to track their behavior and symptoms and have those stored so I could view them later in hopes of establishing some sort of pattern."

Our subjects also expressed interest in having an app that could serve as a social actor for achieving competence. As one focus group participant said, "It must combine my health record with my daily information about health. The users are both service providers, say doctors, pharmacists, gym trainers and so forth and end users, say patients, clients, club participants." One other participant explained "More helpful is if the app does things specifically for you. Like CareZone. It helps you organize your entire health information and needs and that is something I feel is very important especially if you are the caregiver for a family or several people." We found a few comments supporting the use of an app as a medium for managing their health, such as through to-do lists or color-coding. One caregiver explained that "A flexible interface enabling users to control their favorite menus (hide some uninterested menus and tasks, and make a short for favorite menus and tasks) - it might be helpful to touch on necessary info". Another participant also reflected on how he uses this tool ''the red color means that the task is not completed, the green one means it has been done".

3.1.3.1.3 Findings of Psychological Relatedness

We found a variety of comments concerning the achievement of relatedness as a tool. One participant explained how a mobile app could provide information that is important for family and friends to access. "I liked the fact that you could share your profile or journal with other people, which I feel is a very essential feature when you are a caregiver and want to communicate with other people involved in the caregiving." Another participant said, "An app could be great for community posts. It gave me the option of creating a community or viewing communities nearby. I simply type in a specific community or a zip code and I can search through a list of matches. I like that it gives descriptions of what each community does or is for. But it also allows me to volunteer or ask that community for help, or even to contact the organizers directly. Simple to use

and it helps people to keep in touch and offer their services and/or request services from people nearby. It made you feel connected. It also provided the user with webinars, newsletters, and demos of the site" Another participant shared that "I really did like the community support options, so I would have some functions for community support. Sometimes it's encouraging knowing you aren't alone and there are others nearby who are going through the same thing. It can be used as a type of support group." One of the participants suggested "I would like to have a very important feature to be added with these that is at least one doctor should be assigned to per profile, so that when a journal is posted or some changes has been made to that apart from all the persons in that person's contact list, the assigned doctor will be notified and he/she will give some expert advice on that issue."

Participants noted the use of chat boxes and social networking forums as social actors for achieving psychological relatedness. One participant suggested "if there is a guide to help users to pick up a similar person or specific person which you could get contact with, or follow, him/her, chat with, it would be awesome. If the users just want to keep track of their loved ones, it works. And if users intend to share their own story, and request others' attention and care, which may bring some warm-hearted people, the app succeeded to do so." Integration of social forums into an app was important for several focus group participants. Another participant said "Association with other common social media such as Facebook can be helpful in informing the info to the other members on social network".

Other focus group participants mentioned the need for a medium to demonstrate how to communicate with providers "if an app becomes the central place for me to visit and it connects to all healthcare providers I am working with, that would be cool. The reason why I am thinking

about it is because each healthcare provider in U.S.A. has their own database for patients and they do not typically share information with other providers."

3.1.4 Discussion

The results of this study support our integration of three theoretical frameworks to address different components of the data analysis. First, Self-Determination Theory (SDT) represents the essential behavior elements; the second is Persuasive System Design (PSD), which provides design principles and persuasion features and, the third, Fogg's functional role triad, provides the intervention component. All three aspects are critical to developing a mHealth app that will be perceived as useful and easy to use by the intended users. Several types of content and features helpful to developing a mobile app that can target behavioral change to improve the health and lives of ELMCC were identified, including both information and communication needs. Participants suggested several primary information tools be integrated into a mobile app, including reminders/alerts, Calendar, and taking notes, microphone.

Some communication tools were identified by participants that would enable a mobile app to function as a social actor, for example, by providing chat boxes/forums and personal outreach. Participants described examples of media that could be used as a persuasive technology, including games/virtual rewards, coding of health tasks, and simulation on how to communicate with people.

Results from these focus groups should inform additional work to identify the functional specifications for a mobile app for caregivers of ELMCC to meet their healthcare needs and encourage use over the long term. One important contribution of this work is in its application of user-centered design methods to inform the development of an intervention or a mobile app from the caregivers of ELMCC perspective. Our study participants included a variety of caregivers,

including, paid and unpaid, formal and informal, adults and elderly caregivers. Given the user-centered design of our study, the findings can be used to refine existing apps or develop new apps to include the identified needs for caregivers of ELMCC.

SDT Concepts	# of Instances	%
Autonomy		
Tool	8	53%
Social Factor	4	27%
Media	3	20%
Total	15	100%
Competence		
Tool	8	50%
Social Factor	6	38%
Media	2	12%
Total	16	100%
Relatedness		
Tool	4	27%
Social Factor	6	40%
Media	5	33%
Total	15	100%
Other	279/325	85%

Table 3.3: Number and Percentage of Participants' Comments

As shown in Table 3.3, we found a fairly uniform distribution among preferences related to the motivational aspects of autonomy, relatedness, and competency. The total number of quotes that were recorded in the transcript and were related to software issues was 325. We found the greatest emphasis on serving the functional role of tool, followed by social actor. The role of

medium was least mentioned, except in the context of aspects of relatedness. For example, the total number of comments that fit the meaning of autonomy as a tool and in the same time support the PSD principles for autonomy as a tool and the mobile features are 8 out of 15 with a percentage of 53%, and the comments that fit autonomy as a social actor and fit the PSD principle and the mobile features for that criteria are 4 out of 15 with a percentage of 27%. We found a few cases (13%) where comments did not fit the synthesis of PSD and the SDT criteria, which we will examine further in the future.

3.1.5 Limitations

Some participants were not current users of any mobile technology, so it may have been hard for them to specify what tasks and features they need a mobile tracking app to include.

3.1.6 Conclusion

New opportunities for enhancing the lives of ELMCC can be offered by mobile applications. They have numerous functions aside from phone calls and text messaging, such as reminders, calendars, microphones, social forums/chat and charts. All of these features have the potential for improving the ELMCC wellbeing. The focus of this work was on assessing the caregivers' of ELMCC views of different functional specifications and features for inclusion in a mobile app for caring of ELMCC wellbeing. We found it helpful to use a framework synthesized from Self-Determination Theory, Persuasive Design and Fogg's functional triad. Under this model, the comments from our focus group members confirm the need to address both tasks and motivation and suggests specific types of software functionality that might achieve them.

3.2 Preliminary Study 2

The purpose of this study was to assess qualitative data of caregivers' mHealth applications by using an adapted Health IT Usability Evaluation Model (Health-ITUEM) [42]. Qualitative data were collected from two different resources, First, qualitative data was collected from public customer rating data posted on the Google play, Microsoft HealthVault and/or other Android resources. Second, we collected data by conducting focus groups, where previously the participants had all installed three highly rated caregiving apps on their mobile devices and used them for a period of 2-3 weeks.

3.2.1 Overall Study Design

A qualitative content analysis method [17,18] was used to anatomize public consumer reported data published on the Android Market, Google Play, and data collected from the focus groups. Content analysis includes the translation of textual data that has been classified into concepts. Once the identification of concepts or categories has occurred, they are categorized into themes based on their relationships with each other [19, 20].

3.2.1.1 The Selection of mHealth Caregivers Applications for Both Components

On Jan 1st 2016, we conducted a broad web-based search using Google search engine to identify 3 best examples of software specifically for caregivers of the elderly who might want to track health for multiple chronic conditions. We used different keywords in different orders, including: caregiver apps, apps for caregivers, app for caring for elderly. We looked at the web pages of the top-ranked results (shown on the first page of search engine results) in more detail. The applications were included if they were developed using the Android platform, were in English,

and had more than 500 consumer review reports. Applications were excluded if they were in a language other than English, had less than 500 consumer review reports, and were based on the iPhone platform.

Based on the eligibility criteria outlined above, the three mHealth applications included in both components of this study were:

- CareZone. According to the developers, "(CareZone) aims to help the person to stay organized and effective when caring for a parent, child, or someone in need. From the computer, smartphone or tablet you can safely organize files, contacts, and medications, and coordinate with family and other caregivers using a shared calendar and journal. By using CareZone the one is able to care for as many people, families, pets, In addition to the person himself".
- WebMD for Android. According to the developers, "(WebMD) aims to helps the user with his/her decision-making and health improvement efforts by providing mobile access to mobile-optimized health information and decision-support tools including WebMD's Symptom Checker, Drugs & Treatments, First Aid Information and Local Health Listings. WebMD the App also gives you access to first aid information without having to be connected wirelessly – critical if you don't have Internet access in the time of need."
- CaringBridge. According to the developers, "(CaringBridge) is a bridge that allows you and your loved ones to stay in touch. It's a perfect app for a family that rallies around a loved one in need of care, and for those who are facing surgeries, rehabilitation, and procedures that go along with diseases such as cancer, heart disease, diabetes, etc. It offers a place for multiple caregivers and family members to share pertinent information, such as updates, encouragement, and arranging care."

Application Name	User Rating	No of ratings	# of installs	Version	Cost
CareZone	4.4/5	13280	1 million	5.2.0.0	Free
WebMD	4.2/5	52083	5 million	4.0.1	Free
CaringBridge	4.1/5	930	100,000	6.0.1	Free

Table 3.4: Caregivers mHealth Application Information (As of February 4, 2015)

3.2.1.2 Coding Scheme

In exemplar one, while collecting and analyzing the consumer comments, Information needs, flexibility/customizability, learnability, performance speed, and competency were Health-ITUEM concepts that were included to categorize the data. Error prevention, completeness, Memorability and other outcomes were excluded because they were more software-related issues and they were unlikely to be addressed in the consumer reported ratings of the three mhealth applications. Error prevention, completeness, and Memorability were included in content analysis for second component of the study (exemplar 2), which consider comments from the focus groups. Motivational Design was added as an additional class to the analysis for both exemplars, since the original Health ITUEM did not consider this aspect. Each of the concept codes was broken down into positive or negative codes. No neutral codes were included as online consumer reports are mostly positive or negative. The concept codes for identifying a positive response was designated with a plus sign (+). Negative responses were designated with a minus sign (-). Refer to Table 2.6 for the list of adapted codes.

