MHEALTH LITERACY: CHARACTERIZING PEOPLE'S ABILITY TO USE SMARTPHONE-BASED HEALTH-RELATED APPLICATIONS

BY

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DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in the School of Information Sciences
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2017

Urbana, Illinois

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ABSTRACT

This dissertation investigates the following research question: **what skills does a user need to use a health-related app on a smartphone?** It coins the term 'mHealth Literacy' to refer to all such necessary skills.

The research methodology of this dissertation has two parts: a pilot study and a final study. In the pilot study, three phone interviews were conducted with three regular and skilled users of smartphone-based health-related apps (or "mHealth apps," for short). For the final study, face-to-face interviews were conducted with 24 users of mHealth apps.

The coding and analysis of the study transcripts and field notes identified that mHealth app users should have 15 skills. These 15 skills are: Smartphone Literacy, App Literacy, English Literacy, Numeracy, App-centric Health Literacy, Information Literacy, Graph Literacy, Computer Literacy, Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary.

Earlier it was considered a user's responsibility to learn all the required skills to be considered as health literate. However, at present, health literacy is considered as a complex concept that involves not only the users but also their families, healthcare professionals, communities, and the health care system. In the same way, several participants of this study expressed a concern that a poorly designed mHealth app might be unusable even for an expert mHealth app user. Hence, they mentioned that it is not only the user's responsibility to learn the 15 skills to be mHealth literate but also mHealth app

developers should share the same, if not more, responsibilities. As a result, 13 recommendations have been developed, all drawn from participants' experiences and reflections, to design mHealth apps. Five design recommendation were supported by existing research while the remaining eight were suggested by the participants of this study.

This dissertation will contribute to the field of eHealth Literacy. With the emergence of new forms of information technology, the focus of Health Literacy has been extended from the physical world to the cyber world. A new research domain called eHealth Literacy has emerged as a result. By integrating mobile technology, the concept of mHealth Literacy has evolved out of eHealth Literacy. Whereas definitions of eHealth Literacy are up to this point based on theory, this dissertation through an empirical study advances understanding of eHealth literacy when it comes to mobile devices and their applications.

To my mother, Josna Ara Begum, the kindest person I have ever seen

To my father, Md. Abdul Jabbar, the most intelligent person I have ever seen

To my son, Raakeen Affan Ahmed, who always fills my life with joy

To my wife, Moushumi Sharmin, my best friend and dearest love

ACKNOWLEDGEMENTS

First of all, I would like to thank the Almighty Allah for the successful completion of my dissertation. All praise belongs to Him.

I would like to express my deepest appreciation to my Ph.D. advisor and the chair of my dissertation committee, Professor Kate Williams. She taught me how to conduct good research. She was always available whenever I needed any help. She tirelessly helped me and gave constructive feedback to finish this dissertation.

I would also like to thank my other committee members Professor Abdul Alkalimat,

Professor Linda Smith, and Professor Tiffany Veinot for their excellent suggestions and constructive feedbacks.

I would also like to thank my dearest wife, Moushumi Sharmin, for her tireless support to finish this dissertation. Besides my advisor, I discussed my dissertation with her the most.

I would also like to thank my parents, son, siblings, in-laws, and friends for their support and inspiration.

Finally, I would like to acknowledge the support I received from the School of Information Sciences of the University of Illinois at Urbana-Champaign.

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Chapter 1 Introduction

This dissertation consists of six chapters. Chapter 1 introduces this dissertation's research question and key concepts. Chapter 2 presents the findings from the subfields of literacy, Health Literacy, and eHealth Literacy that provide the theoretical and empirical ground for this dissertation. Chapter 3 discusses the experimental methodology of this dissertation: the pilot study and the final study. Chapter 4 reports the findings regarding study participants and mHealth technology. Chapter 5 discusses the findings regarding mHealth literacy requirements. Chapter 6 presents implications of the findings of chapter 4 and 5, as well as the dissertation's limitations and directions for further research.

1.1 Research Question and Definitions of Key Concepts

This dissertation aims at developing an understanding of mHealth literacy, which I define as the ability to use health-related apps on a smartphone. The dissertation's central question is: **what skills does a user need to use a health-related app on a smartphone?**

The definitions of each term associated with this research question are provided below.

Skill: This dissertation adopts the following definition of skill which is provided by the oxford dictionary: skill is "the ability to do something well." This dissertation also equates some literacies with skills. In other words, some skills of using a health-related app on a smartphone can be usefully thought of as literacies. This definition is grounded on existing research, which has identified two dimensions to literacy (literacy is a technical skill and literacy is conceptual).

User: The user is any person who has access to and uses one or more health-related apps on a smartphone. Some healthcare professionals (e.g. doctors, nurses, and pharmacists) may utilize these apps for the purpose of patient care, information extraction, and sharing, but will only be characterized as users when doing so for their personal health management.

Health-related app on a smartphone or mHealth app: Health-related app or mHealth app refers to a specific type of smartphone app that is related to any kind of health management. For instance, MyFitnessPal is a popular mHealth app for weight management. In this dissertation, the two terms Health-related app and mHealth app will be used interchangeably.

1.2 Statement of Significance and Unique Contribution

According to International Telecommunication Union report, in 2013, the world population was 7.1 billion while the number of mobile phone subscribers was 6.8 billion (Sanou, 2013). The provision of health-related services via mobile communications is called mHealth, short for mobile Health (Vital Wave and Consulting, 2009). mHealth can be exploited to lessen the cost and improve research and outcomes of healthcare (Kumar et al., 2013). In her keynote speech at the mHealth Summit in 2011, Kathleen Sebelius, the U.S. Secretary of Health and Human Services, described mHealth as "the biggest technology breakthrough of our time" (Sebelius, 2011), and stated that its use would "address our greatest national challenge." Steinhubl et al. identified three major forces driving the enthusiasm for mHealth: (a) healthcare expenditures are skyrocketing and some disruptive solutions are urgently needed to address this problem; (b) the billions of unique mobile

phone users around the world present a great opportunity for bidirectional instantaneous transfer of information; and (c) there is an increased demand for more accurate and individualized medicine, which can be provided by mHealth tools (Steinhubl, Muse, & Topol, 2013). These authors provide examples showing how mHealth technologies can positively transform the delivery of healthcare while acknowledging concerns regarding the acceptance and extensive use of mHealth technologies.

mHealth technologies are expanding rapidly in the area of research and practice (Free et al., 2010). Mobile phones can be utilized for healthcare purposes by using sensors (on-body sensors and embedded phone sensors), text messages, apps (also known as mHealth apps), web-based services, telephone intervention, and mobile telemedicine system (Agarwal & Lau, 2010; A. L. Baker et al., 2014; Free et al., 2011; Krco & Delic, 2003; Kumar et al., 2013; Lewis & Wyatt, 2014; Lunny et al., 2014).

As text messaging has become a common form of communication, it has been deployed to raise awareness of health issues. Significant research attention has been given to text message-based systems addressing heart disease, HIV, malaria, smoking, diabetes, preventive health care, self-management, fitness, and obesity (Franklin, Greene, Waller, Greene, & Pagliari, 2008; Free et al., 2011; Githinji et al., 2013; Lester et al., 2010; Moonen & Cohen, 2011; Patrick et al., 2009; Zurovac et al., 2011; Zurovac, Talisuna, & Snow, 2012). Text messages can remind users to take medication (Quilici et al., 2013) or as a communicating medium to check in with users on a regular basis (Lester et al., 2010).

Mobile phones can also be used as medical devices (Pai et al., 2013). Some examples of mobile-phone enabled medical devices are: a meter to help diabetic patients to manage

their blood glucose levels (iBGStar, 2014), a wireless blood pressure monitor (iHealth, 2014a), fitness devices (Fitbit, 2014) to track a user's steps, calories burned, and sleep quality, and a wireless scale to measure a user's weight, body fat, and body water (iHealth, 2014b).

Healthcare professionals are using mHealth technology to achieve their "need for better communication and information resources at the point of care" (Ventola, 2014). Their use encompasses five broad types of activities: administration (information and time management), health record maintenance and access, communications and consulting, reference and information gathering, and medical education and training (Ventola, 2014).

Patient caregivers, who typically attend to the need of a child or a dependent adult and who are primarily the relatives or friends of the patients, are using mHealth technology for three major purposes: (a) to enter and update patients' medical information; (b) to send messages about medication and prescription renewal; and (c) to disseminate information about how to handle emergency situations (Scher, 2012).

Among all the aspects of mHealth (sensors, text messages, apps, web-based services, telephone interventions, mobile telemedicine systems, and mobile-phone enabled medical devices), this dissertation focuses on mHealth apps only. The purpose of mHealth apps is "to improve health outcomes, deliver health care services, or enable health research" (Powell, Landman, & Bates, 2014).

Researchers have offered significant insights about mHealth apps from both user's and developer's point of view. Extensive research, including literature reviews, has been conducted on the use by individuals of mHealth apps to address a wide range of issues,

including fitness, obesity, mental health, diabetes, smoking, HIV/STDs, infectious diseases, heart health, cancer, asthma, and dermatology (Azar et al., 2013; Bindhim et al., 2012; Brewer et al., 2013; Bush et al., 2013; El-Gayar et al., 2013; Goldbach et al., 2013; Marcano Belisario et al., 2013; Muessig et al., 2013; Oehler et al., 2010; Pandey et al., 2013; VanWormer et al., 2013; West et al., 2012; Bender et al., 2013; Derbyshire & Dancey, 2013; Donker et al., 2013; Martínez-Pérez et al., 2013; Stephens & Allen, 2013; Whittaker et al., 2012). The underlying assumption made by these researchers is that there are no barriers to the use of such apps. However, such underlying assumption has not been examined yet. Irrespective of how well-designed mHealth apps may be, users who lack the necessary skills will only realize a limited benefit from them or possibly none at all. It appears that no research has focused on understanding these necessary skills or offered a definition of what users need to know to use these systems effectively. This dissertation seizes this opportunity.

On the contrary, some researchers offered guidelines (Broderick et al. 2014; Arcia et al. 2013) to design mHealth apps for people with low health literacy. These researchers assumed that a poorly designed mHealth app might be unusable even for an expert mHealth app user, although these researchers did not identify the skills to be considered an expert mHealth app user. This dissertation also acknowledges such contributions and examines how to design mHealth apps that can contribute to effective use of mHealth apps or do not hinder users from using mHealth apps effectively.

In summary, this dissertation looks at mHealth literacy from two perspectives: mHealth app users and mHealth app developer.

1.3 Reason to Choose mHealth Apps

This dissertation focuses on the use of mHealth apps for the following reason:

Approximately 1.76 billion people all over the world own and use smartphones (eMarketer, 2014), and mHealth apps are becoming pervasive among smartphone users. In the U.S. alone, 42% of adults use at least one downloaded app, and one-third use mHealth apps (Huckvale et al., 2012; Sadasivam et al., 2013). The UK Department of Health has suggested that mHealth apps should be prescribed as part of long-term care (Huckvale et al., 2012; Sadasivam et al., 2013). Currently, more than 100,000 mHealth apps, in diversified healthcare categories, are available (MIT Technology Review, 2014). According to industry estimates, 3.5 billion people will use smartphones and tablets by 2018 and 50% of them will download mHealth apps (USFDA, 2014). Researchers predict that mHealth apps will help doctors, outside of the usual healthcare settings, to diagnose patients suffering from potentially life-threating conditions (Mitka, 2013). Furthermore, Mitka (2013) argues that mHealth apps will help patients to self-manage their health and such apps will provide useful information whenever and wherever they need it. Considering the tremendous potential of these mHealth apps, it is crucial that scholars investigate and present what users must know so that uptake will be as wide and successful as possible.

To maintain their health, people typically receive help from formal caregivers such as doctors and nurses and informal caregivers such as family members and friends. Hence, the necessity of smartphone-based healthcare apps might not be evident. This dissertation does not suggest that mHealth apps will replace formal and informal caregivers. Rather, it suggests that these apps will act as a complementary source of service.

Chapter 2 Literature Review

The study of mHealth Literacy takes its place in a research arc that began with the study of Literacy and then branched into Health Literacy, and in recent decades into eHealth Literacy.

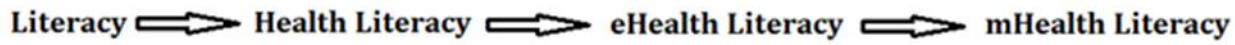

Figure 1: Evolution of mHealth Literacy

With the emergence of new information technology, the concept of Health Literacy has been evolved from the physical medium (e.g., print) to cyber medium (e.g., the Internet, the web). The new term 'eHealth Literacy' was coined to capture this evolution (Norman & Skinner, 2006b), and was defined in the following way: "the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem." By integrating mobile technology, the new concept of 'mHealth Literacy' has subsequently evolved out of eHealth Literacy. Regardless of the domain in which it is exercised (health), or the means by which it is exercised (eHealth or mHealth), central to this dissertation is the concept of Literacy. A review of scholarly understanding of Literacy is thus in order. Both Health Literacy and eHealth Literacy are rooted in the domain of Literacy. More specifically, these two threads of scholarship assume that the skills required in order to be health literate and eHealth literate are literacies. This dissertation also assumes that some skills required to be mHealth literate are literacies. Hence, this chapter will focus on different definitions and aspects of literacy available in scholarly domains.

2.1 Traditional Literacy

In 1958, UNESCO defined "a literate person" as "one who can, with understanding, both read and write a short, simple statement on his or her everyday life" (Carr-Hill, 2008). In 1966, UNESCO and UNDP (United Nations Development Programme) jointly formed the "Experimental World Literacy Programme" and introduced the concept of "Functional Literacy," defined in the following way: "A person is functionally literate who can engage in all those activities in which literacy is required for effective functioning of his (her) group and community and also for enabling him (her) to continue to use reading, writing and calculation for his (her) own and the community's development [and vice versa]" (Carr-Hill, 2008).

2.1.1 **Different Aspects of Literacy**

In 2003, Williams identified 11 theses of literacy (Williams, 2003). She performed an extensive review of the peer-reviewed articles published in the *Journal of Literacy Research* and the *Journal of Adolescent and Adult Literacy*, and all the published books for 20 years on literacy research. For each thesis, she provided comprehensive references that expressed the thesis. These 11 theses are:

1. Literacy is a technical skill
2. Literacy is conceptual
3. Literacy is historical
4. Literacy is social
5. Literacy is intertwined with power
6. There is a literacy divide between school and home

7. Bridging different literacies is desirable
8. Literacy theory is in crisis
9. Literacy problems suggest that democracy is threatened
10. Literacy theory is cultural hegemony
11. The digital format integrates literate forms of communications with non-literate forms

In this study's investigation of how mHealth Literacy is related to traditional literacy, these have been used as a starting point. To identify the relevant literacy theses and literacy types for this dissertation, an interview-based pilot study with three regular and skilled mHealth app users was conducted. The pilot study is discussed in detail in section 3.1 and 3.2. The findings of the pilot study revealed that the first three theses of literacy as set forth by Williams are most relevant to the research question at hand.