3.2.1.3 Sampling

All consumer reported quotes from December 15, 2015 to February 3,2016 for the first two mHealth applications (CareZone, WebMD) and from October 20,2012 to January 6,2016 for CaringBridge were included in the study. Software seller reports, when found, were excluded from the sample.

3.2.1.4 Data Analysis

To analyze consumer reports and the focus group transcripts, a codebook was developed based on Table 2.6 concepts. Each quote was addressed as a separate unit and was not connected with the former quotes. Some of the consumer reports couldn't have more than one code applied to it. The data were extracted independently by the researcher and another check was conducted by the same researcher to verify the coding. No personal information was used when reporting the results or during the content analysis process.

Comments from consumer reports and focus groups (both exemplars) were included in the study if they could be classified into one of the six coding categories and were in English. Any consumer reports that did not give adequate detail on the mHealth application and as a result could not be coded were excluded.

3.2.2 Results from the Online Ratings

Of the 13 highly rated caregivers' mHealth applications specified, 3 caregivers' mHealth applications met the inclusion criteria that mentioned above. (See Table 3.4) Across all three mHealth applications, information needs and application performance were rated highly positive with consumer rating of 4.1 out of 5 and above as in Table 3.4.

There were a total of 376 consumer posts from exemplar one (See Table 3.5). Out of the 376 consumer posts that were identified, 40 were excluded. Thus, 336 consumer reports remained and were included in the current study. The smallest consumer reports were 10 words and the largest was 128 words.

Overall, the analysis for the first exemplar, shows that over 83% (N=312) of the consumer comments were positive on all three mHealth applications for both usability and motivation as shown in (Table 3.5), 17% (N=73) were negative. When focusing on the usability, the analysis shows that around 73% (N=235) of consumer postings were rated positive. Only 17% (N=67) were rated negative. On information needs, 85% (N=106) of consumer reports across all three mHealth applications noted a positive impact of each of the mHealth applications on meeting the information needs of the consumer. Only 15% (N=18) of consumer reports noted that the mHealth applications did not meet the information needs.

	Exemplar 1						Exemplar 1 Total	
	CareZone		WebMD		Caring Bridge			
	+	-	+	-	+	-	+	-
Information needs	33	2	51	5	22	11	106	18
Flexibility	6	2	10	1	5	3	21	6
Learnability	0	0	8	0	1	0	9	0
Performance speed,	11	8	28	0	19	13	58	21
Competency,	10	2	33	4	9	15	52	21
Motivation	13	3	34	0	19	3	66	6
Sum (All)	73	17	164	10	75	46	312	73
Sum (Usability)	60	14	130	10	56	43	246	67
Sum (Motivation)	13	3	34	0	19	3	66	6

Table 3.5: Summary of Overall Analysis of Consumer Comments in Exemplar 1

On flexibility and the ability to customize the application, 22% (N=6) of the postings reported a negative result;78% (N=21) reported a positive result. In regards to the learnability, all nine of the consumer reports were positive. Regarding performance speed, over 73% (N=58) of the consumer reports were positive with only 27% (N=21) reporting negative performance speed. As to competency in the use of the mHealth application, 71% (N=52) of the occurrences coded were positive and 29%(N=21) were negative.

With regards to the motivation of the mHealth application, 92% (N=66) of the consumer data reported positive health outcomes as a result of using the caregivers mHealth applications. Only 8% (N=6) of consumer reports noted negative motivation.

The analysis for the second exemplar, shows that over 76% (N=352) of the consumer comments were positive on all three mHealth applications for both usability and motivation as shown in (Table 3.6), 14% (N=64) were negative.

3.2.3 Content Analysis of Focus Groups Meetings

For our second exemplar, we conducted focus group sessions with a group of college students. Prior to our focus group sessions, we asked the participants to install three predefined app as following: CareZone, WebMD, CaringBridge, for use during a 10-day ecological momentary assessment [36]. During the sessions, we asked participants to provide feedback based on their past 10 days of using the Smartphone and specifically answer the following questions: 1) what are some of the reasons that have motivated you to use the apps on your mobile device? 2) What were some barriers you encountered when using the mobile health apps on your phone? 3) What were some of the strategies you used to overcome these barriers?

3.2.4 Results

There were a total of 19 participants which met in 4 focus group sessions, to accommodate their schedules. Participants for this exemplar ranged in age from 20-30 years old, with an average age of 25. The majority (83 %) of participants were age 26 or less. The majority of participants were male (82 %). All of the participants were smartphone users. (91%) of participants reported using their phone for voice calls and texting, (86%) of the participants reported using their phones for running software apps and (97%) of them report using their phones for accessing the internet.

The results of the focus group are described in Table 3.6. The analysis for the second exemplar shows that over 74% (N=352) of the comments were positive on all three mHealth applications for both usability and motivation, while 16% (N=64) were negative. When focusing on the usability, the analysis shows that around 62% (N=305) of consumer postings were rated positive.

	Exemplar 2						Exemplar 2 Total	
	CareZone		WebMD		Caring Bridge			
	+	-	+	-	+	-	+	-
Error prevention	11	7	34	1	6	2	51	10
Completeness	5	0	31	3	0	2	66	5
Memorability	10	2	33	0	1	0	60	2
Information needs	19	0	12	0	12	0	67	0
Flexibility	4	0	10	0	19	15	33	15
Learnability	2	3	0	0	21	0	23	3
Performance speed,	11	4	14	1	20	2	57	7
Competency,	16	3	13	3	1	9	34	15
Motivation	19	2	18	1	10	4	47	7
Sum (All)	97	21	165	9	90	34	352	64
Sum (Usability)	78	19	147	8	80	30	305	57
Sum (Motivation)	19	2	18	1	10	4	47	7

Table 3.6: Summary of Overall Analysis of focus groups' comments in Exemplar 2

Note that Table 3.6 includes more usability factors than were included for exemplar 1 shown in Table 3.5, since we expected a broader range of consumer comments and feedback in the focus group data. (The added factors were: Error Prevention, Completeness, Memorability.)

3.2.5 Discussion

With the growth in the number of mHealth technologies, there is a need to evaluate the usability and health impacts of such technologies in a meaningful way. The current study aims to examine the usability and motivation impacts of mHealth caregivers' mobile applications using the Health-ITUEM model.

The main findings of the current study suggest that information needs, motivation and application performance are the primary factors influencing the perception of usability among online self-reported consumer postings and focus group comments. Looking at consumer reviews is a useful place to start. The positive results of the content analysis around usability of all three applications as well as the high consumer ratings and high number of downloads supports a relationship between the content analysis results and consumer ratings.

A content analysis of reviews provides evidence for possible explanations of the reviews. For example, we found that a clear majority of all the usability comments were related to issues around information needs, which included comments mentioning the amount of information provided by the app. Comments also mentioned the ability for patients to achieve tasks, user willingness to keep using the app, and also some comments about the app's performance or speed. The results suggest that performance or speed and the ability of an app to address users' information needs are the most significant factors impacting the usability of caregivers mHealth

applications. Previous studies also recommend to test mHealth applications for performance, as an important factor for users, in relation to the applications' ability to perform tasks [18,19].

This study also found that addressing information needs was an important factor influencing the use of caregivers mHealth applications. Over 44% (N=191) of both negative and positive codes were related to information needs. This is consistent with previous studies that show the significance of technology meeting the information needs of diabetic patients [20, 21].

A major new finding of this paper is the importance of motivation and users belief in the benefits to health outcomes in their perceptions of mHealth application. In the analysis of the data we collected, there were a total of 132 comments coded for health including the positive and the negative. Consumer reports discussed useful services such as building medication lists, accessing relevant news and journals, receiving updates about specific diseases treatment, and tracking vital signs (such as blood Glucose, Blood pressure, Body temperature weight), and perceived positive outcomes, such as improved eating behavior.

The usability categories of the adapted Health-ITUEM model have been shown to be helpful in understanding user's comments on software. Most comments fit the Health-ITUEM model, although some categories were not always parts of published reviews (such as error prevention, completeness, or memorability) and it may be useful to add motivation, as we found several comments that seem to fit this category.

3.2.6 Limitations

First, the data collection process could have been expanded to include a longer timeframe for the exemplar1 and it might be useful and more accurate to involve more participants in the focus groups for the exemplar2. This study could have examined more caregivers-related mHealth applications, such as those supported only by the iPhone system.

3.2.7 Conclusion

There is a lack of literature on evaluating the usability of mhealth technology. The study found that mHealth applications with high ratings usually also do a good job of meeting the information needs of the users. This research also found that to analyze usability and motivation of mHealth applications, consumer rated reports can be used, but should be confirmed with the target population.

CHAPTER 4

CaregiverPal Prototype

4 The Design and Development of CaregiverPal

This chapter will provide a description of the goals and functionality of the proposed system and its prototype implementation. The scope and environment of this system will also be discussed, as well the most important use cases.

4.1 Rational for the CaregiverPal

The goal of creating CaregiverPal was to create a mobile software application that would address the tasks and motivation of caregivers. Preliminary studies were done to determine what functionality would be desired and a theoretical analysis was done to align those functions with principles associated with motivation and persuasive design. Then a prototype was implemented, assessed, and refined in an iterative fashion. In this chapter, we discuss the implementation and an assessment based on the Persuasive Design Framework. (In the next chapter, we will consider a usability study.)

As mentioned previously, persuasive systems can be evaluated by the Persuasive System Design framework. The synthesis Framework in Chapter 3 and [45], can also be used for Persuasive Features Evaluation to more directly consider aspects related to motivation.

In this thesis a persuasive features assessment has been done by manually examining of the CaregiverPal prototype against the persuasive design principles. This assessment was conducted by the researcher to determine how well the prototype system addresses the optimal principles described in Sections 3.1.3 and 2.5.4.3 (Some of less essential features were left to future work.)

The researcher went through the application and noted the support for each of the principles, as shown in table 4.1. Under the primary task support principles, Reduction, Personalization, Tailoring, Personalization, Self-monitoring, Simulation and Rehearsal are considered. For the Reduction principle, CaregiverPal tries to help the caregiver to track the patient's health for several chronic conditions; each disease has its own measurements and units and the caregiver can edit any recorded data at any time.

The user himself has to be in charge of the process in the Tunneling principle. In our scope the app will be used by the caregiver to track the elderly MCC patient's health. But this feature can be considered if our app will have a part to help the caregiver wellbeing and it was listed as a future work in chapter 6.

Under the Tailoring and Personalization design principles [9], a system has to adjust to the Patients' needs and CaregiverPal has a short profiling to provide tailored information. In CaregiverPal, personalization is addressed by making each data item optional, as some observations or measurements may be needed by paid caregivers but not unpaid caregivers (or vice versa). One can also customize several features, such as the units of measurement for recording data or the time-span for viewing a statistic.

The CaregiverPal prototype also supports Self-Monitoring [9] since it allows caregivers to follow their patients' status by viewing previously recorded data or viewing statistics calculated over different durations of time.

One of the selected primary task support principles was Simulation. The user of CaregiverPal can view statistics and the average for the measurements over specific days, this provides a way to realize the cause and effect for some chronic conditions measurements.

However, with regards to Rehearsal principle, CaregiverPal designed in a simple way and the user can go through tasks smoothly.

For the dialogue support, Praise and Rewards principles were listed as future works in chapter 6. The most important design principles are Reminders. In CaregiverPal, caregivers are generally encouraged to track and record new measurements. Specific reminders to input data at a specific time are currently under development but not present in the CaregiverPal prototype at this point. Suggestion principle was listed as a future work in chapter 6.

When it comes to the Similarity principle, in CaregiverPal the app will be used by the caregiver and can be used by the elderly patient too. CaregiverPal has a simple and colorful interface, which follows the principle of Liking. Social Role was selected because if a system adopts a social role, users will more likely use it for persuasive purposes. Social Role is supported because caregivers will be able to send information by email while they use CaregiverPal. (None of the excluded principles discussed in Table 2.4, are evident in the CaregiverPal prototype nor would they be recommended as future work.)

From the system credibility support design principles, trustworthiness, expertise and surface credibility were selected. Regarding the Trustworthiness principle, CaregiverPal requires authentication (a login) assuring the user that only he or she has access to the data from the application, unless explicitly shared or uploaded to an outside service such as HealthVault. The Expertise principle was listed in chapter 6 as a future work.

Principle	Present in CaregiverPal	Present in CareZone	Present in CaringBridge	Present in WebMdSchedule
Primary Task Support Category				
Reduction	Yes	Yes	No	Yes
Tunneling	Future Work	No	Yes	No
Tailoring	Yes	Yes	Yes	Yes
Personalization	Yes	Yes	No	No
Self-monitoring	Yes	Yes	No	Yes
Simulation	Yes	No	Yes	No
Rehearsal	Yes	Yes	Yes	Yes
Dialogue Support Category				
Praise	Future Work	No	No	No
Rewards	Future Work	No	No	Yes
Reminders	In Progress	Yes	No	No
Suggestion	Future Work	No	No	No
Similarity	Yes	Yes	No	Yes
Liking	Yes	Yes	Yes	Yes
Social Role	Yes	Yes	Yes	No
System Credibility Support				
Trustworthiness	Yes	Yes	No	No

Expertise	Future Work	No	No	Yes
Surface Credibility	Yes	Yes	Yes	Yes

Table 4.1: Present Persuasive Design Principles

To address the Surface credibility Principle, CaregiverPal has a colorful and simple user interface, similar to a commercial software product. Of the 17 selected persuasive design principles, 11 are present in some form in the CaregiverPal prototype. The principles can be seen summarized in Table 4.1.

4.2 Project Scope

CaregiverPal is a mobile app that helps caregivers (e.g. nurse, family member, paid caregiver, etc.) while they are taking care of their patients or family members. The system allows them to record and review their health and medical activities. The caregiver might be paid or unpaid.

The caregiver will be responsible for entering the chronic condition measurements and the associated activities. Each of these interactions is considered to be a “health task”. Each health task is associated with a date and time. In the beginning, the caregiver has to create an account for each patient by entering the patient information’s profile which includes: the patient name, patient gender, patient date of birth, patient height. After that the caregiver will be able to enter the measurements associated with each chronic condition for the selected patient. For the initial prototype the app will consider conditions associated with obesity, chronic heart failure and diabetes, including changes in weight and blood glucose level. Details about the functions provided by CaregiverPal application will be explained later in this chapter.

4.3 Overall Description

Here we will cover the main details of the implementation framework for the prototype.

4.3.1 Operating Environment

The Windows operating system has been used for development of CaregiverPal. The Android Mobile Operating System has been used for deployment. CaregiverPal should run on any Android mobile platform operating system compatible with the Galaxy, versions s4 and up.

4.3.2 Dependencies

The project uses the Android Platform. Generally, Android applications are written in Java, and is needed here.

4.4 Functions of CaregiverPal

The chronic conditions and health states that the caregiver is able to manage by using CaregiverPal include:

1. **Obesity**. The measurements associated with it are: Weight, Fat percentage, Abdomen, Waist and Hip. Some of these measurement can be measured by the caregiver and some would typically be imported or copied from the clinical reports after the patient's hospital visit. The user will also be able to enter notes related to those measurements. The user can also specify the date and the time. The length measurements (abdomen and hips) can be recorded in Centimeters or feet. The caregiver is able to enter those measurements by pressing on “Weight” button in the main screen.

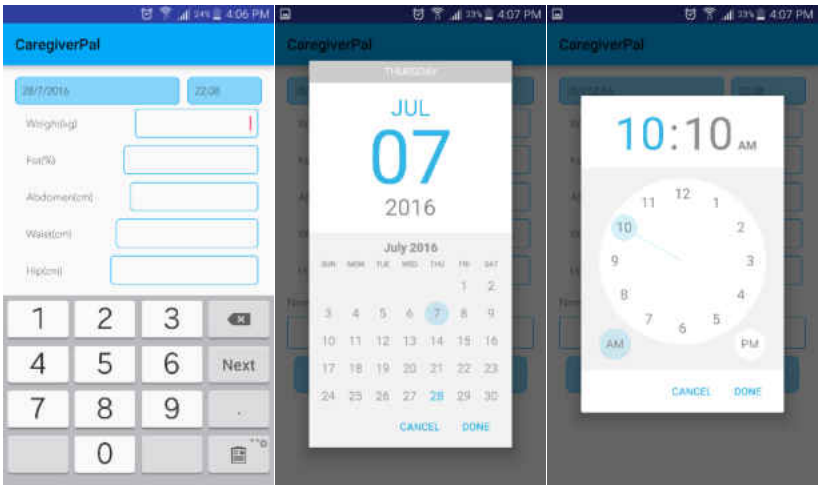

Figure 4.1: Weight Measurements in CaregiverPal

2. **Glucose**. These are measurements typical for tracking diabetes. The measurements associated with it are the blood Glucose (BG) and HbA1c. They can be measured at different times (e.g. Pre and Post Breakfast, pre and post lunch, pre and post dinner, pre and post exercise, at snack time, during sickness time, low BG time). The user will be able to enter notes related to those measurements. The caregiver is able to enter those measurements by pressing on the "Glucose" button in the main screen.

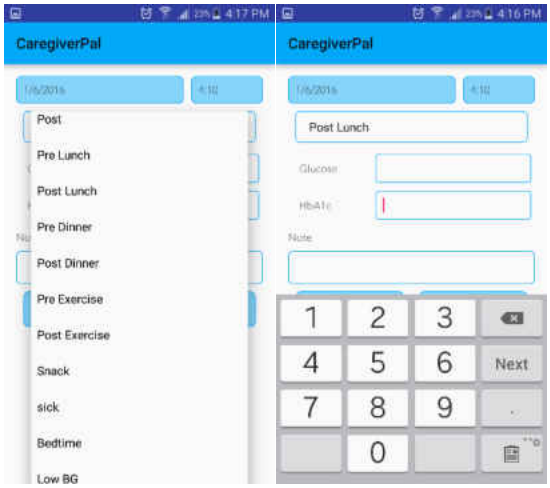

Figure 4.2: Glucose Measurements in CaregiverPal

3. **Vital Signs**. The measurements associated with it are the Systolic(mmHg) and Diastolic(mmHg) and Heart Rate(bpm). The caregiver is able to enter those measurements by pressing on “BP” button in the main screen.