Literacy is a technical skill:

By referring to earlier research articles concerning literacy, Williams showed that literacy is a technical skill (Table 1) and that skill can be measured by a standard test across large populations (Williams, 2003).

Literacy is conceptual:

In developing the thesis that literacy is conceptual, Williams referred to 10 intellectual capabilities (Table 2) listed in a National Research Council report (National Research Council Committee on Information Technology Literacy, 1999). Williams also provided the

following literacy definitions (Table 3) from earlier scholars to show that literacy is not a "context-free, value-neutral set of skills" (Williams, 2003, p. 5).

Literacy Definitions	**Reference**
Literacy is defined as a particular capacity and mode of behavior: the ability to understand and employ printed information in daily activities, at home, at work, and in the community—to achieve one's goals and to develop one's knowledge and potential. Literacy skill is categorized into three domains namely: Prose Literacy (text), Document Literacy (forms), and Quantitative Literacy (arithmetic).	(Organisation for Economic Co-operation and Development and Statistics Canada, 2000)
Literacy is the ability to decode and comprehend written language at a rudimentary level—that is, the ability to say written words corresponding to ordinary oral discourse and to understand them. There are two types of literacy: literacy in the schools, reading achievement; and literacy outside the schools, Functional Literacy.	(Kaestle, 1991)
Literacy as adaptation, [a] metaphor . . . to capture concepts of literacy that emphasize its survival or pragmatic value.	(Scribner, 1994)

Table 1: Literacy is a Technical Skill (Williams, 2003)

#	Intellectual Capabilities
1.	Engage in sustained reasoning
2.	Manage complexity
3.	Test a solution
4.	Manage problems in faulty solutions
5.	Organize and navigate information structures and evaluate information
6.	Collaborate
7.	Communicate to other audiences
8.	Expect the unexpected
9.	Anticipate changing technologies
10.	Think about information technology abstractly

Table 2: 10 Intellectual Capabilities. Table 1 of (Williams, 2003)

Literacy Definitions	Source
Being literate has always referred to having mastery over the processes by means of which culturally significant information is coded.	(de Castell & Luke, 1983/1994)
Reading does not consist merely of decoding the written word or language; rather, it is preceded by and intertwined with knowledge of the world. Language and reality are dynamically interconnected.	(Freire & Macedo, 1987)

Table 3: Literacy is Conceptual (Williams, 2003)

Literacy is historical:

Williams contends that "Literacy researchers have made the broader observation that culture changes; thus, literacy is historical" (Williams, 2003, p. 6). Williams further argues that the "definition of literacy has changed over human history." Table 4 presents definitions of literacy in American education across time (de Castell & Luke, 1983/1994).

Types of Literacy	**Time Frame**	**Definition**
Classical literacy	19th Century	Being able to read Greek and Latin, to practice rhetoric, make an analysis of key texts (notably the Bible), and to be familiar with a defined literature. This was the literacy of a gentleman, and it included some oral, non-written activity.
Progressive literacy	Early 20th Century	Being able to express oneself in writing and use the written word to communicate, to be part of a given social milieu and realize one's potential.
Technocratic literacy	Most Recently	The functional literacy that affords a person survival skills and minimum competencies, especially in the workplace.

Table 4: Literacy is Historical (Williams, 2003)

2.1.2 **Types of Literacy**

The following types of literacy taken together constitute mHealth Literacy: English Literacy, Numeracy, Computer Literacy, Information Literacy, Graph Literacy, Smartphone Literacy, Web Literacy, Privacy Awareness, App Literacy, and App-Centric Health Literacy. This section discusses Computer Literacy, Information Literacy, Graph Literacy, Smartphone Literacy, and Web Literacy. The remaining literacy types are discussed in section 2.2 and 3.2.2.

Computer Literacy:

Williams (2012) provides a comprehensive definition of Computer Literacy after synthesizing the relevant scholarly work across several disciplines including computer science, education, and literacy studies. Table 5 summarizes the eight points that are required to become computer literate.

Information Literacy:

The definition of Information Literacy evolved over time. The first definition was proposed by Zurkowski (1974, p. 6), where he described it as:

> People trained in the application of information resources to their work can be called information literates. They have learned techniques and skills for utilizing the wide range of information tools as well as primary sources in molding information solutions to their problems.

1. Having contemporary skills (e.g., browsing or text editing)
2. Knowing foundational concepts (e.g., networks)
3. Possessing intellectual capabilities (e.g., evaluating sources)
4. Understanding Computer Literacy as an aspect of life in an information society
5. Being familiar with at least the basics of computer programming
6. Practicing Computer Literacy that is tailored to individual needs, interests, and goals
7. Being part of the community of people who can use IT, which means knowing
    (a) how to keep learning,
    (b) who or where to go for new concepts and skills (including software help features and online sources), and
    (c) how to solve problems with others in that community
8. Not assuming that someone with Computer Literacy is better than someone who isn't computer literate

Table 5: Computer Literacy. From Williams (2012, p. 60).

The American Library Association (1989) described Information Literacy as:

> Ultimately, information literate people are those who have learned how to learn. They know how to learn because they know how knowledge is organized, how to find information and how to use information in such a way that others can learn from them. They are people prepared for lifelong learning because they can always find the information needed for any task or decision at hand.

According to Norman and Skinner (2006b, p. 5),

An information literate person knows what potential resources to consult to find information on a specific topic, can develop appropriate search strategies, and can filter results to extract relevant knowledge.

Graph Literacy:

Graph Literacy is defined as "the ability to understand graphically presented information" (Galesic & Garcia-Retamero, 2011, p. 444). Although graphs (e.g., pie charts, bar charts, line plots) have become ubiquitous, many people have difficulty comprehending even the simplest forms (Galesic & Garcia-Retamero, 2011). To assess the ability of eighth-grade students to interpret graphs in general, Kramarski and Mevarech (2003) designed a 36-item "Graph Interpretation Test." In addition, Galesic and Garcia-Retamero (2011) developed a 13-item Graph Literacy scale for the healthcare domain.

Smartphone Literacy:

Rosen (2015) identified two broad types of skills as making up Smartphone Literacy:

1. Basic skills:
    a. how to turn a smartphone on;
    b. how to create and enter one's password, along with remembering it;
    c. how the two-thumb keyboard works; and
    d. how to download, update, and organize apps.
2. Advanced skills:
    a. how to use a smartphone for more than ordinary communication;
    b. how to develop goals for using a smartphone;

c. how to make a smartphone do what they want it to do; and

d. how to use a smartphone for learning.

Web Literacy:

Mozilla, a free-software community that established the popular web browser Mozilla Firefox, defines Web Literacy as follows:

> Web Literacy comprises the skills and competencies needed for reading, writing and participating on the web.[1]

2.2 Health Literacy

This section will first define Health Literacy and then discuss the major tools used to measure Health Literacy.

2.2.1 Definitions of Health Literacy

Table 6 summarizes three definitions of Health Literacy that have been accepted by many researchers. Health Literacy became a global issue. U.S. Department of Education utilized four literacy levels (Below Basic, Basic, Intermediate, and Proficient) to report the result of Health Literacy assessment. According to this assessment, 36% of US adults (ages 16 and older) had either basic or below basic Health Literacy level (Kutner et al., 2006). One-third of older people in the UK find it difficult to read and comprehend basic health-related written information (Bostock & Steptoe, 2012).

[1] https://teach.mozilla.org/teach-like-mozilla/web-literacy/

Health Literacy Definitions
Health Literacy is the degree to which individuals can obtain, process, and understand basic health information and services needed to make appropriate health decisions. (US Department of Health and Human Services, 2000; Nielsen-Bohlman et al., 2004; Ratzan & Parker, 2000)
Health Literacy refers to a set of skills to function efficiently in the healthcare environment. Health Literacy should include three types of human capabilities: (a) Print Literacy: The capability to read and comprehend documents and to locate and understand information in those documents; (b) Numeracy: The capability to utilize numeric information for tasks, such as understanding food labels, measuring blood glucose levels, and following the medication regimens appropriately; and (c) Oral Literacy: The ability to speak and listen effectively. (Berkman et al., 2011, Ad Hoc Committee on Health Literacy for the Council on Scientific Affairs, 1999; Baker, 2006)
Three aspects need to be considered to be health literate: (a) The ability not only to read but also to comprehend health information, (b) The broader capability to involve with the healthcare process, and (c) The elimination of redundant complexity and barriers to patient understanding and engagement. (Raynor, 2012)

Table 6: Definitions of Health Literacy

Initially, the concept of health literacy evolved around individuals. More specifically, it was considered a user's responsibility to learn all the skills needed to be considered as health literate. However, the concept has shifted and health literacy is now considered a complex concept that involves not only the users but also his/her families, healthcare professionals, and communities, and the healthcare system. According to the Institute of Medicine, health literacy is the outcome of several complicated social and individual factors.[2]

2.2.2 Tools for Measuring Health Literacy

A significant amount of research has been conducted in order to design measuring tools to identify people with low Health Literacy (Raynor, 2012) . Below is a short description of some of these tools:

REALM (Rapid Estimate of Adult Literacy in Medicine):

In 1991, Davis and colleagues designed a quick screening tool for physicians to measure the reading levels of patients with regard to health information (Davis et al., 1991) . This tool offered a form consisting of 125 preselected words selected from typical directions and educational materials prepared for patients (e.g. "eye," "dose," "rectal," "fatigue," "pelvic," "syphilis," "emergency," "medication," and "inflammatory"). In 1993, Davis and colleagues reduced the number of words presented in the initial REALM tool from 125 to 66 (Davis et al., 1993). To complete the original version took three to five minutes, and to complete the revised version took one to two minutes.

[2] http://grants.nih.gov/grants/guide/pa-files/PAR-13-132.html

REALM works in the following way: the words are ordered according to the level of difficulty of reading, based on the number of syllables. Thus words such as “fat” and “flu” are read first, followed by words such as “allergic” and “osteoporosis.” Participants are instructed to read loudly as many words as they are able to. The administrator keeps a record. Standard dictionary pronunciation is the gold standard. A point is given for each word read correctly. If a participant finds it difficult to read a word, she or he is instructed to skip it and move on to the next word. At the end of the reading session, the score is totaled. Possible scores on the revised REALM are grouped into four grade-level Health Literacy levels: 0–18 (<=3rd grade), 19–44 (4th to 6th grade), 45–60 (7th to 8th grade) and 61–66 (>=9th grade).

To evaluate the efficacy of the 125-word REALM, Davis and colleagues tested this tool on 207 adults recruited from 6 public and private primary care clinics. The results were compared with the results of two standardized reading tests, the Peabody Individual Achievement Test-Revised (PIAT-R) (Markwardt, 1989) and Slosson Oral Reading Test (SORT-R) (Slosson & Nicholson, 1990). The researchers showed that the 125-item REALM correlated highly with the above mentioned two standardized tests. Seeking to do the same for the 66-item version, the researchers recruited 203 patients from 4 university hospital clinics. They compared the results with the results of three standardized reading tests: the PIAT-R, SORT-R, and the Wide Range Achievement Test-Revised (WRAT-R) (Jastak & Wilkinson, 1984) . The results indicated that the 66-item version correlated well with the results of all these three standard tests.

Different Forms of REALM:

Bass, Wilson, and Griffith (2003) reduced the 66 items to 8 ("osteoporosis," "allergic," "jaundice," "anemia," "fatigue," "directed," "colitis," and "constipation") and named it REALM-R (Rapid Estimate of Adult Literacy in Medicine – Revised). The administration time was reduced to less than a minute. The researchers performed the testing with 157 patients and showed that their tool correlated with WRAT-R. Arozullah et al. (2007) shortened this version to seven words ("behavior," "exercise," "menopause," "rectal," "antibiotics," "anemia," and "jaundice"), calling the new test the REALM-Short Form (REALM-SF). Like REALM, the final score on the REALM-SF is mapped onto four grade levels as follows: 0 (<=3rd grade), 1–3 (4th to 6th grade), 4–6 (7th to 8th grade) and 7 (>=9th grade). The researchers recruited 1336, 164, and 50 patients for model development, validation, and field testing, respectively. REALM-SF and REALM correlated highly mainly in the development and the validation stage. On the contrary, the REALM-SF and Wide Range Achievement Test scores correlated highly in field testing validation.

Test of Functional Health Literacy in Adults (TOFHLA):

Parker, Baker, Williams, and Nurss (1995) designed TOFHLA to assess a patient's functional Health Literacy. This assessment tool consisted of 67 items: 50 to assess reading comprehension skill, and 17 items to test numerical ability. It required up to 22 minutes to administer. By performing an extensive user study among 256 English- and 249 Spanish-speaking patients, Parker et al. showed that TOFHLA is a valid and reliable instrument to measure a patient's ability to read health-related materials.

Different Forms of TOFHLA:

Baker, Williams, Parker, Gazmararian, and Nurss (1999) proposed an abbreviated version of TOFHLA, naming it Short Test of Functional Health Literacy in Adults (S-TOFHLA). S-TOFHLA consisted of 4 numerical items instead of 17 and 2 prose passages instead of 3. The maximum time needed for administration was correspondingly reduced from 22 minutes to 12 minutes. After evaluating through a group of 211 patients, Baker et al. showed that S-TOFHLA is well correlated with REALM.

2.3 eHealth Literacy

Having observed the increasing involvement of the World Wide Web and other technology-based applications in the public health and healthcare environments, Norman and Skinner (2006b) introduced the concept of "eHealth Literacy." They defined eHealth Literacy as "the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem." In another article published the same year, Norman and Skinner put forth the eHealth Literacy Scale (eHEALS), an 8-item assessment of consumers' combined knowledge of, comfort with, and self-perceived skill in finding, evaluating, and applying eHealth information pertaining to their health problems (Norman & Skinner, 2006a).