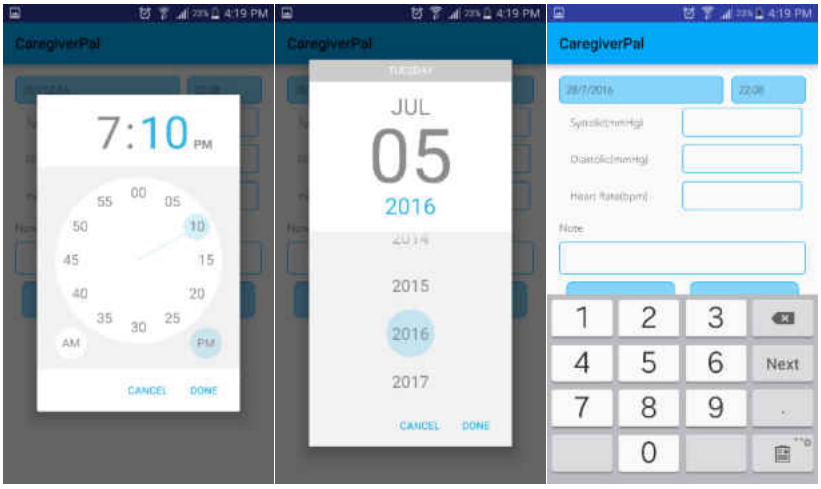

Figure 4.3: BP Measurements in CaregiverPal

4. **Cholesterol**. The measurements associated with it are High-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol count (Total), Triglycerides level. The caregiver is able to enter those measurements by pressing on “Cholesterol” button in the main screen.

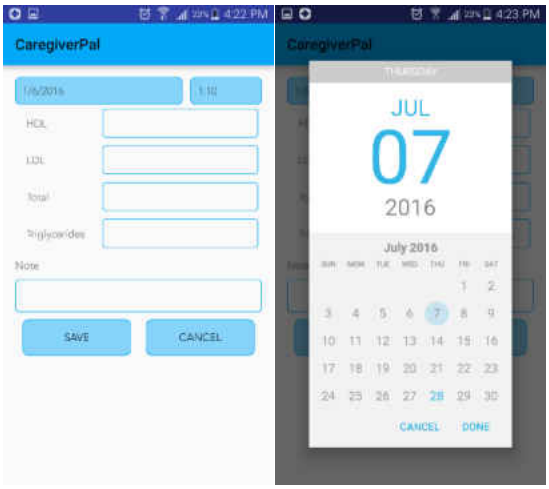

Figure 4.4: Cholesterol Measurements in CaregiverPal

5. **Thyroid**. The measurement associated with it is thyroid-stimulating hormone (TSH level). The caregiver is able to enter those measurements by pressing on “Thyroid” button in the main screen.

Furthermore, the caregiver will be able to view a diary for all the chronic conditions by pressing the “Diary” Button. Five tabs for the five chronic conditions will appear. The caregiver can view the measurements for each condition and he is able to edit any previously recorded measurement.

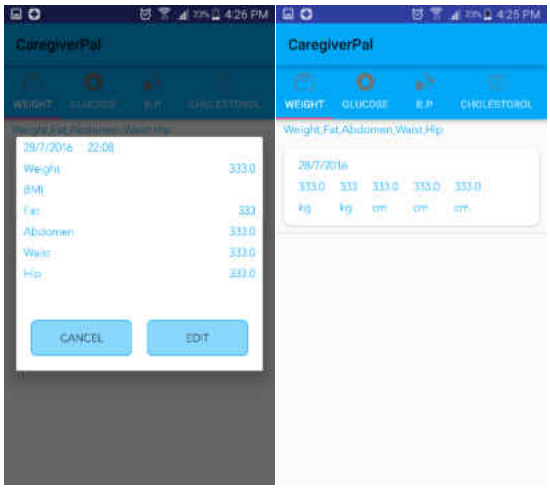

Figure 4.5: Edit Chronic Conditions Measurements in CaregiverPal

In addition, the caregiver is able to schedule and track Medications, Food and Activities for selected patients. When the caregiver adds a medication he can choose a date and time, insert the medication's name, and he can also select a description of the associated time (e.g. Pre and Post Breakfast, pre and post lunch, pre and post dinner, pre and post exercise, before and after snack, before activity, during activity, after activity, after and before bed). The units or measurements unit vary, as appropriate to the type (e.g. mg, pills, puffs, suppositories).

When the caregiver wishes to add a food, he can choose a date and time, insert the food's name, also he can select the status ((e.g. Breakfast, Lunch, Dinner, Snack and other). The unit of measurement for foods is grams.

Also, when the caregiver would like to add an activity, he can choose a date and time, insert the activity's name, and also select the time (e.g. Pre and Post Breakfast, pre and post lunch, pre and post dinner and other). The unit of measurement for the duration of an activity is minutes.

Moreover, the caregiver can view the average of values over recorded measurements for each chronic condition by pressing on the "Statistics" button. He can choose a standardized period

for aggregating the statistics (e.g. week, month and six months). Or, he can select a customized number of days over which to view their statistics.

The caregiver can press on the “Manage” button to do a variety of tasks. He can add/edit user, switch between measurements units: from mmol/L to mg/dl in case of Glucose, from DCCT% to IFFC in case of HbA1c, from kilogram to pound in case of weight, from centimeter to feet in case of Length and he/she can switch between two date format (day/month/year) or (month/day/year).

4.5 Use Cases

This section describes the use cases for higher-level tasks supported by the current implementation. Each figure describes the intended goal of a task, the critical assumptions, and the steps that a caregiver must take to complete the task using the app.

Use Case	**Create New Patient Account**
Description	Addition of a new patient information into the database
Actors	Caregivers, Internal Database
Assumptions	Caregiver must have the application running Database must be connected in to the application Caregiver must have patient selected in application
Steps	Caregiver opens the app Caregiver enters in patient name, gender, DOB and height Caregiver presses “Save” Database then adds the new patient to the patients’ list

Figure 4.6: Create New Patient Account Use Case

Use Case	Add Chronic Disease Measurements
Description	Addition measurement for several chronic conditions for s specific patient (Weight, Glucose, Blood Pressure, Cholesterol, Thyroid)
Actors	Caregivers, Internal Database
Assumptions	Caregiver must have the application running Database must be connected in to the application Caregiver must have patient selected in application
Steps	Selects a specific patient Selects a specific chronic condition(s) Presses “Save”

Figure 4.7: Add Chronic Disease Measurements Use Case

Use Case	View Measurements Reports
Description	View Diary measurements for all chosen Chronic Conditions
Actors	Caregivers, Internal Database
Assumptions	Caregiver must have the application running Database must be connected in to the application Caregiver must have patient selected in application
Steps	Selects a specific patient Press on “Diary” button Navigate among the five tabs Select specific measurement Press on “Edit” button Press on “Save”

Figure 4.8: View Measurements Reports Use Case

Use Case	Add Logs
Description	Caregiver adds Medication, Food, Activity
Actors	Caregivers, Internal Database
Assumptions	CaregiverPal is open Caregiver is on specific patient pane Caregiver must have patient selected in application Database is connected to application
Steps	Selects a specific patient Press on “Add Log” button Navigate among the four tabs Selects specific tab and insert data Press on “Save”

Figure 4.9: Add Logs Use Case

Use Case	View Statistics
Description	Caregiver view calculated statistics or a specific period or specific number of days
Actors	Caregivers, Internal Database
Assumptions	CaregiverPal is open Caregiver is on specific patient pane Caregiver must have patient selected in application Database is connected to application
Steps	Selects a specific patient Press on “Statistics” button Select Period for Statistics Press on “Calculate”

Figure 4.10: View Statistics Use Case

Use Case	Setting Management
Description	Change settings of the application
Actors	Caregivers, Internal Database
Assumptions	CaregiverPal is open Caregiver is on specific patient pane Caregiver must have patient selected in application Caregiver is settings pane
Steps	Navigate to settings Pane Adjust Selected Settings Apply Setting Changes

Figure 4.11: Setting Management Use Case

CHAPTER 5

Usability Testing

5.1 Overview of Methods and Results

Usability testing is an important part of user centered design; it often detects design flaws and also validates recommended design features. In this section, possible usability issues in the CaregiverPal application are explored. CaregiverPal is intended for caregivers of ELMCC. In this thesis, two categories of user were considered, the elderly and younger people, as both are commonly caregivers, but might respond differently to the use of the app. The evaluation of the prototype will include measures related to usability as well as to persuasiveness as described in the persuasive systems design framework.

The usability evaluation methods will include the Think-aloud protocol technique for observing participants during the test and also structured interviews with the participants for more feedback, in addition to a SUS survey.

Before discussing the methodologies of usability testing in detail, a review of the main research questions of this dissertation is given below:

1) What might motivate users to remain engaged with mobile applications? And what are methods that can be used for that purpose?

Motivation: This research question was proposed to provide recommendations for the developers of mHealth applications to include new design features in order to engage users to keep using the mHealth apps.

2) How can designs explicitly address the context and motivations of caregivers?

Motivation: This research question was purposed to provide recommendations to mHealth application developers to help in overcoming the usability issues faced by caregivers and patients

3) How well do the approaches address factors associate with intrinsic motivation (e.g. autonomy, competence, relatedness)?

Motivation: This research question was intended to assess the motivational design of mHealth apps. We will assess factors related to intrinsic motivation, as these would seem to be necessary to encourage consistency of usage over time.

5.2 Methods

During the usability test, data was collected through a think-aloud technique where individuals explain aloud what they think of the application as they perform a set of tasks in the CaregiverPal. This technique provides two types of information. The first type are the statements of the participants, which describe their perceptions of the experiences. The other type involves the recorded and observed actions that occur while the participant is completing the assigned tasks [18].

At the end of the usability tests, participants also will complete a written questionnaire which can also provide valuable information for enhancing mHealth application developers' understanding of any usability issues concerning this type of application. The questionnaire focuses on user expectations and experiences. The measurements used when gathering the information are total time for completion, time spent to complete each task and number of irrelevant touches for completing the task.

5.2.1 Selection of Participants

In the usability test, several students and caregivers were selected to participate. The students were chosen from University of Wisconsin - Milwaukee (UWM) and have a computer science background whereas caregivers were selected from our previous subjects from the focus groups. To communicate better about the usability test and tasks, English was used as a mode of communication. Only participants who were able to express themselves in English were selected.

5.2.2 Usability Test Panning

The evaluation of CaregiverPal was conducted at the UWM library and/or UWM union. The guidelines for usability [1] and the Institutional Review Board (IRB) were followed while conducting the usability test. A brief introduction was given to the participants to what they were going to perform and they were also provided details about the tasks that they had to achieve at the beginning of the usability test. Participant were asked to play with the app and a short description manual was given to them to help them understand some medical concepts while using the app.

The usability test was conducted in two phases. In phase1, the researcher went through the mHealth application to familiarize the subjects with the application. Tasks that should be performed during the usability test were selected. A pre-test was conducted with caregivers and students to ensure that the descriptions of the tasks to be achieved were comprehensible. Quantitative measurement parameters were defined based on the pre-test results. In phase2, the actual test was conducted where the participants' interaction with the system was observed and noted by the researcher.

5.2.3 Tasks for Observational Tests

Usability tests were organized to evaluate the usability of the CaregiverPal prototype. A set of descriptions summarizing several tasks designed to cover the main features of the application to be completed was given to participating users. These tasks are presented in Table 5.1. (For all tasks, the participants will have already downloaded the CaregiverPal application onto the user's own mobile phone.)The main features to be evaluated were: adding a new user, editing user info, inserting his/her weight measurements, inserting his/her Glucose measurements, inserting his/her blood pressure measurements, inserting his/her Cholesterol measurements, inserting his/her Thyroid measurements, viewing the diary measurements, adding logs measurements, viewing statistics, changing measurements units and changing the date format.

Task 1: Open a user account in the mobile application
a. Open the application b. Enter a new user name c. Fill in the personal information in text fields provided. Note: you can add more than one user or patient
Task 2: Fill the chronic condition diseases data if available
a. Choose which patient you would like to start with (if multi patient were inserted) b. Fill the data or measurements for each chronic condition (Weight, Glucose, Blood pressure, Cholesterol and Thyroid c. You should insert measurements for at least three different times then save your data
Task 3: View the data that have been inserted
a. Find the "Diary" button and navigate through the tabs b. In the same window, edit the first weight measurement c. Save data
Task 4: Insert Medication, Food, Activity

a. Find the “Add Log” and navigate through the tabs b. Under “Food” tab, choose Breakfast first and then Snack and enter two food names with two amount for each of them c. Under “Activity” tab, add an activity before the breakfast with the period spent for that activity d. Under “Meds” tab, add a medication with an amount
Task 5: Statistics Calculation
a. Find “Statistics” button b. Calculate the statistics for 2 custom days and navigate through the average of measurements for each chronic condition.
Task 6: Edit and Manage
a. Find “Manage” button b. From the menu list, choose “Edit User” c. Change the first user gender, change the date of birth for the same user d. Save data and go back to the menu list e. Change the current measurement unit for Glucose, Weight, Length f. Change the current date format

Table 5.1: Usability Test Tasks

5.2.4 Questionnaire

Quantitative data was obtained using questionnaires. Items on the questionnaires assessed the perceived strengths and weakness of the mHealth application [2]. The data gathered through the questionnaire was analyzed through statistical analysis using Qualtrics survey software. The observed results were categorized into the five quality components proposed by Nielsen by the researcher. We rated the five components using a five-level Likert-type scale; each question was answered along the scale from strongly disagree to strongly agree.

5.2.5 Procedure

As described in section 2.6, the think aloud method was used to conduct the usability tests. Each individual completed all six tasks and their interaction with the mobile application was noted by the researcher. The test was conducted in an environment where the participant was free to

move around in the room while using the application. The equipment used included a mobile phone, an audio recorder and a time calculating device to record how long it takes to perform a specific task by the participant.

A convenient time for the participants was chosen before conducting the test. While conducting the test, the conductor (researcher) wrote notes of the user's actions when he/she was using the application. After the test, each user was asked to fill a System Usability Scale questionnaire. In order to get the immediate reaction to the question and the application, the users were asked to fill the questionnaire without excessive thinking of the answers. At the end of the test, the user and the test conductor discussed the application in more detail. This discussion focused on what the user thought about the application and asked him or her to mention if there was something that he or she noticed during the test and had not mentioned yet. Participants were also asked for recommendations to improve the CaregiverPal.

5.3 Results

The results showed overall satisfaction with the application but some usability issues were identified. Several specific recommendations for improvement of the CaregiverPal concerning usability aspects were provided during the test. The observed usability problems will be helpful for enhancing the design of CaregiverPal and for designing efficient mobile applications in the future.

A total of 9 (five students and four caregivers) participants took part in this test. All the students had experience using smartphones and had used a number of mobile applications. In the case of caregivers, some of the people did not have experience in using mobile applications.

5.3.1 Participant Demographics

The 9 participants ages ranged from 26 to 59 years or older. The majority (56 %) of participants were age 26 to 40. The majority of participants were male (56 %). All participants were smartphone users. All participants reported frequently using their phone for voice calls, texting, running software apps and for accessing the internet.

	Response	**%**
Gender		
Male	5	56%
Female	4	44%
Total	9	100%
Age		
25 or under	0	0%
26-40	5	56%
41-55	2	22%
56 or older	2	22%
Total	9	100%
Smart Phone User		
Yes	9	100%
No	0	0%
Total	9	100%
Frequent uses of phone		
Voice calls	9	100%
Texting	9	100%
Running software apps	9	100%
Accessing internet	9	100%

Table 5.2: Caregivers of ELMCC Focus Group Participants

5.4 Finding of Usability Tests

As mentioned in the above Table 5.2, every participant performed six tasks. During the test each participant provided comments and recommendations regarding the interface during the test. The obtained results were classified into qualitative and quantitative data.

5.4.1 Task1:

The task is to open a user account in our mHealth application (CaregiverPal).

- All participants were satisfied with the interface for creating an account. The steps to create an account were simple. Each participant was able to create an account without any problem.
- To open an account, users had to go through one page/wizard.
- Participants sometimes commented on the labels beside the text field and sometimes had difficulty entering data in the fields. One of the participants, when she typed in the text fields, she took 2 seconds to type the name, 15 seconds to choose the DOB and 3 seconds to type the height. We observed that it took longer than normal because she made a mistake, entering the height with the unit as centimeter rather than feet, so, she had to re-enter the height again. During the test, she recommended that it would have been better if there was an increase in the size of the font for the height and its label fields to avoid any future mistakes.

5.4.2 Task2:

The task is to fill the chronic condition diseases data

- The researcher observed that four of the participants were confused and they were not able to understand the label for every text field, so the researcher explained more about each label. Based on this observation, the researcher provided a brief document describing each of the health symbols to the participants to be used as a reference while conducting the test.
- Three Participants were observed looking for a help guideline inside the app itself, but there was no help guide provided within the app.

- Two Participants were confused about whether they were to enter numbers or text in a text field.

5.4.3 Task3:

The task is to View the data that have been inserted.

- All participants found it easy and simple to navigate between the tabs for this task.
- All participants found the saved data were presented in a good manner.
- They commented that they did not realize that the viewable data were also editable, but they felt that it was attractive feature that they could edit any data that had been inserted previously.
- Participant were successful editing the data when they tried it.

5.4.4 Task4:

The task is to Insert Medication, Food, Activity:

- The researcher observed that three participants were curious about the use of multiple tabs and icons and they spent around 8-10 seconds reading the labels before doing any action.
- Four Participants found it useful and attractive to be able to specify the time during the day e.g. before breakfast
- One participant found it hard to add medication since she had to return back to the previous page to insert the number of units or to specify the amounts.
- The researcher noticed that three participants liked this feature a lot and they wanted to spend more time on it and inserting more food and activities.
- All participants successfully inserted at least one new medication, food, and activity.

- All participants found it very useful to have the fourth tab, labelled “Miscellaneous”, to insert more daily notes.

5.4.5 Task5:

The task is to view statistics calculation.

- All participants found it very useful and easy to use. They spent around 3-6 seconds each to view the statistics for two days.
- Two participants commented that it is great to have the three choices for selecting the period of statistics (“Week”, “Month”, “6 Months”)
- Six participants found it very easy to insert a customized number of days
- Six participants mentioned liking the system's response when there was no data inserted from which to report statistics.

5.4.6 Task6:

The task is to Edit and Manage the features in the app.

- Five participants were confused in the beginning because some of the visible icons don’t yet work and the researcher explained that he is still working on them.
- All participants were able to add a new user and edit the user profile successfully.
- Two participants commented that it is a great feature to be able to change the units from the one used here in the US to that ones that are used in other countries. Similar comments were given related to being able to change the date format.
- All participants were successfully able to change the measurement units and the date format.