2.3.1 **Lily Model**

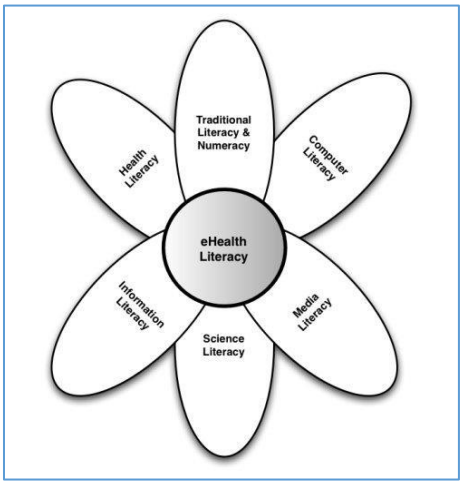

Figure 2: eHealth Literacy Lily Model. From Figure 1 of Norman and Skinner (2006b).

In defining eHealth Literacy, Norman and Skinner argued that a person must possess six different forms of literacy to be eHealth Literate. These are: Traditional Literacy, Information Literacy, Media Literacy, Health Literacy, Computer Literacy, and Scientific Literacy (Norman & Skinner, 2006b). To illustrate the relationship among these skills and how these are connected to the core concept of eHealth Literacy, they proposed a model called the "Lily Model" (see Figure 2). According to them (Norman & Skinner, 2006b, p. 2), "using the metaphor of a lily, the petals (literacies) feed the pistil (eHealth Literacy), and yet the pistil overlaps the petals, tying them together."

2.3.2 **eHEALS: the eHealth Literacy Scale**

Although the Lily Model did lay out the skill set needed for a person to be eHealth Literate, one major question remained: how to assess a user's capacity for engaging in eHealth (Norman & Skinner, 2006a). To answer this question, Norman and Skinner designed eHEALS, an 8-item measure of eHealth Literacy. They psychometrically evaluated the

properties of eHEALS through a six-month-long user study among 664 participants. The participants were recruited from 14 secondary schools from a large city in Canada. Table 7 shows the final eight questions selected for eHEALS.

#	Question
1	I know how to find helpful health resources on the Internet
2	I know how to use the Internet to answer my health questions
3	I know what health resources are available on the Internet
4	I know where to find helpful health resources on the Internet
5	I know how to use the health information I find on the Internet to help me
6	I have the skills I need to evaluate the health resources I find on the Internet
7	I can tell high-quality from low-quality health resources on the Internet
8	I feel confident in using information from the Internet to make health decisions

Table 7: Questions in eHEALS. From Table 1 of Norman and Skinner (2006a).

2.3.3 eHealth Literacy and Web 2.0

Since the field of eHealth is dynamic, Norman (2011) has argued that the context of eHealth Literacy must evolve as well to keep pace. When the Lily Model was first introduced in 2006, the first generation of the web was in full swing and Web 2.0 and social media were at a very preliminary stage. In this paper, Norman revisited the Lily Model and identified some problems and opportunities for eHealth Literacy as an evolving concept. After considering the critiques by other researchers (Chan & Kaufman, 2011; Stellefson et al., 2011; van der Vaart et al., 2011; Xie, 2011), Norman proposed that the following should be evaluated in measuring eHealth Literacy in the Web 2.0 domain: the confidence to clearly

express oneself in online social media; the skill to synthesize professional and nonprofessional advice; the ability to navigate through informational websites using mobile devices; and the capability to filter for relevant and trustworthy information from the web.

2.3.4 **Studies using eHEALS**

van der Vaart, Drossaert, de Heus, Taal, and van de Laar (2013) conducted two studies to measure the actual eHealth Literacy among patients with rheumatic diseases. Another goal of these two studies was to identify the problems that patients encounter when using the Internet in relation to their diseases. In the two studies, the patients had to answer the questions they were asked about their current disease-related Internet use. The eHealth Literacy of the patients was observed during performance tests. The results of these studies indicate that many patients did not have enough skill to properly use Health 1.0 (information websites) and Health 2.0 (interactive applications such as peer support forums, online consults, and access to electronic medical records).

Since older adults typically do not have much Computer Literacy (Rideout, Neuman, Kitchman, & Brodie, 2005) and it is very daunting for them to navigate the eHealth domain, Xie (2011) performed a study on 146 older adults aged 56 to 91 to examine the effects of a theory-driven eHealth Literacy intervention for older adults. The intervention was comprised of two weeks of learning by the subjects to enable them to use the SeniorHealth.gov website to access reliable health information. The results of the study revealed that: (a) the intervention significantly improved knowledge, skills, and eHealth Literacy efficacy from pre- to post-intervention (b) the participants showed positive

attitudes toward the intervention and (c) the intervention led to positive changes in their own healthcare.

eHEALS was initially only in English and no validation data was available. Van der Vaart et al. (2011) translated eHEALS into Dutch and then performed a study with two populations to evaluate its validity. The first consisted of patients with rheumatic diseases (n=189) and the second consisted of a random sample of regular Dutch people (n=88). The results showed that the internal consistency of eHEALS was high, which made it sufficiently reliable. However, the results also indicated that further study is required to be certain about the validity of the eHEALS instrument, since the correlation with Internet use was not very strong and expected relations with age, education, and performance were insignificant.

Choi and DiNitto (2013) focused on an especially vulnerable segment of the older adult population, the low-income disabled and homebound. Face-to-face interviews and telephone surveys were conducted on 980 subjects living in central Texas. They divided these people into two categories, based on age: 78% were age 60 or older and 22% were under age 60. The researchers compared the two groups in terms of Internet usage patterns, the main causes of their discontinued Internet use, and the degree of eHealth Literacy. The researchers used two different instruments in their research: eHEALS, to measure the degree of eHealth Literacy, and the Attitudes Toward Computer/Internet Questionnaire (ATC/IQ) to measure attitudes towards Internet/computer use. Internet use was very low among these subjects: among those age 60 years and older, only 17% of subjects used the Internet and 16% among them stopped using the Internet during the

course of the study. Among those under 60, 34% of them used the Internet and 35% of them discontinued later. The researchers reasoned that either lack of exposure to computers and the Internet, the high cost of obtaining a computer, or poor medical conditions, disabilities, and associated pain prevented them from using the Internet and computers.

2.4 mHealth Literacy

As mentioned earlier, integration of mobile technology brought many changes in how people access and utilize information available in the web (which was the main concept of eHealth Literacy). Several researchers considered that eHealth and mHealth are linked closely (Consulting 2009). For example, Mechael considered mHealth as an extension of eHealth (Mechael 2009). On the contrary, some researchers argued that these two domains are separate, a sentiment clearly indicated by the following statement, "*It [mHealth] is not a subset of eHealth, in the same way that TV is not a subset of Cinema*"[3]. In 2010, Eytan identified six differences between mHealth and eHealth. However, he defined eHealth and mHealth in the following ways: mHealth is "*the use of wireless communication devices to support public health and clinical practice*" while eHealth refers to as "*desktop Web/computer interaction in health/health care*." The six differences identified by Eytan (Eytan, 2010) are as follows:

[3] https://mhealthinsight.com/2010/03/22/the-definition-of-mhealth/

- mHealth is becoming pervasive all over the world whereas the web, the fundamental component of eHealth, is accessible to 26% of world population.
- Access to eHealth via desktop was favorable to "more educated, more affluent people" whereas an inverse relationship existed in terms of access to mHealth via wireless communication.
- It is more difficult to develop mHealth apps as opposed to developing and creating a web service for eHealth purposes.
- Telecommunication companies will play an important role in the spread of mHealth.
- While the US was contributing a lot to generate eHealth content on the web, mHealth innovations were done mostly in recourse-poor countries outside of USA (e.g., India, China, South America and Mexico).
- eHealth is largely not personalized but mHealth is. Most mHealth apps gather and use personalized data about the user.

This dissertation does not deny the overlap between eHealth and mHealth. However, it recognizes the importance of mHealth as a separate domain from eHealth and the requirements of mHealth literacy should be different than the requirements of eHealth literacy.

Few researchers focused on designing mHealth apps considering the low literacy of the users. For instance, Broderick et al. (2014) provided some design guidelines for "health literate app" and Chaudry et al. (2012) worked with low-literate, chronically-ill users to test four GUI widgets and three cross-page navigation styles in mobile applications. These findings are relevant and also aligned with some findings of this dissertation. In addition,

this dissertation considered mHealth literacy issues from a user's perspective and identified the skillset a user needs to use mHealth apps (currently available in the app stores.)

2.5 Summary

To summarize, section 2.1 discussed 11 theses of literacy identified by Williams (2003). This section also discussed some types of literacy (e.g., Computer Literacy, Information Literacy, Graph Literacy, Smartphone Literacy, and Web Literacy). Section 2.2 first provided the major definitions of Health Literacy and then discussed the different tools used for measuring Health Literacy. Section 2.3 discussed the Lily Model from eHealth Literacy and the eHEALS to measure a user's capacity for engaging in the eHealth domain. It also discussed different user studies, which revealed that the eHEALS score depends on a user's demographic background. The Lily Model was designed based on theories of literacy.

Section 2.4 discussed the fundamental differences between eHealth literacy and mHealth literacy. It also shows that this dissertation looked at the mHealth literacy problem from user's point of view which was ignored in previous research.

Chapter 3 Research Design

The research methodology of this dissertation has two parts: a pilot study and a final study. Section 3.1 first discusses the rationale for doing a pilot study and then provides the details of the user recruitment process, the demographics of the users, the interview questions, and the measures used. Section 3.2 details the pilot study findings. Section 3.3 discusses the final study, which was designed based on results of the pilot study. The sampling and user recruitment procedure, interview process, and post-fieldwork analysis technique, which was followed for conducting the final study, as well as the revised interview questions, are also discussed in the same section.

3.1 Pilot Study

Although Norman and Skinner (2006b) did not conduct any empirical study to identify the skill set a person should have to be considered as eHealth literate, this dissertation acknowledges the importance of doing so. Due to the lack of precedent of any such empirical study in the mHealth app domain, a pilot study was conducted first.

3.1.1 **Participants of the Pilot Study**

Upon receiving Institutional Review Board approval from the University of Illinois, three semi-structured interviews were conducted during August 2014. Appendix D contains the IRB approval letter for the pilot study.

To recruit the users, a recruitment message was posted on the researcher's Facebook profile. Some Facebook friends also shared the same message in their Facebook profiles,

which helped to reach more people. Six people responded to the recruitment message. Three of them were interviewed based on their availability. Appendix A contains a sample recruitment flyer (a generic social media/email message). Table 8 shows the demographics of three pilot study participants. These three pilot study participants were regular (individuals who use mHealth apps at least twice a week) and skilled (individuals who use smartphone and mHealth app for a longer period of time) mHealth app users. They were between 28 to 35 years old and came from two countries (USA and Bangladesh). All of them were male and had Master's degree. During the interviews, all of them were working for reputed companies in the USA and in Bangladesh.

	Participant 1	**Participant 2**	**Participant 3**
Gender	Male	Male	Male
Age	35	28	35
Education	MBA (Finance)	MS (Divinity)	MS (Electrical Engineering)
Profession	Senior Assistant Vice President of a bank	Software Engineer	Senior Principal Design Engineer
Current Location	Bangladesh	USA	USA

Table 8: Demographics of Pilot Study Participants.

3.1.2 **Semi-structured Interviews and Coding**

Three semi-structured interviews were conducted over the phone. Before starting an interview, verbal consent of the participant was asked. Appendix B contains the consent

Code	Concept	Text to search for
SL	Smartphone Literacy	Any text describing people's skill in using a smartphone.
AL	App Literacy	Any text describing people's skill in using apps on the smartphone
EL	English Literacy	Any text describing people's skill in understanding English text.
Nu	Numeracy	Any text describing people's skill in understanding numbers (arithmetic).
HL	App-centric Health Literacy	Any text describing people's skill in understanding their health needs and/or knowledge of different health-related acronyms.
IL	Information Literacy	Any text describing people's skill in finding the appropriate mHealth apps from the app store and/or following the app instructions properly.
GL	Graph Literacy	Any text describing people's skill in understanding graphically presented information.
CL	Computer Literacy	Any text describing people's skill in using a computer.
WL	Web Literacy	Any text describing people's skill in using the Internet and web (e.g., searching via Google).

Table 9: Basic Coding Dictionary.

form while Appendix C contains the questionnaire used in the interviews. The interview consisted of 15 questions (both open-ended and close-ended), which included questions on

user demographics, experience with mHealth apps, comments and suggestions on mHealth Literacy, and recommendations on improving the mHealth apps. Table 9 shows the basic coding dictionary to code the transcriptions of the interviews. The sources of these codes are as follows:

- Seven codes (SL, EL, Nu, IL, GL, CL, and WL) came from literacy theory.
- Two codes (AL and HL) came from the pilot study.

3.2 Pilot Study Findings

Table 10 shows that all three participants were avid smartphone users (around 5 years of experience) and used mHealth apps frequently (at least twice a week). Two of them used iOS-based smartphones and the remaining participant used an Android-based smartphone. They used three different types of mHealth apps such as Nike Running, MyFitnessPal, and Instant Heart Rate. The duration of their mHealth app usage varied from three months to one year.

3.2.1 **Skills = Literacy**

As discussed earlier, Williams (2003) identified 11 theses of literacy. A closer examination of the responses of the three pilot study participants revealed that the required skills to use mHealth apps can be mapped to two theses of literacy reported by Williams.

Literacy is a technical skill: Participants 1 and 3 pointed out that mHealth app users should possess similar technical skills mentioned by Williams (see section 2.1.1). A sample of user comments highlights this finding:

A person should know how to get the reviews [of the app] and how to parse the review. – P3

The summary report of the jogging app is given every month, both in numeric and graph format. The user should interpret and understand the summary report. – P1

These two statements closely match with Prose Literacy and Quantitative Literacy (arithmetic).

	Participant 1	**Participant 2**	**Participant 3**
Smartphone OS	Android	iOS	iOS
Duration of smartphone use	5 years	5 years	4–5 years
App name	Nike Running	MyFitnessPal	Instant Heart Rate
App purpose	Tracks the user's running history and running pattern	Counts calorie intake and assists in weight management	Measures heart rate instantly
Duration of current mHealth app use	9 months	1 year	3–4 months
Frequency of use	Every day	Sometimes, every day. At other times, twice a week.	5-6 times per week

Table 10: Usage of mHealth Apps by Pilot Study Participants.

Literacy is conceptual: As discussed in section 2.1.1, Williams (2003) showed that literacy is conceptual and referred to 10 intellectual capabilities which were categorized as foundational concepts. All three pilot study participants agreed that mHealth app users need to understand mobile-related and health-related concepts. For instance, in the app store, the information on mHealth apps includes app descriptions and user reviews. According to the participants, it is not enough to read the descriptions and reviews—users also need to understand the meaning of them. Participant 3 said:

> It is also important to internalize the reviews after reading. – P3

3.2.2 mHealth Literacy Requirements

Subsequent inquiry in the interview process aimed at identifying the skills that mHealth app users should possess. No participant was an expert in the literacy area and no one explicitly mentioned any particular literacy. Rather, their answers were mapped to different literacies based on the coding dictionary (see Table 9) mentioned earlier, revealing the six that are required for successful use of mHealth apps.