All participants were able to complete all the tasks. A summary of time taken for completing each of the tasks is given in Table 5.3 and Table 5.4 below:

Subjects	Total time (Minutes)	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
1	4:30	1:35	30s	33s	22s	35s	55s
2	5:06	1:40	35s	37s	30s	40s	1:02
3	4:45	1:20	39s	32s	29s	42s	45s
4	4:30	1:10	31s	41s	41s	44s	1:12
5	4:51	1:25	33s	29	25s	39s	1:00

Table 5.3: Summary of task duration (Students)

Subjects	Total time (Minutes)	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
1	6.26	1:50	50s	56s	41s	47s	1:12
2	6.53	1:35	56s	49s	45s	52s	1:35
3	6.05	1:55	59s	39s	29s	42s	1:05
4	6:30	1:45	55s	43s	39s	49s	1:03

Table 5.4: Summary of Task Duration (Caregivers)

Table 5.5 lists findings from the observations. After the subjects completed doing the tasks described above, an interview with each participant was conducted to help clarify the nature of subjects' difficulties and to assess how important they were to them. Table 5.6 provides a list of the usability problems identified across all usability tests, and their level of importance.

Tasks	Observation
Task 1	Creating an account is easily understandable. All the text fields are well organized. Options for adjusting the font size is needed but zoom in/out in smart phones is able to solve this issue. Colors are attractive, text boxes size are suitable.
Task 2	Some health measurements fields are beneficial for nurses but they are confused when it comes to unpaid caregivers, brief health measurements documentation is needed.
Task 3	This was the easiest step for the participant. An edit button can be added as a help guide.
Task 4	Having high number of steps while adding a new Food, Med, Activities was somewhat annoying.
Task 5	There was a difficulty going back to the home screen after working on "Add logs" function. The participant had to undo all steps in order to get to the home page.
Task 6	Some icons are still under implementation. Participant commented that they are excited to try their functions in the future.

Table 5.5: Summary of Observations

In the usability test, we measured the time taken to complete each task (Table 5.3, and Table 5.4), we also computed averages across the two types of subjects (elderly caregivers and students.) The graph in Figure 5.1 below shows the average time taken by elderly caregivers and by the students. It can be observed while performing the test, that caregivers generally took more time than the students. During the usability tests, the author has also observed that the importance of the problems which occurred while using the application did not appear to be perceived in the same way by caregivers and students.

For example, caregivers more frequently mentioned the importance of increasing the font size compared to the students. However, although most of students reported being comfortable

with the present size of the font, some did recommend that the researcher increase the font size for the sake of elderly caregivers.

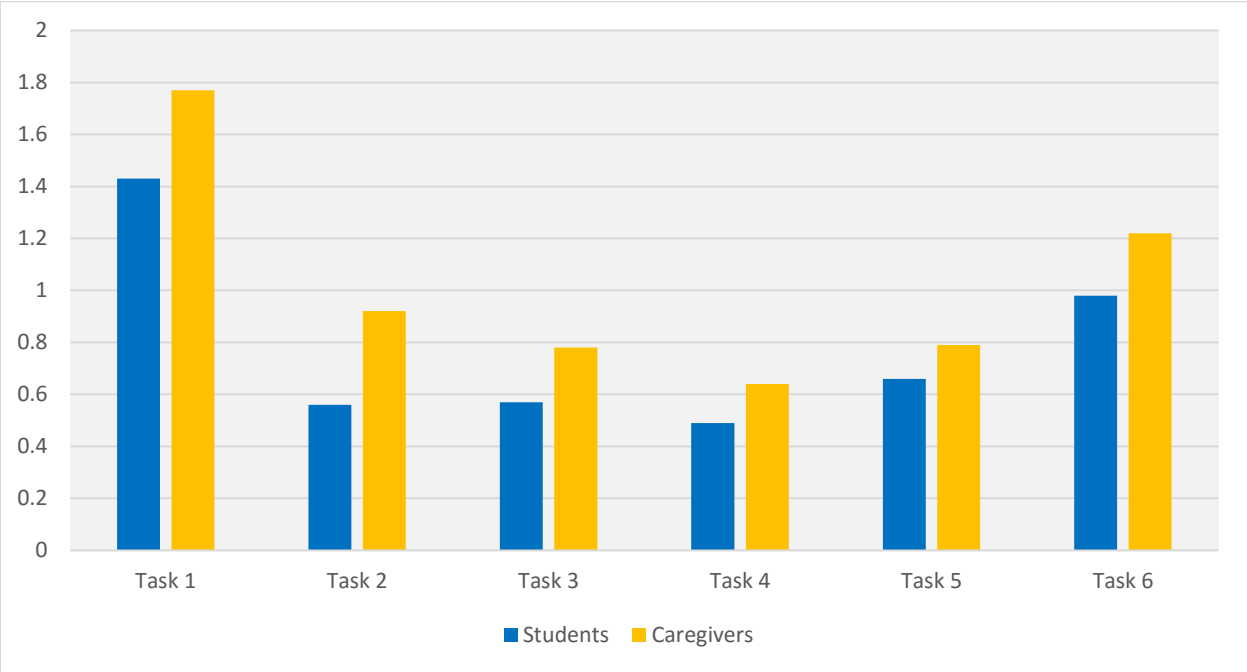

Figure 5.1: Time taken by students and caregivers

ID	Usability Problem	Severity	Fix in Final Prototype
1	User could not edit the measurement that he has already inserted	Critical	User is able to edit the measurements under "Diary" tab
2	User is sent to the first patient by default after finishing a specific task	Moderate	User is given reminder to choose the current patient
3	Text beside the text boxes is not clear	Minor	Made the text more clear

4	User had difficulty dealing with lists	Minor	Design has been switched to tabs

Table 5.6: Usability Problems Extracted from the Usability Tests

5.5 Discussion of Finding from Observations

This section discusses the significance of the results based on the observations from all the participants. Many subjects used more time than might be expected to complete a task. The researcher noted that subjects might experience some initial confusion, because participants were unfamiliar with the app and might not have felt that they knew where to start since the app has features for 5 chronic diseases, and they did not know if there is a relationship between the diseases or if they had to choose one of the diseases before the others. When the participants were asked to perform the first task and insert measurements for at least three different times periods, they often started by jumping to the second disease, which was unnecessary.

Many subjects mentioned the size of the font. As some of the caregivers' participants were elderly people, it is natural that they might have lower vision and that the font must be more easily adjustable, and it certainly impacted their level of satisfaction.

We also noted some issues related to the icons. It often appeared that participants did not perceive the icons as actionable buttons in the fifth and sixth tasks. In the diseases tab of three of the diseases, participants did not seem to understand all the details about how to input the measurements and so a short documentation was prepared to resolve this issue. Some participants also seemed annoyed by the readability of the icons and they suggested using bolder colors for icons and text boxes to improve the contrast with the background.

5.5.1 Questionnaire Results

Following the usability tests, participants were asked to complete a written questionnaire. The questionnaire includes 15 Likert-type items covering perceptions of learnability, efficiency, memorability, error rate and satisfaction. The averages of results obtained from both students (Stn) and caregivers (Cgive) are shown in the Table 5.7 below. Questions in the questionnaire are listed in appendix A.

Usability Attributes		Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
		*Stn	*Cgive	*Stn	*Cgive	*Stn	*Cgive	*Stn	*Cgive	*Stn	*Cgive
Learnability	1	0%	0%	0%	0%	0%	0%	0%	25%	100%	75%
	2	0%	0%	0%	0%	0%	0%	40%	75%	60%	25%
Efficiency	3	0%	0%	0%	0%	40%	0%	0%	50%	60%	50%
	4	0%	0%	0%	0%	20%	25%	0%	25%	80%	50%
	5	0%	0%	0%	0%	20%	25%	40%	25%	40%	50%
	6	0%	0%	0%	25%	0%	25%	40%	25%	60%	25%
	7	0%	0%	0%	0%	0%	0%	100%	75%	0%	25%

	8	0%	0%	0%	0%	40%	0%	0%	75%	60%	25%
Memorability	9	0%	0%	0%	0%	20%	0%	40%	25%	40%	75%
	10	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%
Error rate	11	0%	0%	0%	0%	0%	0%	40%	25%	60%	25%
	12	0%	0%	0%	25%	20%	25%	20%	75%	60%	0%
Satisfaction	13	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%
	14	0%	0%	0%	0%	0%	25%	20%	25%	80%	50%
	15	0%	0%	0%	0%	20%	0%	20%	50%	60%	50%

Table 5.7: Usability Evaluation of CaregiverPal (*Cgive: Caregivers, *Stn: Students)

5.5.2 Discussion of the Questionnaire

The bar graphs Figure 5.2 and 5.3 below show the overall responses on the questionnaire in appendix A from both students and caregivers. The graphs make it clear that while many aspects of the app were satisfying, some aspects must be improved and that there were often large differences between the two types of subjects or between subjects of the same time. For example, by looking at the graphs below, specifically when learnability is considered, some elderly caregivers reported having difficulty in understanding the CaregiverPal and they felt it was not

easy to learn. However, the caregivers were split between “strongly agree” and “strongly disagree” when answering learnability items on the questionnaire.

When considering the efficiency, it was observed that caregivers more often selected disagree to describe the efficiency of the app, when compared to students. This may be due to the structure of navigation in the app. Caregivers sometimes appeared to have difficulty in understanding the navigational structure when performing the tasks. Another problem that might have led to the selection of disagree was that they were not able to understand meaning of the measurement data for some fields, although they were given a short documentation for the measurements. They also may not have understood that the measurement fields were all optional and can be safely ignored if they are unfamiliar or not possible for them to obtain (such as percentage of body fat).

When memorability was considered, caregivers most often chose agree while students chose strongly agree. This might be interpreted due to differences in cognitive differences (related to age) or their amount of skill and proficiency with using mobile applications.