1. English Literacy
2. Numeracy
3. App Literacy
4. App-centric Health Literacy
5. Information Literacy
6. Graph Literacy

English Literacy

English Literacy usually refers to the literacy in terms of the English language. For instance, if the definition of literacy given in section 2.1.1 is considered, an English-literate person should have the capability to understand English text and use this capability to achieve his or her goal. All three participants also implied a similar definition of English Literacy.

Although English is not the native language of two of the three participants, all emphasized the importance of English Literacy. The underlying rationale was that app descriptions and user reviews for most mHealth apps are written in English. According to participant 3,

> A person should know how to get the reviews [of the app] and how to parse the review. – P3

Numeracy

Participants also underscored the importance of Numeracy. As discussed in section 2.2.1, a person with Numeracy skill should be able to utilize numeric information to perform his or her regular tasks. Since most, if not all, mHealth apps provide results in a numerical format, the participants considered Numeracy a must-have skill. According to participant 1,

> The summary report of the jogging app is given every month, both in numeric and graph format. The user should interpret and understand the summary report. – P1

App Literacy

All three pilot study participants pointed to a particular skill for using mHealth apps that had not been defined previously in the scholarly domain. Participant 3 coined the term "App Literacy" to describe this skill. Here is his comment on App Literacy:

> An app might have several features… Some apps have only one screen with three or four icons. Some apps have several tabs to embed more information…. Every person might not have the skill [to use the features]. For some sophisticated apps, the user should have the skill to use them. I prefer to say this skill as App Literacy rather than Computer Literacy. – P3

Although it seems that the ability to use different features of an mHealth app is considered "App Literacy," a closer examination of responses of three participants revealed that App Literacy is not a single skill, but rather a combination of several skills. These are:

1. Users should be able to download and install the app.
2. Users should be able to follow the app instructions. For instance, a user of a jogging app should know how to calibrate the GPS of the app, a user of a pulse rate monitor should know how to enter the initial setting of the app, and so on.
3. Users should be able to differentiate between correct and incorrect information, a common dilemma mHealth app users come across regularly.
4. Users should be able to pinpoint an issue. For instance, if an app gives erroneous results or stops working without any notice, users should be able to identify the issue.
5. Users should know about potential resources to consult with in order to fix issues related to mHealth apps. Likewise, they should know when to abandon the app and switch to a new app, if the first is not fixable at all.
6. For some mHealth apps, initial setup is required (e.g., GPS calibration, creating a username and password, or finding the appropriate category for inputting

information). Users who are not comfortable with performing the initial setup are likely to abandon the use of the app out of frustration at its poor performance.

App-centric Health Literacy

The coding of the pilot study transcripts revealed that mHealth app users need a threshold-level understanding of the information pertaining to their health needs. For instance, if a person uses an mHealth app for diet tracking, it would suffice for them to understand Body Mass Index (BMI), the calorie count, and how different kinds of food impact calorie consumption. They may not need to understand the different medical terms associated with blood pressure (e.g., systolic, diastolic) or diabetes (e.g., hemoglobin A1C). Hence, in place of "Health literacy," this dissertation uses a new term, "App-centric Health Literacy." This is defined as the degree to which individuals can use mHealth apps relevant to their health needs to obtain, process, and understand basic information and services needed to make appropriate decisions.

The analysis of participants' responses identified two aspects of App-centric Health Literacy. First, users of mHealth apps should be aware of their health-related goals. Without such goals, they may fail to receive any benefit. According to participant 1:

> The first skill [that someone] needs to know is the main purpose of his health that means what he wants to achieve. – P1

> A person should have a clear idea of his health purpose. – P1

Second, mHealth app users should be aware of different health acronyms and the basic assumptions made by the mHealth apps. Two relevant quotes from participant 2 and 3 are presented below.

> A person should also know the health acronym such as BMI [Body Mass Index] relevant to his health. – P3

> It is easy and straightforward only if you understand the assumption the app has made. One basic assumption of the app is that a person needs 2000 calories per day. – P2

Information Literacy

Hundreds of thousands of mHealth apps are available. For mHealth app users, it may be a daunting, if not impossible, task to find the right one from this sea of mHealth apps. However, the pilot study participants felt that it is an absolute necessity to be able to select the right app and use information generated by the app. To quote participant 1 and 3:

> After determining his health purpose, the user should find a few apps and then decide which one he should use. He should choose an app which is more convenient for him. – P1

> A person has heard about an app. Now he needs to know where the app can be found. If he knows the app store then he needs to know where that app is. The app store has categories for health. A person should know how to find the right app from that category. – P3

In addition, the participants felt that being able to find the right app is necessary but not sufficient. The ability to differentiate between correct and incorrect information generated by mHealth apps is also very important for users.

A closer look at the skills mentioned by the pilot study participants revealed that this particular skill is Information Literacy. One thing is important to note here. Unlike English Literacy, Numeracy, and App-centric Health Literacy, Information Literacy was mentioned by two out of three participants.

Graph Literacy

Graphical representation of the data, as the participants observed, prevails in a majority of mHealth apps. Considering this fact, participant 1 and 3 advocated for having the specific skill of understanding graphical representation of data, "Graph Literacy." According to them,

> The user needs to interpret the summary, which is shown graphically, by his own. – P1

> Interpreting the graphical format is another skill a user should have. – P3

While all mHealth apps do feature numerical data representation along with graphical representation, due to the ubiquitous nature of the latter, it is desirable to have this skill.

3.2.3 **Summary**

In summary, the pilot study found that six literacies are important to use mHealth apps: English Literacy, Numeracy, App Literacy, App-centric Health Literacy, Information Literacy, and Graph Literacy. Among these six, four were considered especially important

by all three participants: English Literacy, Numeracy, App-centric Health Literacy, and App Literacy. The two other literacies (Information Literacy and Graph Literacy) were mentioned by two participants only.

3.3 Final Study

The pilot study helped to finalize the interview questionnaire, sampling method, and data collection and analysis procedures for the final study. This section provides the details of sampling and the user recruitment procedure, the interview process, post-fieldwork analysis techniques, and the revised interview questions of the final study.

3.3.1 IRB Approval

Another IRB application was submitted for the final study. This IRB was similar to the IRB of the pilot study and was accompanied by an elaborate research method, extended interview questions, and modified recruitment flyer. To evaluate the extended interview questions, an interview session with another mHealth app user was conducted. Based on his response, the questionnaire was finalized. IRB approval was received on May 26, 2015. Appendix H contains the IRB approval letter for the final study.

3.3.2 Sampling and User Recruitment

The data collection process consisted of semi-structured interviews with 24 participants. Among these 24 participants, two users had never used an mHealth app before. To participate in this study, both of them installed mHealth apps in their smartphones and used it for at least one week before the interviews were conducted. Participants were recruited from the general population residing in Memphis, Tennessee. The qualifications

for participation were being 18 years of age or older and currently using any kind of mHealth app.

Recruitment	**N**	**%**
Recruited via flyer	15	62.5
Recruited via snowballing	9	37.5
All	24	100

Table 11: Recruitment of Participants.

To recruit mHealth app users, convenience sampling was used. First, the researcher informally visited several local organizations in Memphis. During these visits, the corresponding authorities were contacted by the researcher to get the permission to post recruitment flyers. Appendix E contains the recruitment flyer for the final study. Upon receiving permission, flyers were posted on the poster walls. One organization (Germantown Public Library) did not allow the posting of flyers. Hundreds of people who came to these local organizations were also directly approached by the researcher with the flyer and asked to take part in the study.

Fifteen participants were recruited in this way (flyer and/or direct approach) and the other nine participants were recruited by snowball sampling (see Table 11).

Table 12 is a list of local organizations where flyers were posted and the number of people recruited at each location. Selection criteria included:

1. Subjects who used any mHealth app were recruited. No individual was excluded on the basis of sex or ethnic background. Focus was on recruiting people from diverse backgrounds to collect a range of views.

2. Two subjects were also recruited who had never used an mHealth app before. As preparation for the study, both of them downloaded mHealth apps voluntarily and used the chosen app for at least one week before participating in the study.

Local Organization	**Number of Participants Recruited**
University of Memphis	19
Muslim Society of Memphis	3
Masjid Ar-Rahman	1
Germantown Public Library	1
Memphis Public Library and its 18 branches	0
Masjid An-Noor	0
Christ United Methodist Church	0
Total	24

Table 12: Locations where Flyers were Posted.

3.3.3 **Semi-structured Interviews**

The interview times and places were scheduled via telephone, text message, or email. Participants were asked to bring their own smartphones during the interview session. Before starting any interview, each participant was given a consent form to read and sign. Appendix F contains the consent form for the final study. The consent form was designed according to the guidelines of the IRB of the University of Illinois at Urbana-Champaign. The consent form explained in detail the research question, method, and rights of the users. All participants were given an honorarium of $20. The study was generously supported by

the Estabrook Research Grant from the School of Information Sciences of the University of Illinois at Urbana-Champaign.

All the interviews were conducted during a seven-week period over June–July 2015. Between one and three interviews were conducted in each day. Table 13 shows the physical locations where the interviews were conducted. The locations were chosen based on the convenience of the participants and the interviewer.

Interview Location	**Number of interviews**
The university of Memphis, main campus	15
Participant's office	6
Participant's home	1
Memphis Public library	1
Local mosque	1
All	**24**

Table 13: Interview Locations.

All interviews were performed face-to-face. Each interview was conducted in a single session (the interviewer and interviewee met one time only). Each interview lasted up to 84 minutes and the average duration was 67.4 minutes. Each interview session had four parts. First, participants were asked questions regarding their use of and experience with mHealth apps (question 1 to 15 of the final study). In this part of the interview, the interviewer and the participant were sitting on two chairs and talking to each other face-to-face. In the second part of the interview, each participant was asked to show and walk-through the interviewer different features of the mHealth app that he or she was using or

had used in the past (question 16 to 20 of the final study). While showing the different features, the participant kept his or her smartphone on a table and both the participant and the interviewer placed their chairs on the same side of the table so that the interviewer could see the features of the app shown by the participant. Before showing the app features, each participant was encouraged to explain each feature in detail. Hence, each participant not only showed the app features but also gave a verbal description of the app features that they showed the interviewer. Whenever the interviewer needed more explanation, he explicitly requested the participant for further explanation. The interviewer also asked several questions to understand different app features. Like the first part, the second of the interview was audio recorded. Also, the interviewer took notes during this part of the interview. The app descriptions provided by the participants will be discussed in chapter 4. No personal information was collected and user's interactions with the app were not logged during this app walk-through process. In the third part of the interview, each participant was shown an mHealth app (S-Health) on the interviewer's smartphone (question 21 to 22 of the final study). The interviewer walked the participant through the S-Health app or the participant walked through the S-Health app by himself/herself. During this part of the interview, the interviewer's smartphone was kept on the table and the sitting arrangement was the same as the previous part of the interview. The participants also asked several questions which were answered by the interviewer. This part of the interview was also audio recorded. The S-Health descriptions provided by the interviewer will be discussed in chapter 4. Finally, in the fourth part of the interview, the interviewer asked questions to learn about the participant's perspective on mHealth literacy requirements (question 23 to 26 of the final study) and to know

participant's additional demographic information (question 27 to 30 of the final study). The final question was asked to recruit future participants (question 31 of the final study).

During this part of the interview, the interviewer and the participant went back to their original sitting position and talked to each other face-to-face. The fourth part of the interview was also audio recorded.

Field notes were also taken during each part of the interviews. No physical or mental risks were associated with participating in the study except those involved in ordinary everyday life. Participation was entirely voluntary and participants had the right to skip any question or stop participating at any time with no negative consequences.

3.3.4 **Extended Interview Questions**

Re-evaluation of each question of the pilot study helped to finalize the questionnaire for the final study, which consisted of 31 questions. Appendix G contains this revised questionnaire. The interview questions focused on nine different aspects (see Table 14).

The interviewer asked all the 31 questions to every final study participant. Although participants could skip any question and/or stop participating at any time, no one skipped any question or ended the interview before completion.

For questions 23 to 26, the interviewer also explicitly asked some probing questions to all participants to understand whether they also agreed on the skills which were identified by the pilot study participants or the previous final study participants. For instance, if the interviewer found that the study participant did not mention about graph literacy (how to use graphically presented information) while answering questions 23 to 26, the

Part	Questions	Goal
1	1–8	To learn about the participant's demographic information and background, his/her familiarity and usage experience with the mHealth apps, and his/her competency level to use an mHealth app. Answers to these questions were helpful to understand whether mHealth Literacy is dependent on these factors.
2	9–10	Since people may get health benefits in dissimilar ways by using mHealth apps, the answers to these questions were helpful to understand the relation, if any, between mHealth Literacy and the perceived health benefits of using mHealth apps.
3	11–13	To learn about the involvement of participant's social circle (e.g., family members, friends, colleagues) regarding his/her mHealth app use.
4	14–15	To learn about the involvement of a participant's doctors or healthcare professionals in his/her mHealth app use.
5	16–20	To know participant's experience with the mHealth app he or she is currently using or has used in the past.
6	21–22	To know participant's perspective on a new app (S-Health).
7	23–26	To learn participant's perspective on the major literacy a user will need to use mHealth apps to receive health benefits.
8	27–30	Additional demographic information (e.g., age, gender).
9	31	Question targeted at future user recruitment (snowball sampling).

Table 14: Extended Interview Questions for the Final Study.

interviewer explicitly asked the participant whether he or she would consider graph literacy as a necessary skill to use mHealth apps. Table 15 highlights the probing questions asked to the participants. 85 probing questions were asked to 24 participants (on average, 3.54 probing questions were asked to each participant). Among these 85 probing questions, for 59 times, participants mentioned that a particular skill (mentioned in the probing question) is required. Participants were only asked about any of the literacies if they didn't mention that during their interview.

Probing question on mHealth Literacy	Number of participants were asked	Number of Affirmative answers
English Literacy	18	10
Graph Literacy	16	6
Information Literacy	14	14
App-centric Health Literacy	13	13
Computer Literacy	9	3
Web Literacy	6	5
Numeracy	4	4
Privacy Awareness	4	3
Smartphone Literacy	1	1

Table 15: Probing Questions Asked to the Final Study Participants.

3.3.5 **Post-fieldwork Analysis**

Data analysis was conducted in the following stages: Audio recording, Note taking, Transcribing, and Text coding. The audio was recorded using two separate mediums: (a) a laptop audio recorder and (b) a smartphone audio recorder. As soon as the interview was over, the audio files were moved to a hard drive as well as to the Google Drive, both of which are password protected. The field notes, which were written down during the interview session, were also stored safely in a private place (only accessible to the interviewer).

Transcriptions of the audio records were performed after the interviews were conducted. Table 16 shows the transcription size of each interview. The longest, shortest, and average size of transcripts (in pages) are 18 pages, 37 pages, and 27.9 pages respectively. The longest, shortest, and average size of transcripts (in words) are 11535 words, 5048 words, 8153.5 words respectively.

As part of the interviews, field notes about each user's interaction with the two smartphone applications were also created. The coding scheme described in section 3.1.2 was utilized to code the interview transcripts and field notes pertaining to nine literacies.

For the rest of the transcripts, the following coding methods (Saldaña, 2015) were used:

- Attribute Coding
- Magnitude Coding
- In Vivo Coding since in some cases, participant's own language was used for coding.
- Descriptive Coding to summarize a passage of transcription text in a short phrase.

Participant ID	Transcription (pages)	Transcription (words)
1	18	5048
2	22	7646
3	26	7424
4	20	5258
5	28	9450
6	30	7288
7	27	6937
8	23	6670
9	25	8029
10	35	11075
11	26	8094
12	24	7716
13	28	8728
14	28	9039
15	29	6729
16	31	6884
17	29	11535
18	34	8813
19	28	8126
20	34	9869
21	35	10834
22	27	6767
23	37	9297
24	26	8428
Total	**670**	**195684**

Table 16: Transcription size of each interview.

Coding Method	Codes used	Explanation of the code
Attribute Coding	ID	Identification of the participant
	Interview location	Location of the Interview (e.g., Memphis Public Library)
	Recruitment Place	From where the user was recruited (e.g., University of Memphis)
	Gender	Gender of the participant
	Race	Race of the participant
	Age	Age of the participant
	Education	The highest degree the participant earned
	Country	Country of the citizenship of the participant
	City	The city from where the participant came from
	Occupation	Occupation of the participant
Magnitude Coding	Expert Level	Expertise level of the user to use mHealth apps (e.g., Beginner/Intermediate/Expert)
	App Frequency	How frequently the participants was using the app
	App Time	For how long the participant is using the app

Table 17: Coding Methods Used on the Transcript.

Coding Method	Codes used	Explanation of the code
In Vivo Coding	Privacy awareness	A user should be privacy-aware to use an mHealth app
	Negative Impact Awareness	A user should be aware of whether mHealth app has any negative impact on smartphone
	No Fear of Technology	A user should remove the fear of technology
	Desire	A user should have a strong desire to use an mHealth app
	Consistency in Use	A user should be consistent to use mHealth apps
	Consult a Doctor	A user should know when to consult a doctor
Descriptive Coding	App	Name of the mHealth app used by the participants
	App Description	What does the mHealth app do?
	App Design	What features an mHealth app should have
	App Features	Different features of the mHealth app Described by the participant
	S-Health	Participant's perspectives on S-Health app
	User	Additional information participant provided about his/her app usage

Table 17 (cont.)

Table 17 shows the exact codes used for these four coding methods. In vivo coding was used to identify the six other skills necessary to use mHealth apps. Besides these four coding methods, simultaneous coding method was also used since for some part of the transcriptions, two codes overlapped.

The result is a set of skills that define mHealth Literacy and a set of design recommendations, all drawn from users' experiences and reflections. To ensure participants' privacy, individual information was anonymized (e.g., participant 1, participant 2, and so on) and is reported only in a summarized manner in this dissertation.

Chapter 4 Findings Regarding Participants and mHealth Technology

This dissertation's central question is: **what skills does a user need to use a health-related app on a smartphone?** As mentioned in chapter 3, 24 semi-structured interviews were conducted for the final study. Due to the relatively small number of participants, the results might not be generalizable. Hence, it is utmost important to contextualize the results collected from these participants. To achieve that goal, an introduction of these 24 participants along with their mHealth technology use are required to give a basic understanding of their demographics and their mHealth app usage. This chapter (chapter 4) will shed some light on this while chapter 5 will discuss the actual findings from these 24 interviews.

Chapter 4 first offers a detailed summary of demographic information of final study participants. Then, it discusses the mHealth technology (e.g., mHealth apps and mobile operating system) used by the participants. More specifically, it highlights the features of the mHealth apps that the participants liked and disliked and challenges they faced while trying to use these apps. In addition, this chapter reports findings related to participants' practices and experiences surrounding mHealth app use and their motivation for using them. Then, it reports app selection process followed by study participants before finalizing an mHealth app. Then, it discusses the social aspects of mHealth app usage (social circles involved by study participants which were their major sources of information about mHealth apps.) This chapter also discusses the health benefits study participants received after using their mHealth apps. Finally, this chapter discusses an mHealth app (S-Health), which was shown to all participants to get a baseline. More specifically, it shows what

participants' opinions were about one single mHealth app (S-Health), what differences participants found between S-Health and their own apps, and the challenges they encountered when they tried a new app for the first time.

The findings of this chapter are crucial to answering the dissertation's central question mentioned above. These findings will help us to understand the impact of users and mHealth technology used by them, if there is any, on mHealth literacy requirements. Since the findings of mHealth literacy requirements will be discussed in the first part of chapter Chapter 5, the impact will be discussed at the end of chapter 5 (section 5.3).

4.1 Demographics and Expertise of the Participants

This section provides the details of demographic information of 24 final study participants (Table 18 to Table 24). Participants came from four different countries (see Table 18), are diverse in their social, educational, and professional background, and have varying levels of experience in using mHealth apps. Although all participants were living in Memphis, Tennessee when the interviews were conducted, they originated from different geographical locations (see Table 18 and Table 19). Table 20 shows the ethnic diversity of the 24 participants.

To learn about mHealth app experience from different groups of users, participants from different age range were recruited for the study. To capture gender diversity, both female and male participants were recruited. Table 21 and Table 22 show the age range and gender diversity of the 24 participants. The minimum, maximum, median, and average ages of the 24 participants were 23 years, 57 years, 32.5 years, and 34.25 years respectively. In

Country of Citizenship	N	%
USA	10	41.7
Bangladesh	7	29.2
Iran	4	16.6
India	3	12.5
All	24	100

Table 18: Country of Citizenship of Participants.

USA Region	N	%
South	5	50
Midwest	2	20
West	1	10
Northeast	1	10
All	10	100

Table 19: Regional Distribution of USA Participants.

Ethnicity	N	%
Asian	14	58.3
European	6	25.0
African American	3	12.5
Asian American	1	4.2
All	24	100

Table 20: Ethnicity of Participants.

Age	N	%
20–29	7	29.2
30–39	11	45.8
40–49	5	20.8
50+	1	4.2
All	24	100

Table 21: Ages of Participants.

Gender	N	%
Men	13	54.2%
Women	11	45.8
All	24	100

Table 22: Gender of Participants.

Educational Level	N	%
Two year's College/Associate Degree	2	8.3
Bachelor's degree	7	29.2
Master's Degree	14	58.3
Ph.D. degree	1	4.2
All	24	100

Table 23: Educational Level of Participants.

terms of highest educational degree earned, all 24 participants had at least a college degree (shown in Table 23). In terms of occupation, three different types were reported: graduate

student, professional-managerial, and office worker. Table 24 provides the distribution of occupations of the participants. All 10 students were graduate students at the University of Memphis in a range of fields: Computer Science, Electrical Engineering, Earthquake Research, Educational Psychology, and Civil Engineering.

Study participants also had varying levels of experience with smartphone and mHealth app use. The minimum, maximum, and the average number of years of smartphone usage were 0.67, 11, and 5.11 years, respectively. The majority of the participants (50%) had used a smartphone for 4 to 6 years (shown in Table 25).

Current Occupation	**N**	**%**
Graduate student	10	41.7
Professional-Managerial	10	41.7
Office Worker	4	16.6
All	24	100

Table 24: Current Occupations of Participants.

Years of Smartphone Usage	**N**	**%**
<=3 years	6	25
4–6 years	12	50
6–11 years	6	25
All	24	100

Table 25: Years of Smartphone Usage by Participants.

The distribution of participants with respect to app expertise level is shown in Table 26. Participants were classified into the three following categories, based on their expertise level with mHealth app usage:

a) Beginner: Participant had been using mHealth apps for less than 6 months;
b) Intermediate: Participant had been using mHealth apps for more than 6 months but less than 1 year; and
c) Expert: Participant had been using mHealth apps for more than 1 year.

This table shows that participants were almost evenly distributed into these three app expertise levels. Two participants who had never used an mHealth app before were considered as beginners since as preparation for the study, both of them downloaded mHealth apps voluntarily and used the chosen app for at least one week before participating in the study.

App Expertise Level	**N**	**%**
Beginner	8	33.3
Intermediate	7	29.2
Expert	9	37.5
All	24	100

Table 26: App Expertise Level of Participants.

In summary, although the number of participants of the final study is relatively small, they were diverse in their age, gender, social, ethnic, educational, and professional background, and had varying levels of experience in using mHealth apps. How such diversity impacts

the mHealth literacy will be discussed in section 5.3.mHealth Technology Used by the Participants

To contextualize the answer to the research question, it is also important to get an understanding about participants' mHealth technology usage. Perhaps, users who use mHealth apps for health issues where the solutions are generally more familiar to laymen (e.g., diet, exercise, and sleep), they may need different skill sets to be mHealth literate as opposed to users who use mHealth apps for health issues of a more technical medical nature (e.g., high blood pressure, diabetes, and cancer). This section will discuss the mHealth technology practices of the final study participants. Here, mHealth technology will be categorized into two different categories: mobile operating system and mHealth apps.

4.1.1 **Mobile Operating System Used by Participants**

App Operating System	**N**	**%**
iOS for iPhone	13	54.2
Android	11	45.8
All	24	100

Table 27: Operating Systems of mHealth Apps Used by Participants.

There are multiple operating systems used for smartphones such as Android OS, Blackberry OS, Palm OS, iOS, webOS, and Symbian OS. Among these, only two mobile operating systems were used by the 24 participants. Table 27 shows that 13 participants (54.2%) used iOS, the operating system for iPhone, and the remaining 45.8% used Android-based phones. Although a few participants had used two other operating systems

earlier (Blackberry OS and Symbian OS), all of them used either iOS or Android while the interviews were conducted.

4.1.2 **mHealth Apps Used by Participants**

Participants were asked about the mHealth apps they were using at the time of the study or had used in the past (question 16 to 20 of the final study). The coding and analysis of the final study transcripts and field notes revealed that there was a great diversity among the 24 participants in terms of mHealth app usage. Here, mHealth app usage refers to participants' motivation for using any specific mHealth app. Table 28 lists the names of the mHealth apps used by the 24 participants. Overall, participants reported 31 different mHealth apps that they used at some point or were using during the study. Fifteen participants mentioned using multiple mHealth apps simultaneously while nine reported using a single app during the time of the study. The average, maximum, and minimum number of different apps used by the participants are 1.29, 4, and 1. The average app usage time (for how long a participant was using his/her mHealth app) of the participants was 11.62 months while the maximum and the minimum app usage time were 4 years and 1 week respectively. Table 29 classifies the apps into five broad categories based on the specific health related service they provide. Brief descriptions of various mHealth apps reported by users are presented below.

App Name	App Purpose	N
MyFitnessPal	Counts calorie intake and tracks diet	8
Apple Health	Monitors health and fitness data (Heart rate, calories burned, blood sugar, cholesterol)	5
Moves	Tracks daily activities	3
MapMyRun	Tracks workout (walking, jogging, and running) and counts calories	2
Fitbit	Tracks daily activities	2
WebMD	Provides first aid information without Internet connection	2
Heart rate	Measures heart rate and track record	1
Sleep Better	Tracks sleeping	1
7 Minute Workout	Supports comprehensive and rigorous exercise in 7 minutes	1
Blood press	Monitors blood pressure	1
Relax Lite	Relaxation app through breathing and meditation	1
Lose it!	Weight loss program	1
MapMyWalk	Tracks walking with traveling route in an interactive map	1
Ovia Pregnancy Tracker	Tracks pregnancy and baby's development	1
MyHeart Counts	A research app from Stanford university to study users' activity and the health of their hearts through smartphone	1
Misfit	Tracks daily activities and monitors sleep	1
Max Trainer	Tracks work out and count calories burned	1
Map My Fitness	Track workouts, running, cycling, walking, and counts calories	1
Google Fit	Tracks daily activities	1
Fitness Buddy	Exercise workout trainer	1
Adrian Peterson Driven	Fitness training app	1
My Pregnancy & Baby Today by BabyCenter	Provided week-by-week pregnancy tips and trackers	1

Table 28: Names of mHealth Apps Used by Participants.

App Name	App Purpose	N
My Plate Calories Tracker	Tracks calories	1
Nike Fit	Personal Trainer app	1
P Tracker	Tracks women's periods	1
Run Keeper	Tracks running, walking, cycling, workout, pace, and weight	1
S-Health	Tracks daily activities	1
Sleep Cycle Alarm Clock	Analyzes user's sleep and wakes the user in the lightest sleep phase	1
Stress Relief	Stress management app	1
Sworkit	Provides personalized video workouts	1
WalkLogger	Tracks physical activities	1

Table 28 (cont.)

App Type	App Purpose
Activity tracker	Tracks different day-to-day life activities
Calorie Counter	Calorie counter and diet tracker
Physical and Mental exercise	Supports comprehensive and rigorous physical and mental exercise
Physiological Data monitoring	Monitors different physiological data (e.g., blood pressure, heart rate)
Health Information	Provides first aid information

Table 29: Types of mHealth Apps Used by Participants.