When error rate was considered, the graphs show that the students were somewhat more positive than the elderly caregivers, but that the caregivers were more divided. We noted that students spent more time have trying the functions and navigation controls of CaregiverPal when compared to the caregivers. Caregivers thus had fewer opportunities to observe the range of error messages that can be produced by the app while they were focusing on completing the tasks. This difference in experience may have led to a difference in the level of agreement between caregivers and students on this part of the questionnaire.

When considering the satisfaction, students expressed more strong satisfaction with the app, but caregivers were all either satisfied or strongly satisfied. A few students rated the app lower

than the caregivers. This lower rating may reflect the students experience with commercial products. Students might be expected to have much more experience in using mobile applications than caregivers who participated in the test. During the usability test, several elderly participants mentioned that they thought the CaregiverPal would be useful. However, they felt that if the rest of functionalities were completed that they would be completely satisfied. Both students and caregivers agreed that applications to support caregiving have the potential to improve the quality of life.

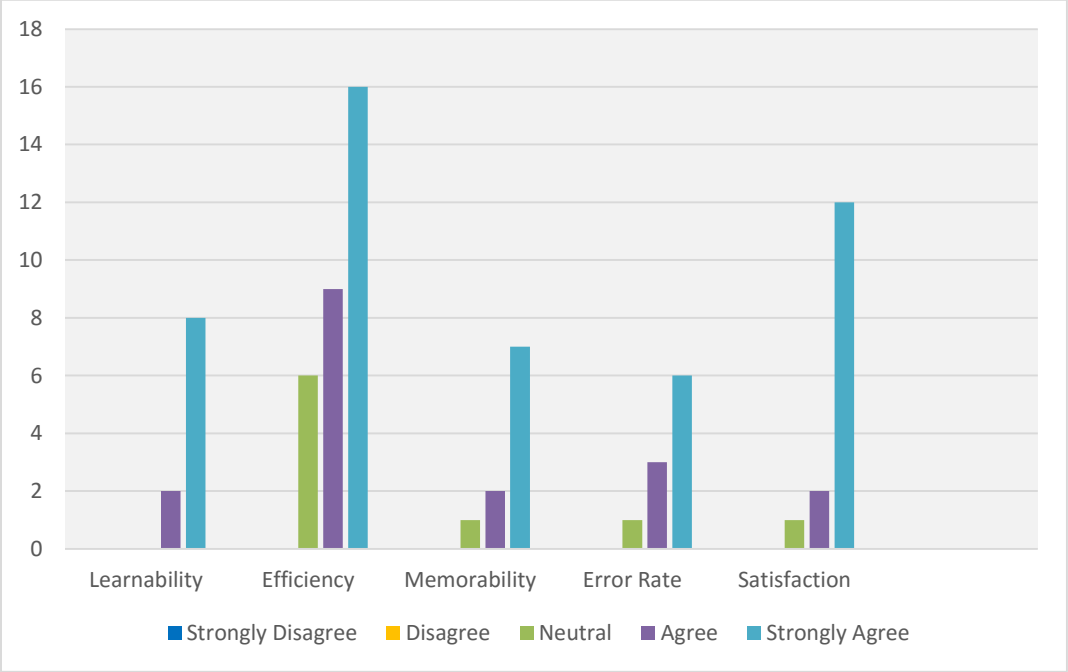

Figure 5.2: Students Responses on Questionnaire

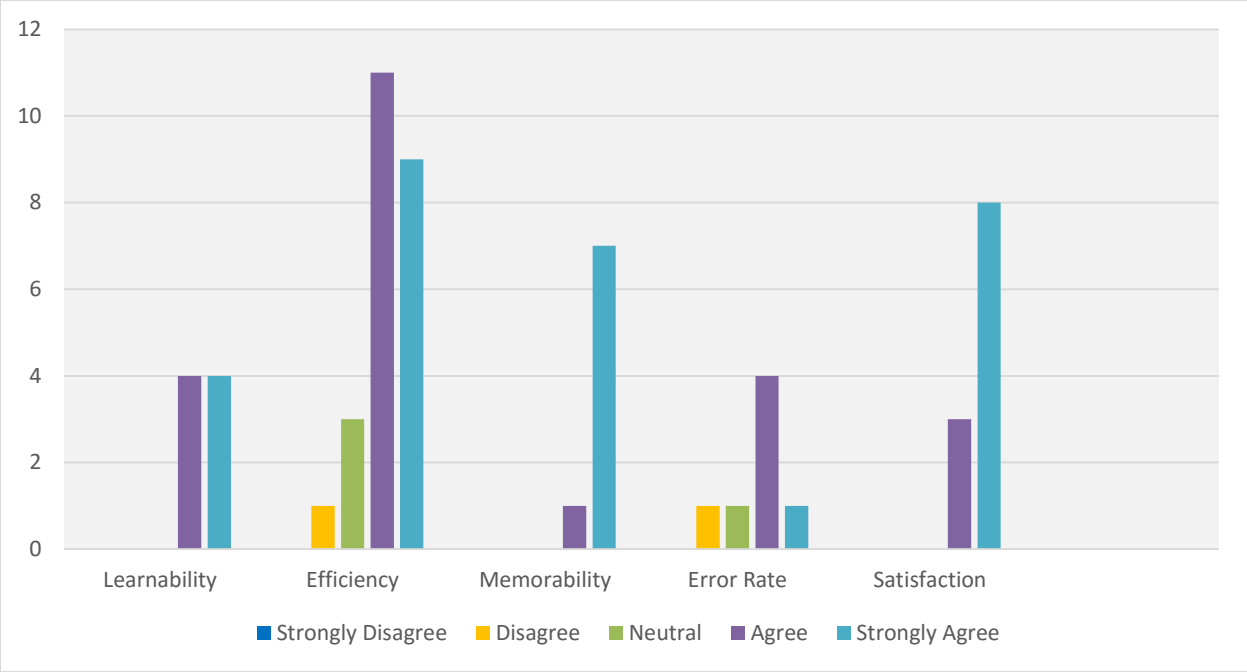

Figure 5.3: Caregivers Responses on Questionnaire

5.6 Results and Discussion of the System Usability Scale Assessment

The System Usability Scale (SUS) [43] is a widely used assessment tool. It is a validated instrument, with a scoring system that allows one to compare across systems as well as to compare scores to established benchmarks for usability. A SUS score alone does not provide feedback for specific design features but it provides a usability measure of the mobile application as a whole. Therefore, an additional questionnaire was created above that includes specific components. In the SUS, there are ten usability statements, where half of them are worded positively and the other half worded negatively as given in appendix F. Participants were asked whether they agreed or disagreed with each item by using a five point Likert scale. The score is calculated by following these steps:

1) For odd items, take the user response minus 1
2) For even items, take 5 minus the user response
3) Sum all scores
4) Multiply the total by 2.5 resulting in a SUS score out of 100 instead of 40.

SUS scores for individual participants (each of the five students in Table 5.8 and four caregivers in Table 5.9) are given below.

	S1	S2	S3	S4	S5
SUS Score	90.0	87.5	85.0	92.5	90.0

Table 5.8: SUS Score for Students (S1: Subject 1)

	S1	S2	S3	S4
SUS Score	82.5	85.0	87.5	80.0

Table 5.9: SUS Score for Caregivers (S1: Subject 1)

Generally speaking, the SUS score for every subject was quite high, as all the scores were 80 or higher as in Tables 5.8 and 5.9 above. It has been reported that average scores of satisfaction using the SUS are usually between 65 and 70 [44] which suggests that our subjects were highly satisfied with the usability of the CaregiverPal compared to other systems.

5.7 Recommended Usability Improvements to the App

Overall, the results of our observations and analysis of the questionnaires suggest that the app would be welcomed, but that there should be improvements to its efficiency, visibility and the training provided to target users

To improve visibility, an explicit option for customizing the font size should be added so that individuals, especially elderly caregivers who may have difficulty using multi-touch interfaces, can more easily choose the appropriate font size for their abilities and device. The issue of training can be addressed by creating a brief tutorial video showing how CaregiverPal works. It should demonstrate both the functionality and the methods for navigating the app. Within the app, tips icons would also be helpful, for example to explain what a measurement is and remind them it is optional.

5.8 Research Questions Answers

1. What might motivate users to remain engaged with mobile applications? And what are methods can be used for that purpose?

Motivation: This research question was proposed to provide recommendations for the developers of mHealth applications to include new design features in order to engage users to keep using the mHealth apps. The author conducted a literature review and found that features that support principles from the theory of Persuasive Design, Self Determination theory, Fogg's Triad Role model might contribute to engagement. A new framework has been proposed including persuasive design principles and software design features. Some preliminary studies involving focus groups and surveys of existing software suggest what functionality or features might achieve this framework.

2. How can designs explicitly address the context and motivations of caregivers?

Motivation: This research question was proposed to provide recommendations to mHealth application developers to help in overcoming the usability issues faced by caregivers and patients. This question has been answered by creating a prototype using the principles of the proposed synthesis framework and participatory design methods within the framework of User Centered Design (UCD). The latter suggest collecting feedback from target users throughout the design process and building a consistent application with simple navigational structure and which handles the errors well.

3. How well the approach addresses factors associate with intrinsic motivation (e.g. autonomy, competence, relatedness)?

Motivation: This research question was intended to apply motivational design of mHealth apps. This question was answered by using the implemented prototype to conduct a usability study, including think-aloud comments, observations by the researchers and two types questionnaires, including a SUS and a new survey more geared toward specific features that might support motivation.