MyFitnessPal

MyFitnessPal[4] was the most popular mHealth app among study participants, with eight participants (P2, P3, P4, P7, P10, P12, P15, and P17) reported using it during the study. Six of them (P3, P4, P7, P12, P15, and P17) mentioned using it every day while participant 2 mentioned using it occasionally. Although participant 10 used this app earlier, he was not

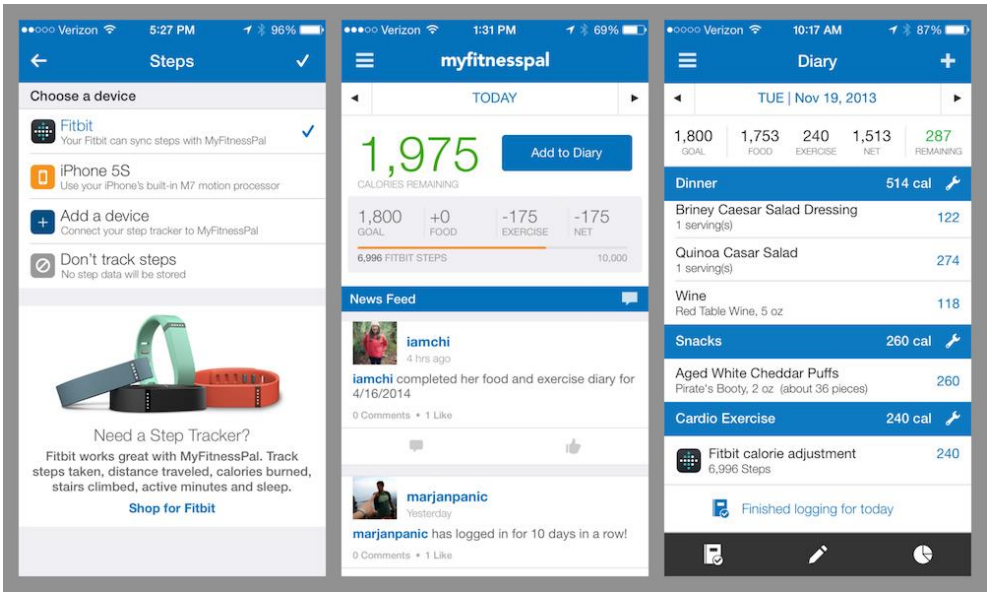

Figure 3: Sample screenshots of MyFitnessPal app

actively using this app while the interview was conducted. For these eight participants, the duration of app usage ranged from 1.5 weeks to two years. Figure 3 presents some sample screenshots of MyFitnessPal. Participants chose this app for different purposes such as to track calorie intake, to manage weight, and to find recipes, etc. The following participants

[4] https://www.myfitnesspal.com/

shared their experiences on how they were using different features of MyFitnessPal and how this app was helping to improve their health.

> I use the MyFitnessPal to log how many calories I am eating. It [the app] has all the options like weight, exercise, and food. So if I want to add food it gives me the option of [adding] breakfast. I put my breakfast and it tells me how many calories I eat. If you want the bigger breakdown, you click on the food and you see it has breakdowns of sugar, cholesterol, and protein. It also has a nice feature. If I enter carbohydrate goal of 50 grams and if I am getting 60 grams [of carbohydrate], it will give me an alert that I am eating too many carbohydrates. If I go to nutrition [a feature of MyFitnessPal], it tells how much calories I've eaten and what percent each meal of that was. It breaks down everything. It also gives you a lot of recipes. Healthy recipes and food that you can add. [In] blog [another feature of MyFitnessPal], everyone shares their recipes… And then you can set reminders. I have never used this feature. You can also make friends. It [MyFitnessPal] syncs to your Facebook. All of your Facebook friends who are using MyFitnessPal, you can send them friend requests. You can send them messages and talk to them. – P3

> I have had my MyFitnessPal previously but I only ever used it for tracking my running… I used MyFitnessPal and I used it for the GPS function on my phone so that we would have some sense of how far we were running. In particular, we used it when we were training for our first half marathon because we had to keep certain numbers of miles on certain days. I wanted to have a record of it because I was very proud of myself. – P10

Apple Health

Five participants (P1, P16, P19, P23, and P24) used Apple Health[5] for managing their health. Three of them used this app every day while one used it once a month and the other used it infrequently. The duration of app usage ranged from 6 months to a year. Figure 4 shows sample screenshots of Apple Health. Participants used Apple Health for various purposes such as tracking daily activity, measuring calorie consumption, monitoring their heart rate, and consulting the dashboard to review health information.

Figure 4: Sample screenshots of "Apple Health" app

The following participants shared their experiences on how they were using different features of Apple Health and how it was helping to improve their health.

[5] http://www.apple.com/ios/health/

It [Apple Health] tracks your steps and flights of stairs. It also would track my sleep but I have not gotten around to setting that up. It's really accurate. It seems like keeping up with stuff so I really like it. I check the Apple Health every day just to keep up with what I am doing… I try to keep my phone in my pocket all the time so I can tell how far I've gone. Today I haven't really gotten all my walking in yet… And I can enter in my food. If I don't know what something is and I have it with the barcode I can scan it. It will tell me all the nutritional information about it. I can do for every meal and then it will keep up with how many calories I have had. Then you can enter your exercise in there and then it will balance. – P1

It [Apple Health] has a dashboard. It shows by days, week, month, year, how many steps you do. And then you change it to week, month, and year. The steps, walking and running distance, flights climbed, sleep analysis. But I was not using that much of the sleep analysis because I didn't know actually that it has that because I didn't browse that much. But I first used this one quite frequently. I think they automatically collect blood pressure. But for other things, I think you have to put the data, like the body fat percentage. I am not sure [whether] I want to share that type of information on my phone. I am not sure about the privacy issue. – P19

It [Apple Health] also shows all the record of my health. I don't have medical ID. I have to contact my doctor and I think I have to receive ID from him or the health care center or so. If I put in my ID, all the records will be in the app. And I can show those records everywhere. – P23

It [Apple Health] was introduced in iPhone 6, but not in previous [iPhone] models. You get with the latest software version. It will count the steps per day, per week, per month, and per year. It also shows visually in a graph with the time. It also records historical information showing when you had the steps and at what time… You can also keep your nutrition information, body measurements, BMI, and your medical information. And you can create a medical ID. I didn't do any of them, but there are options to save your medical information and everything… As I told you, I basically record four categories of information. The first one is steps - it records how many steps I did from past day. Say, I am at here at 10:32 am and I didn't move even a little bit. I did not step [out] after sitting at this spot from 10:32 am. So, it just says 60 steps at 10:32 AM. So it just stops there unless you make another move and it updates the time and it updates the step. And you can see that [information] by day and by month. If you click on a particular category, it gets a big result like this - recording every minute… The second one is walking plus running distance. The first one is basically [counting the] steps whenever you walk at your home or you just going to the bathroom - it just counts the steps. But if you really want to know how much distance you run without measuring, you just go to this app and see walking plus running distance. And it also tells you [at] what time you ran and [at] what time you achieved how many miles… [Apple Health also contains] health-related data. It got all the categories. The main categories are - vitals, results, nutrition, "Me profile", and fitness. [I] added four among all these categories. But if you ever want to use anything else you just click on it and click show on the dashboard… If you want to add few more like body weight, height, and mass index, [you just click it]. It can

predict accurate data, BMI or something like that. It has many nutrition categories which I never used. [It also has a feature called] the cycling distance. I do not have a bicycle so I don't use that. And I never used the food related things because I am not interested. I don't want to count my food. I think you can't count food by looking at what I am eating. I think I need to put manually what I eat which is a waste of time… Medical ID provides medical information about you that may be important in an emergency. The medical ID can be accessed from the emergency dialer without unlocking your phone. So I think if you create this information and if you passed out on a road, someone calls from the large screen without inputting the password and it just tells their medical information. – P24

Other apps used by participants

Figure 5: Sample screenshot of Moves app

While MyFitnessPal and Apple Health were the most popular apps used by study participants, they mentioned using 29 other mHealth apps for various health-related activities (e.g., tracking physical activity, weight management, and stress management).

Participant 7, participant 8, and participant 18 mentioned using an app called Moves[6] (see Figure 5), which enables tracking of activities and connects them with locations where the activities took place. All three participants mentioned using the app every day at multiple times. The duration of app usage ranged between 2 months to 6 months. According to participant 7 and participant 8,

> Currently, I am using one app that is called "Moves." It tracks the movement, location, step counts, the location and transportation time, summary of where you are and for how long [you are] in this is location. I was moving in a car so [it shows] transport and here I am in Dunn Hall. It will show how long you have taken your steps. It will also give you the whole summary. Actually, I was interested in one app that will track the dietary but the problem I face [is that] they collect my sms, my media, my logs, contacts. I did not find any app that did not take this type of data. At the time of installation, they say that they will track my logs, contacts, sms, and media. I don't feel comfortable. I did not install because of the privacy. I don't know what they will do with my data. The app shows the step counts and the mode of transportation whether it is biking or other transportation. - P7

> [Moves has features like] step count, location, and location history. It also shows daily activities, say time spent at home, time spent at my work, and transport [I took] and how much steps I walked. It also provides a comparison with other days…

[6] http://www.macrumors.com/2014/04/24/facebook-moves-fitness-app/

When I first installed this app, I was very excited. The phone can detect all the activity, even each step. – P8

Figure 6: Sample screenshot of Fitbit app

Several participants used more than one mHealth apps to support their health needs. For example, participant 3 used MyFitnessPal and Fitbit app[7] concurrently (see Figure 6). While both apps encourage an active lifestyle, participant 3 used both together to gain access to specific features that these apps provided to meet her needs. She explained this:

> Fitbit just records your activities. For the Fitbit, I have to wear a device which tracks all my steps… These two apps [MyFitnessPal and Fitbit] are for different motives. One is keeping a count on how much I'm eating and other is keeping a count on how much I am spending. So both are important… Fitbit device comes with a small

[7] https://www.fitbit.com/app

Bluetooth dongle that I connect to my PC. If I'm within 50 meters [of the PC], it syncs… You can track your exercise normally whatever steps you're walking, it will sync. Then it'll put the number of step counts and how many miles you walked. Also, it inputs all the data from MyFitnessPal. The best thing about it is that if you wear it on your wrist, it will tell you how good sleep you have had. It works like a sleep tracker. If you click on this it will tell you [at] what time how much calories you burned. – P3

Figure 7: Sample screenshot of "Fitness Buddy" app

Similar to participant 3, participant 23 was using two apps concurrently: Apple Health and Fitness Buddy[8] (see Figure 7). He explained this:

[8] https://www.smartlivingnetwork.com/condition-specific/b/5-free-fitness-apps-in-varying-degrees-of-awesomeness/

Fitness Buddy helps me [to do] workout. It tells me what I should do. It has yoga and everything. It also shows workout plan. It shows what should you do, like first chest biceps and I think it shows the routine. – P23

(a) Stress Relief App

(b) Relax Lite app

Figure 8: Sample screenshot of "Stress Relief" app and "Relax Lite" app

Participant 22 was using two apps for managing her mental stress - Stress Relief and Relax Lite (see Figure 8). According to her,

> Both of these apps are for managing your stress and help you to keep calm. Stress relief is basically just a 45-minute yoga thing like an inspirational talk. It guides you until you fall asleep. You can concentrate on a single part of your body. So what they were doing was hypnotizing. It has music and everything that help you to concentrate. It helps you to keep calm and helps you to have a better day. You can listen to it [while] going to sleep or after waking up or whenever you feel you have time and you need this kind of things. So that's basically just a recorded-woman that is talking to you to hypnotize. The other one is breathing procedure. It has different patterns for breathing. It gives you 5 minute or 10 minute time and you can do a

different combination of inhaling. So it's a breathing practice and if you continue to do that it helps you to be calm. It has also an 8-minute talk for relaxation purpose… It helps you to be calm and concentrated. When I was distracted, I was sitting and working but my mind was in every other place like what should I do about something else, what should I do about the banking. With listening to it, my mind becomes concentrated and does not go any other places. – P22

Figure 9: Sample screenshots of "Sleep Better" app

Participant 6 mentioned using a sleep tracking app called "Sleep Better"[9] (see Figure 9). He was using "Sleep Better" for almost one year and shared his experience about this app.

Currently, I am using "Sleep Better", a sleeping app. It tracks the sleep. When you go to sleep, you start the app. When you wake up, you can tell what your mood is. When I wake up, it will do an alarm. It's not like the regular alarm, it is slowly musical alarm. If you want to wake up at 6:30 am, the alarm will start half an hour

[9] https://itunes.apple.com/us/app/sleep-better-smart-alarm-clock/id922541792?mt=8

ago. So from 6:00 am, very slow sound, like musical sound, not like ring ring ring, not like that. So when you wake up, you can tell what your mood is, how you are feeling. When you are going to sleep at night, you can tell, like either a stressful day or you eat late or you took caffeine or you took alcohol or you worked out. I was just tracking [to know] how I am sleeping. – P6

Figure 10: Sample screenshots of WalkLogger app

Participant 11 used an mHealth app called WalkLogger[10] for five months to track her walking (see Figure 10). She shared her experience with this app.

It [WalkLogger] measures my steps that I take a day when I walk [at] the track or when I walk around campus. It tells me how many calories I burn. It tells me the sensitivity of it which means, I guess, the level or degree that I am walking. Based on

[10] http://walklogger.com/

> the exercise that I am doing, it tells me the active calories that I burn and the total calories. – P11

While participant 11 was walking through the app to the interviewer, she explained some additional features of this app.

> It's really simple. This is the main screen. It shows [that] I started walking at six. It [automatically] came on. I didn't turn it on. Right here, at six it measured so many steps and before noon this was my steps. Right now it is 12:25 pm and it doesn't show any steps after this time [noon]. Because I'm sitting here [with you for the interview]. So as I was saying, it hasn't measured any of my steps since twelve. And see, these are steps that I have not turned it on today. It starts measuring at six o'clock. So, I do not know why it turned on, but it turned on. Now, it hasn't measured any steps. But, if I get up and walk, it is going to count upward as to how many steps. It says I have taken 2,134 steps. – P11

Participant 20 mentioned using an mHealth app called MapMyRun[11] (see Figure 11) and explained his motivation for using this app.

> I usually run short distances. Sometimes I just use it for walking. And it has GPS. Actually, it uses GPS of my cell phone. It records the path and then it can get information about your speed and distance. And you can save everything. That's it… – P20

[11] http://www.mapmyrun.com/

Figure 11: Sample screenshots of MapMyRun app

While he was walking through the app to the interviewer, he also shared his overall experience with MapMyRun.

> When I go to the application, it shows me my current location. It tries to find my location by GPS. If I push the "Begin workout" button, it starts counting distance and duration. It also tells me about the calories [I consumed] and then my pace [of my run]. Whenever I finish one mile, it tells me that you finished one mile. It is very useful because I don't like to look at my phone to get that information. I usually pass on my phone to my wife. I usually listen to music. When I reach one mile, it reduces the volume and gives me that information. When I finish, I just press pause or I can slide to finish or if I want to resume, I can resume. I think they have a database. I think it is a server. I can get information like it tells me this week, last week, last thirty days, this kind of things. I have reports for the last several months now. – P20

Participant 21 was using an mHealth app called "Lose It"[12] (see Figure 12). She shared her experience with this app.

Figure 12: Sample screenshots of "Lose It" app

So here's your log of your week and you can set your goal weight. Then each day you can log your meals, your snacks, how much you exercise. There's a social aspect to it but I didn't use that part. There are some goals. So you can put in your goal and then it will track where you are at. If you earn a badge it's going to reward you. And it's really cool because you can actually scan an item; that's what I found was most helpful. You can scan an item and it's going to pull up, how many servings you had. It tracks the calories, so it knows the product which is really cool. – P21

[12] https://www.loseit.com/

When she was walking through the “Lose it” app to the interviewer, she explained several additional features of this app.

> Basically, this is the main screen and it’s going to show how many calories you eat in a day. And so it’s here. And then you can just add to how many calories by logging it in. So if I want to add lunch in, I can select it from the list that previously used. Or I can scan a food item. Which is so cool. And then you can select from previous ones and it pops up the icons so I really like that. And then you can go to previous meals, you can even do recipes, but I never created a recipe. And then it has the brands. And I think that's really cool. It is going to change how much nutrients are in a chicken sandwich depending on which place you eat. And so I think that's a really good feature that maybe is not common in other ones. – P21

Figure 13: Sample screenshots of “7 minute workout” app

Participant 9 shared his experience of using an app called “7 minute Workout” (see Figure 13), which he was using for two years. He shared his experiences about this app.

The reason I downloaded it [7 minute workout app] was a promotion provided by Apple. And they had it as a free download. Usually had to pay $2 or $0.99 or something but I had it for free. So I downloaded it. But then I liked it. It was okay. My son [4-year-old] uses it more than I do. He puts it on and goes baba exercise. And he starts jumping up and down and doing all the exercise. [I use this app] not as frequent as I used to. Before I was doing it once a day and slowly, maybe few times a week. So here is the full body workout. You can do upper body, core, lower body, cardio, fat burn, explosive, and all these other things. How many times do you want to go through? You want one cycle. The instructor, you can do a voice-over, or you can I guess pick a different name and a different voice. But you have to pay for it. So, you click here, start, whistle, and let's go. See it shows jumping jacks, right now you are doing jumping jacks and it counts, it has a counter, so usually you'll put it down and we go like this when we're doing it… When it [the app] tells you, you have ten seconds to go you're almost done. You just start in its high-intensity. Next up: Wall-Sit. You rest for ten seconds. So the next exercise is Wall-Sit, where you sit against the wall, see he knows. And we've done it, obviously, you can tell. See? That's the Seven Minute Exercise. And then it just goes through this obviously, see, different exercise, obviously this one you do not need to know the warm-up that much. So then it does through the whole thing and that's it. Then it gives you the ability to track for the seven days or how many times you've done it. So, achievements, it has achievements so you can track how you're doing and then here, of course, you have to learn about the exercises. These are the different exercises it has. – P9

Besides using "7 minute workout" app, participant 9 was also using another mHealth app called WebMD[13] (see Figure 14).

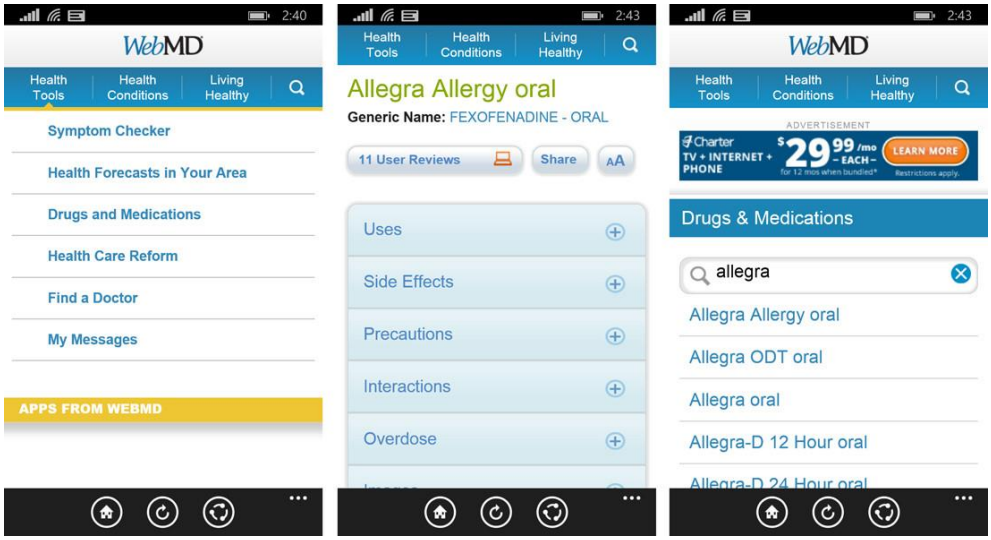

Figure 14: Sample screenshots of WebMD app

4.1.3 Information Sources about mHealth Apps

Participants were asked about the sources of information related to the mHealth apps they were using (question 5 of the final study). Based on their responses, participants' sources of information can be divided into two broad categories: (1) human sources (e.g. friends, colleagues, and word of mouth) and (2) non-human sources (Internet, app store, while exploring smartphone, insurance company, magazines, app-specific promotions, and exercise device). 19 participants revealed the sources of information of the mHealth apps they used. Five participants (P5, P6, P17, P21, and P23) mentioned multiple sources. Table 30 reports the list of these information sources. This table shows that Internet and Friends

[13] https://itunes.apple.com/us/app/webmd-trusted-health-wellness/id295076329?mt=8

are the two most popular information sources about the mHealth apps the participants were using.

Information Source about mHealth app	Number of participants
Internet	5
Friends	5
App store	3
While exploring smartphone	3
Colleagues	2
Word of mouth	2
Insurance company	1
Magazine	1
App specific promotions	1
From exercise device	1

Table 30: Information Sources about mHealth Apps.

4.1.4 Motivation for using mHealth Apps

While the participants were asked about their mHealth apps (question 3 of the final study), six participants (P4, P7, P9, P10, P11, and P23) discussed their motivations to use these apps. Based on their responses, three types of motivations were identified: Health improvement, Health Tracking, and Knowledge Acquisition.

Health improvement:

Two participants (P4 and P11) reported that they started using mHealth apps to improve their health. While participant 4 wanted to lose weight, participant 11 wanted to control her blood pressure. To quote these two participants:

> I wanted to use MyFitnessPal because I wanted to lose some weight. – P4

> I want to keep my blood-pressure under control. I do not have high blood pressure, but exercising helps keep your blood pressure down. I can tell the difference in my

> blood pressure when I exercise. That's how beneficial it was to me. It keeps me off of medication. I do not have high blood pressure but I notice the fluctuation in my blood-pressure on the days that I exercise versus the days that I do not. – P11

Health tracking:

Three participants (P7, P10, and P23) reported that they started using mHealth apps to track their health condition. They shared their experiences in the following ways:

> I was eager to see how much physical activity I was doing and how much I weigh. – P7

> I want to know that I am making adequate progress for a goal that I have set. I like to know [that] on average I get the right amount of sleep. I can see that I get eight hours, ten minutes of sleep on average, which is wonderful. So that's something that's actually been helpful because I used to think I didn't get enough sleep. – P10

> I just wanted to see what my speed is and what the record of my running is. - P23

Knowledge acquisition:

One of the motivations for participant 9 was knowledge acquisition using WebMD app. According to him,

> Sometimes if I feel symptoms or someone else does I use the symptom checker. I used it once or twice for the medicine identifier. You can put in the description of certain medications if you do not know. I used that a few times. And also to look up information on different diseases. I heard somebody had a weird disease. I have never heard of it before. I type it in, I read about what I do not know. This way it helps me [to] learn. – P9

4.1.5 **App Selection Process**

There are a numerous number of mHealth apps available in the app stores. 12 final study participants explained their techniques to finalize an app from the hundreds of thousands of available mHealth apps. Based on their responses, five selection techniques were identified: App Rating, Trial and Error, Recommendation from others, User Interface, and Curiosity.

App Rating:

Six participants (P6, P9, P11, P20, P21, and P22) selected their apps based on the app rating (e.g., the users' review about the app, the number of downloads, and the number of stars given to the app). Participant 21 used multiple techniques including the app rating. Five of them (P6, P11, P20, P21, and P22) shared their experiences in the following ways:

> I basically did a search for an app to measure my steps and it was one that was suggested [by app store]. So, I just chose it by chance because it was on the top list of pedometers apps. So I chose it that way… I just took a chance on it. – P11

> I went to App Store and then checked the applications to see which one is more popular. Based on the number of downloads, I selected this [app]. It was free and I installed this one, a couple of other applications and I started using all of them and found that this one is easier to use. – P20

> In July, in one blog, I saw a couple of apps and reviews. I like this one [app]. - P6

> I like pictures and reviews. If it [the app] has a good review then I'll more likely download it, based on reviews. – P21

> I check the stars [the app received] and the reviews [of the app]. This [app] is the best one. Its rank is in the top 10. – P22

Participant 9 had an interesting observation. He usually relied on good reviews to select an app. However, according to him, a bad review does not mean that the app is faulty. He shared his experience to deal with bad reviews of an app.

> If it [the app] is featured, if it's recommended, obviously I'll have a look at it. If it has good reviews, I'll look at it. If it doesn't have good reviews, I tend to look inside and see what the problem is. Because of a lot of times, they [users] put a bad review but it's actually the user's fault for not fully knowing how to use these apps. So if it has bad reviews, I like to look at it and see why it is getting bad reviews. Because sometimes it isn't really the people's fault or the app designer's fault but more of what the users are doing. I know a lot of people do not do it, but I do it. I like to verify what's being said. – P9

Trial and Error:

Two participants (P2 and P10) tried several apps before finalizing a particular app. To quote these two participants:

> I ended up getting MyFitnessPal because I was looking for a calorie counter. That seemed to be the best choice. I probably tried a few others, can't tell you what they were but it [MyFitnessPal] is the one I settled on and I started using that briefly. Then get rid of the ones that I do not like. – P2

> We looked at the Fitbit and we looked at the jawbones and we looked at all of them that were out there. We spent a few months off and on. – P10

Recommendation from others:

Three participants reported that they started using mHealth app after getting recommendations from others. To quote these two participants:

> My other lab members are using this app and they were highly recommending this. So after such recommendation, I thought maybe I can give it a try. – P7

> If you are talking to a friend and he or she is using something and if that is benefiting that person, then I'd say a "word of mouth" [and I will use it]. – P19

> I remember there was a big promotion for it [NikeFit] and a lot of my friends used it. So that's how I heard about NikeFit [which I am currently using] – P21.

User Interface:

Participant 3 chose MyFitnessPal since she liked the user interface. According to her:

> I start using MyFitnessPal since I want to start from somewhere. I did not waste too much time doing research. There were dozens of apps and I opened two or three of them. I liked it since the UI (User Interface) was very clean. I like the color blue. I wanted to start from somewhere. So how does it matter? Let's start with it. – P3

Curiosity:

Participant 19 reported that he did not have any intention to use any mHealth app first. He became curious when he first discovered Apple Health while exploring the features of his newly bought iPhone. According to him,

> When I got the phone, I was looking what other features that iOS has and that's how I knew this one had this health app. So that's why I was curious about it. – P19

Multiple techniques:

Four participants (P4, P7, P19, and P21) applied multiple techniques to finalize their mHealth apps. According to participant 4 and participant 7,

> First, I look for the rating. If I heard something about this app from my friends then I use them. After a while, if the feature works fine, I continue using that. Otherwise, I delete that and choose another one. – P4

> I researched by myself and I really spent few days reading reviews which have been good. Then I tried to install myself 1 or 2 apps. And then I use it for few days and said I didn't need to use it on my phone. P7

4.1.6 **Social Aspects of App Use**

The final study participants were asked about the social circles they involved while using mHealth apps (questions 11 to 13 of the final study). Based on their responses, it is evident that social aspects may play an important role to use mHealth apps. For instance, participant 3 advised her friends and family members to eat a healthy diet. According to her,

> Because I am logging my calories, I have a better idea of which food contains how much bad stuff like oil, sugar, something like that. So when I see them (my friends) eating fries, I say do not eat fried because it has all the bad food. So it helps them too. I tell my mom that okay, do not eat so many sweets because they are all rich in sugar. It is bad for you. It has 200 calories. I keep bugging her all the time… I keep giving advice to all my friends like this food is good. They actually call me nutritionist. - P3

Participant 7 reported how she helped her friends to keep them healthy.

> I also try to motivate people to eat healthily, eat vegetables, use less oil. Everybody knows [that] I am really concerned about this thing. So they named me "nutrition apa" [nutrition sister]. – P7

Participant 10 explicitly uttered the importance of social aspects to become healthy. According to him,

> When you do not have friends who exercise, you're not going to exercise. – P10

Talk to others about mHealth App use:

Sources of Talk about App Use	**N**	**%**
Friends	15	62.5
Family members	13	54.2
Colleagues	3	12.5
No one	3	12.5

Table 31: Sources of Talk about App Use.

Participants were also asked about the people to whom they talked with (e.g., shared opinions about an app) about their mHealth apps (question 11 of the final study). Although three participants never talked with anyone about their mHealth apps, the remaining 21 participants identified three types of people in their social circle to whom they talked with about their mHealth apps: Friends, Family members, and Colleagues (some mentioned multiple sources). Table 31 shows that participants mainly talked with their friends (62.5%) and family members (54.2%). The following participants shared their experience in this regard:

> I told to my friend that I am using this app and this helps me to get familiar with the nutrition; how many calories I use every day. I talk to my friend and my family. - P4
>
> Yes, I talk to my friends about this app… I motivated my wife [to use this app]. Ha ha ha. – P8
>
> Yeah, sometimes [I talk about my app use]. If I know that people want to exercise more, I've recommended it to a few friends. They were intrigued by the idea that you get a lot of exercises done in 7minutes. – P9
>
> Every now and then, we used it with my mom to train, to motivate her to train for a 5k. So even though she's in a different area of Tennessee, we both used the MyFitnessPal so we could see each other's' times and distances and what not, just to make sure that we did run. – P10
>
> I have suggested it [the app]. I do not know how many people have used it but I have suggested it to family and friends. – P11
>
> I talk to my mother in Bangladesh. But she is not a tech person. I talk to her about

> many apps like blood pressure app, glucose and diabetes app. – P13
>
> Yes, I talk definitely to my family. When I got this one [app] first, I was very curious. I just told everyone how it works, how helpful this one if you try to use it. And definitely, when I am in the office, I talk to all of my friends about this app, the different features. I mean sharing the different thoughts about this app or something like that. – P19
>
> I talked to my couple of other friends [about my app use]. When I start posting this kind of things on my Facebook, some of them asked me what is this application, how you use it, is it free or not free, how we can use the application, this kind of simple questions. – P20

Participant 24 reported that he usually talked about his app use with others when someone explicitly asked about the app. He mentioned that,

> Yeah, if a person asks how to use these things [app features], I'll just share whatever I know about that [app]. – P24

As mentioned earlier, three participants (P5, P7, and P21) reported that they did not talk with anyone about their app use. To quote participant 5 and participant 21:

> I didn't talk to them [my friends]. Right now, I am using for my own. – P5
>
> I didn't tell anyone about it [Lose it app] because everyone pretty much knows about the app. Maybe not this app, but there are other apps do the same thing. Since it's been around there's no sense in telling anyone about it. I didn't tell any of my family members about it [the app]. I bet they know they exist. But I never felt the

need to tell them about it because it didn't seem like it would fit their needs or interest. – P21

Participant 7 reported that she did not talk with anyone about the app use but she would consider it for future. According to her,

> No, I didn't do it [sharing app information with others] because I was not fully satisfied [with this app]. But now since it is motivational, I can share with my family. – P7

Help from others:

The participants were also asked whether they sought help from anyone about using the mHealth apps they were using (question 12 and 13 of the final study). The coding of the final study transcripts revealed that most participants did not seek help from others and solve the issue by themselves. Table 32 shows that 50% of the participants never received any help from their social circles. Only 8 participants (33.3%) mentioned that they had

Sources of Help with App Use	N	%
No one	12	50%
Friends	8	33.3
Family members	3	12.5
Online	2	8.3
Colleagues	2	8.3

Table 32: Sources of Help with App Use.

received help from their friends with the use of mHealth apps. The following participants shared their experiences.