CHAPTER 6

Conclusion

6.1 Conclusion

The aim of the study was to identify the desired content and features of a mobile application for caregivers of the ELMCC and also to identify the main limitations of existing systems in order to help us implement a new mobile application that will better address caregivers' tasks and motivate users to remain engaged.

After discovering that long-term acceptance has been an issue, we considered some theoretical approaches to motivation and persuasive design. Since no one model seemed to cover all of our aims, we developed a new model that synthesized key ideas from several, including Self-Determination Theory, Persuasive Design and Fogg's functional triad.

A qualitative research study of caregiving and mHealth support tools was conducted in order to identify the desired content and features of a mobile application for caregivers of the ELMCC. Four focus group sessions with 27 English speaking caregivers were held in the city of Milwaukee, Wisconsin.

Under our new model, the comments from our focus group members confirm the need to address both tasks and motivation and suggest specific types of software functionality that might achieve them.

We also found that new opportunities for enhancing the lives of ELMCC can be offered by mobile applications. They have numerous functions aside from phone calls and text messaging, such as reminders, calendars, microphones, social forums/chat and charts. All of these features have the potential for improving the ELMCC wellbeing.

A usability test of the new mHealth application was conducted with the participants. A questionnaire was designed after findings from the usability test were gathered and analyzed. The questionnaire was distributed to students and caregivers who had participated in the usability test. The questionnaire helped us to identify the satisfaction level of participants and specific usability problems that appeared when the participants interacted with the user interface of the mHealth application.

6.2 Limitations

Some participants were not current users of any mobile technology, so it may have been hard for them to specify what tasks and features they need a mobile tracking app to include. Having more current caregiver participants in the focus groups and in the usability tests would help in enhancing such a mobile app targeting them.

6.3 Future Work

Our CaregiverPal app is an android version, which means people who are Apple or iPhone users will not be able to use our app. Having an iPhone/Apple version of CaregiverPal would be beneficial in the future because there is some chance that this target group may respond differently. The implementation can follow the same design features for persuasive design that have been recommended in this study.

One more significant recommended future work would be to conduct a long term study for CaregiverPal usability to determine the effectiveness and acceptance over time. During a longer term study, caregivers should be tracked to see how often they use the app and what features they use and to see if there are any health benefits.

As explained in chapter 4, some principles were included in the design and some principles can be added in the future. Rewards and Praise principles can be added to the CaregiverPal prototype by allowing the user to gain rewards after achieving a specific task or goal.

Other principles that might be addressed include: the suggestion principle, the expertise principle, or the tunneling principle.

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APPENDIX A:

Questionnaire

No.	Questions	Disagree	Level of agreement			Agree
		1	2	3	4	5
Learnability						
1	The application is easy to learn.					
2	Application is reliable and touch screen is responding well					
Efficiency						
3	Novice or experts, anybody can understand the application.					
4	The steps to perform the task are minimal					
5	The interface of the application is attractive					
6	Font (Size, Style, Color) are easy to read on-screen					
7	Navigational structure is simple and related information is in place together					
8	I am able to deduce the information I need from the report					
Memorability						
9	The application is easy to remember.					
10	No need for reviewing guidelines once used.					

Error rate						
11	In case of error, the application has notified.					
12	I am able to determine the cause of error.					
Satisfaction						
13	I am Satisfied with the application.					
14	The application helps in improving the quality of life.					
15	I am satisfied with the present functionalities					

APPENDIX B:

Questions to Focus Group 1

1- What software have you used either for tracking the health of the person you are caregiving or for your own health?

2- What are some of the reasons that have motivated you to use mobile technology?

3- If you have stopped using it, what were some of the reasons?

4- If you have never used any such software, what were some of the reasons?

5- If someone were to provide software that met your needs and avoided your concerns, for what tasks do you think the software might be most helpful to you?

6- We are working on creating some new software to help caregivers; we are interested in having a few people try it and give us their opinions about how we might improve it. Would you be willing to meet with us in a few weeks to do that?

APPENDIX C:

Questions to Focus Group 2

Pretest Questions:

1- What type of personal health information have you viewed using mobile health technology?

2- What are some of the reasons that have motivated you to use mobile technology?

3- What were some difficulties you encountered when using mobile technology to meet your health Information needs?

4- What were some of the strategies you used to overcome these difficulties?

Posttest Questions

1- What are some of the reasons that have motivated you to use the app on your mobile device?

2- What were some difficulties you encountered when using mobile health app on your phone?

3- What software have you used either for tracking the health of the person you are caregiving or for your own health?

4- If you have stopped using it, what were some of the reasons?

5- If you have never used any such software, what were some of the reasons?

6- If someone were to provide software that met your needs and avoided your concerns, for what tasks do you think the software might be most helpful to you?

7- If someone were to provide software that met your needs and avoided your concerns, where and when do you think you would be most likely to use it?"

8- We are working on creating some new software to help caregivers; we are interested in having a few people try it and give us their opinions about how we might improve it. Would you be willing to meet with us in a few weeks to do that? If so, could you please put your contact information on the card that I gave you and give it to me (or XXX) before you leave? I will also leave you with my card, so if you want to let me know later you can contact me.

APPENDIX D:

Demographic Survey

Q1 What is your gender?

- Male
- Female

Q2 What is your age?

- 25 or under
- 26-40
- 41-55
- 56 or older

Q3 Please enter your home Zipcode?

Q4 Do you use mobile phone regularly?

- Yes
- No

Q5 What is your most frequent uses of phone (Select all that apply)?

- Voice calls
- Texting
- Running software apps
- Accessing internet

APPENDIX E:

Informed Consent

University of Wisconsin – Milwaukee IRB Protocol Number: 13.427

Informed Consent

Dear Participant,

You are invited to participate in a research study, entitled "Usability and Persuasive Design Testing of CaregiverPal mhealth App". The study is being conducted by Suboh Alkhushayni (PhD student) And Prof.Susan McRoy of the University of Wisconsin – Milwaukee.

The purpose of this research study is to This study is focusing on assessing the usability of health mobile application for different reasons: Very few evaluation frameworks are available for assessing the usability, more than 95% of mobile health apps have not been tested, and most of these apps are having usability issues so they don't target the end user, moreover there are some usability studies have been conducted but few of them were focusing on the usability of mobile apps .The purpose of this study is to help us evaluate the usability of our mobile health app. Subjects will be asked to give their feedback by answering some given questions, Subject will be asked to install it on their mobile devices and participate in answering survey and questionnaire related to software Usability and persuasive design.. Approximately 2-12 subjects will participate in this study. If you agree to participate, you will be asked to install the app on your device and then participate in answering survey on paper or online. The survey you will be asked to

discuss/share your experiences with our app. This will take approximately (1-2) hours of your time and may be less time for the paper/online survey and the discussion might be audio recorded.

Risks that you may experience from participating are considered minimal. There may be some questions that make you uncomfortable and you can feel free not to answer those questions. In order to minimize this risk please do not share anything you do not want others to know. There will be no costs for participating. There are no benefits to you other than to further research.

In the usability testing or in the paper/online survey your name will not be used unless you have a desire to participate in another stage if there is any, then your contact information will be requested. Your responses will be treated as confidential and any use of your name and or identifying information about you or anyone else will be removed right after the meeting. All study results will be reported without identifying information so that no one viewing the results will ever be able to match you with your responses. Direct quotes may be used in publications or presentations. Data from this study will be saved on computer in a locked room at EMS Room 974 for 6-10 moths. Only Prof.Susan McRoy and Suboh Alkhushayni will have access to your information. However, the Institutional Review Board at UW-Milwaukee or appropriate federal agencies like the Office for Human Research Protections may review this study's records. Audio recordings will be destroyed after 10 months.

Your participation in this study is voluntary. You may choose not to take part in this study, or if you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will not change any present

or future relationships with the University of Wisconsin Milwaukee. There are no known alternatives available to participating in this research study other than not taking part.

If you have questions about the study or study procedures, you are free to contact the investigator at the address and phone number below. If you have questions about your rights as a study participant or complaints about your treatment as a research subject, contact the Institutional Review Board at (414) 229- 3173 or irbinfo@uwm.edu.

To voluntarily agree to take part in this study, you must be 18 years of age or older. By signing the consent form, you are giving your consent to voluntarily participate in this research project.

Thank you!

Suboh Alkhushayni

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Milwaukee, WI 53212

(414) 334-4069

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APPENDIX F:

System Usability Scale

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

CURRICULUM VITAE

Suboh Alkhushayni

Place of birth: Jordan

Education

B.A., Computer Information Systems, Al-Hussein Bin Talal University, January 2007
M.S. of Science (IT), University Utara Malaysia, October 2008
M.S., Computer Science, University of Wisconsin-Milwaukee, December 2013

Dissertation Title:

mhealth Technology: Towards a New Persuasive Mobile Application for caregivers that Addresses Motivation and Usability

Conference Publications

Alkhushayni, S., (2016, April). Improving mHealth Apps for the Caregivers while Addressing Motivation and Software Usability. In Proceedings of the 6th International Conference on Digital Health Conference. ACM.

Alkhushayni, S., & McRoy, S. (2016, April). mHealth Technology: Towards a New Mobile Application for Caregivers of the Elderly Living with Multiple Chronic Conditions (ELMCC). In Proceedings of the 6th International Conference on Digital Health Conference (pp. 11-15). ACM.

Course TA

Introductory Computer Programming in Java (CS 201)
Programming using Java (CS 250)
Computer Organization and Assembly Language Programming (CS 315)
Artificial Intelligence (CS 710)
Natural Language Processing (CS 723)