> If I have a problem with anything like that I just go online and look for a solution. - P1

> I'm just keep exploring by myself. – P5

> I usually just play around to figure it out. – P21

> I just see it online or Google if I can't find it. – P24

However, three participants (P3, P13, and P19) benefited from the help they received from others. To quote these three participants:

> One of my friends helped me in keeping the motivation because honestly, I was on a diet of junk food earlier. So when you switch from a diet of junk food to healthy food, it's really traumatic let's put it that way because your body is always revolting. Some friends pulled me through it. – P3

> Yeah, [I got information from] a lot of people in my office. I saw a lot of people using the steps, the stairs, and climb. I mean how many steps you climb or something like that. I find that a lot of people use that one. – P19

> I ask other people a lot. Like what app you're using, do you know a good app or not? – P13

Participant 9 reported that he got recommendations from others. However, he prefers to choose his app by himself. According to him,

> My wife sometimes recommends because she has some fitness tracking apps that measure how many steps you take in the day. I haven't really used this one… And she tries to get me to use them. I'm like no, it's okay. I'm good. – P9

Doctor's involvement:

The participants were also asked about the involvement of their doctors or healthcare professionals in their app use (questions 14 and 15 of the final study). 22 participants mentioned that they never involved their doctors in this regard. To quote some participants:

> We [my doctor and I] talked about my [physical] activity but we never check my phone to see how far I have gone. – P1

> No, not really. [I do not involve my doctor]. And the thing is I haven't visited the doctor too much in the past anyway. So that's probably part of the reasoning. I know when we did visit our doctor, back in Utah, they did have the recommendation to go a user online portal where we could communicate with the doctor, send e-mails or messages and make it respond to make it more interactive. My wife did use that, but I did designate to her that, you know, you take care of that. I never did it. – P9

> My doctor is retired and I haven't found a new one yet. So no [I don't involve my doctor]. If it did blood-pressure, absolutely, I would love that [share app data with my doctor]. – P10

> I went there [doctor's office] last week. It didn't come up. I didn't even think about it [app use]. – P11

> Before I went to China, I had to go to the doctor. So I did, but I didn't tell anyone about my apps. – P21

Only two participants (P3 and P7) reported that they involved their doctor in their app use. Here are some examples:

> Yeah, I did [involve my doctor]. They were happy. Let's put it that way. Actually, I went to the fitness assessment trainer and also the nutritionist. From them, I got a good feedback and accordingly I changed my goals and my act. They said that it's a good thing to do. – P3

> I want to be clear with my doctors. I share the overall summary [with the doctor]. – P7

4.1.7 **Perceived Health Benefits**

Participants had varying opinions about the health benefits they received by using mHealth apps. To understand the types of perceived health benefits, the following two questions were posed to each participant during the study (question 9 and 10 of the final study):

- Do you feel your health has improved after you started using this app?
- What, if any, is the evidence for that improvement? Could you please explain or share an example?

Two types of answers were collected from participants' responses to the first question. The first answer reflected users' opinion in a yes/no format followed by a discussion that explained a user's initial response. To summarize, 22 participants (91.7%) reported that their health has improved while 2 participants (8.3%) mentioned that their health was

improved marginally (see Table 33). None of the participants mentioned that their health was not improved or they experienced any negative health consequence by using the mHealth apps.

Was health improved?	**N**	**%**
Yes	22	91.7
Marginally	2	8.3
All	24	100

Table 33: Health Benefit of Participants.

Evidence of Health Benefit	**N**
Motivation to lead a healthier lifestyle	10
Better health management	14
Increased health awareness	9
Lifestyle change	8
Increased energy level	3
Gained more health knowledge	2

Table 34: Evidence of Health Benefits.

Six different general categories of evidence of health benefits were identified from participants' responses to the second question, as listed in Table 34. Some participants cited more than one type of health benefits of using mHealth apps. These evidence of health benefits are discussed below.

Motivation to lead a healthier lifestyle:

Ten participants reported that use of mHealth apps directly motivated them to lead a healthier lifestyle (e.g., monitoring health conditions, being more cautious in food habits, actively trying to achieve health goals, taking stairs instead of an elevator, walking a certain distance, and maintaining or losing weight, etc.). Participants felt that regular use of mHealth apps are motivating them to make healthier choices in everyday situations. For example, one participant talked about how she parked her car further away in the parking lot after she started using the app. Even when there was a lack of any physical evidence (e.g., no change in weight despite being physically more active), participants believed that their health and lifestyle improved. To quote three participants:

> This app motivates me to use less fat and eat healthier food. – P4
>
> I actually did notice a difference, just in my physical well-being. Because at the time I downloaded it [the app], I wasn't as physically active. This [app] helps to become more physically active, just maintain strength and good health. So it did help. – P9
>
> I was like a ship without a sailor! When I do pushups, after pushups I can't do pull-ups. [Now, as app suggested], first I will do pull-ups then I'll do pushups. Because once I do pushups all my energy is gone from the shoulders. So that was the difference that Sworkit [the app] helped me out. I just followed it [the app] and I found it is perfect. – P23

Better health management:

Fourteen participants mentioned that mHealth apps helped to manage various aspects of their health in a better way. They primarily reported four types of health management with the help of apps: Observing an improvement in weight management (N=7), Improvement in sleep quality (N=3), Better stress management (N=2), and Better blood-pressure management (N=2). To quote some participants:

> I lost 48 pounds. I couldn't even climb one flight of stairs. I would breathe like a dying whale. Now I can run. So I think that's a big improvement. Whoever asks me, I say that 90% of the credit goes to these apps. – P3
>
> Previous I slept at midnight or at 12:30 am. But [now after started using the app], I try to sleep early like 11 pm or 11:30 pm. – P6
>
> My blood pressure was pre-hypertension. Now, it stays in the normal range. – P11
>
> [After started using the app] My blood pressure becomes normal, the heart rate becomes better than before, and [bad] cholesterol level goes lower. – P13
>
> I did not gain that much [weight] but I did not lose that much either. I stayed pretty much where I was actually. – P19

Increased health awareness:

Nine participants started being more aware of their health conditions after they started using the apps. As one of the common features provided by the mHealth apps is information dashboard, participants had easy access to their overall health condition as well as specific information of interest. For example, participants interested in weight

management could access their history of weight, any trend in weight gain or loss, relationship with other factors contributing to weight gain (loss), etc. Overall such detailed information made users more aware of their own health state and motivated them to take steps in improving their health. The increase in health awareness also led to an active lifestyle, better eating habits, and regularity in exercise. To quote two participants (P1 and P8):

> I am more aware. I am probably a little bit more active. – P1

> Definitely [MOVES app] increased my awareness. – P8

Participant 14 was pregnant during the interview and shared an interesting anecdote. Before getting pregnant, she was very confident and relaxed. However, during her pregnancy, she started using a pregnancy-related app (Ovia Pregnancy Tracker). She also used WebMD for getting health-related information. She became more cautious after starting to use these two apps, and the knowledge regarding potential bad outcomes for her baby made her scared and nervous.

Lifestyle change:

Eight participants reported noticing a change in their lifestyle after they started using mHealth apps. For example, participants mentioned being more physically active (N=3) and giving more attention to what they are eating (N=5) after starting to use these apps. To quote participant 24:

> In the last six months, I have been doing jogging every day. I lost a little weight and I feel so happy to going out and walking other than sitting at home. It just relieves me

> from my mental stress. [Earlier] when I tried to jog or when I climbed a lot of steps like six or seven floors, I got a little respiration problem. But I don't get it now because my heart used to run faster than before. – P24

Often the health benefits the participants received are intertwined. For example, when participants became more aware of their health conditions they started to actively change their lifestyle, which resulted in improved health. Even when health awareness, monitoring and changed lifestyle did not result in concrete physical evidence, it offered a sense of self-belief. The following two quotes exemplify these perceived benefits.

> I didn't lose ten pounds. But I am more conscious of what I eat. So little by little it is going to affect my health. – P21

> Now [after started using the app] I am conscious of taking more walk daily. So it is self-realization that I should take more walk. – P7

Increased energy level:

Three participants (P9, P10, and P23) reported that their physical energy level increased after using mHealth apps. For instance, participant 7 mentioned that the 7-minute workout app helped him to become more physically active. According to him,

> I actually did notice a difference just in my physical well-being, because at the time I downloaded it ["7 minute workout" app], I was not as physically active. So this helps [me to] become more physically active, just maintain strength and a good health. So it did help which is probably why I think I should get back to using it more often. – P9

When participant 9 and participant 10 were asked whether they felt more energetic after using their mHealth apps, they replied:

> Oh yeah, Oh yeah. – P9

> Oh yeah, absolutely. – P10

Participant 23 was not able to complete his workout before using the mHealth apps. After starting to use the mHealth app, he changed his workout order, which helped him tremendously to conserve his physical energy to complete his workout. According to him,

> The app helped me to retain some energy. I just followed it and I found it perfect. – P23

Gained more health knowledge:

Two participants (P4 and P14) reported that their knowledge about their health improved after using mHealth apps. Participant 14, who was pregnant while the interview was conducted, shared her experience on how an mHealth app improved her knowledge about pregnancy.

> It [the app] tells you about risks. It gives you things that can possibly happen. Before I had started the app, I did not know anything about SIDS (Sudden Infant Death Syndrome). But there was an article on the app [which] explains SIDS. It made me paranoid during my first pregnancy. It gave me a lot of the tips to make sure that my baby is on his back to sleep. I just read about pertussis and how it's rising in the US more than last year. Now I'm telling my husband, 'You need to get the pertussis vaccine.' My mom, she went and got it, because you know you get a new baby and it

> tells you it's severe in infants, and if the infant catches it, it's hard for them to get rid of it. I wouldn't have known about that if it wasn't for the app. That's not anything that your doctor really just tells you or that you can just go to the Internet and find unless you're basically searching for it. But the app, it gives you like, topics and stuff. Like, that you wouldn't normally see so. – P14

Participant 4 mentioned that MyFitnessPal helped her to gain more knowledge about nutrition. To quote her:

> Now I know many things about nutrition. This is a very good experience for me. – P4

4.1.8 **Additional Findings**

While participants were discussing their apps with the interviewer, six of them (P3, P4, P5, P19, P20, and P21) admitted that they did not use many features available in their apps. They were using these mHealth apps to meet their specific health needs and goals, however, they seemed uninterested in learning about other features offered by the apps. All of these participants were aware that the apps they were using offered additional services, but chose to ignore them for various reasons (e.g., confusion, lack of need, and lack of trust). To quote these three participants:

> This is the first time I saw the pie chart in this app when I was showing you. – P3

> Maybe it has this feature [differentiation between regular sugar and fruit sugar] but I don't know anything about this. – P4

> I didn't use all the features of this app. - P21

Three participants (P5, P19, and P20) also showed a lack of awareness about their mHealth apps. To quote these three participants:

> I don't know why this [app] is giving the light. It's confusing to me. – P5
>
> I don't know [if an app collects user information if GPS is off]. I haven't checked that so I might explore that. – P19
>
> I don't know how it [the app] works [to use Wi-Fi] but I have to be connected to the internet. – P20

Participant 10 used an mHealth app to track his sleep. He was unsure about the difference between deep sleep and shallow sleep. However, even with such confusion, he found the app useful as it helped him to sleep better.

4.1.9 **Summary**

In summary, this section discusses the findings regarding the mHealth technology used by the final study participants. The participants used 31 mHealth apps. All of these mHealth apps belong to one of the five categories such as Activity tracker, Calorie Counter, Physical and Mental Exercise, Physiological Data Monitoring, and Health Information Repository. No participant used any mHealth apps for managing any health issues of a more technical medical nature (e.g., high blood pressure, diabetes, and cancer). Among these 31 apps, MyFitnessPal and Apple Health were the two most widely used mHealth apps among study participants. Occasionally participants discontinued using a particular app in favor of a different app (Misfit over MyFitnessPal) or due to changing their phone (some apps only work on a specific platform). However, none of them seemed to abandon mHealth apps.

The only instance where one participant stopped using mHealth apps was because she no longer needed them (she used pregnancy-support apps). However, she continued using other apps that were appropriate after her pregnancy (baby-centered apps).

All apps were running either in an iOS-based smartphone (54.2%) or an Android-based smartphone (45.8%).

Participants utilized two types of information source to collect information about their mHealth apps: (1) human sources (e.g. friends, colleagues, and word of mouth) and (2) non-human sources (Internet, app store, insurance company, magazines, and app-specific promotions).

Participants became motivated to start using mHealth apps for three reasons: to improve their health, to track their health condition, and to acquire health-related knowledge.

Participants also discussed the selection process they adopted to choose their mHealth apps. Six participants selected their apps based on app rating (e.g., user reviews about the app, number of downloads, and star-rating) while two participants adopted trial and error technique before finalizing their mHealth apps. For some participants, a recommendation from others (N=3), the aesthetically pleasing user interface of the app (N=1), or user's curious nature helped to finalize choice of an mHealth app (N=1). Two participants applied multiple techniques to finalize their mHealth app. All participants reported that their health was improved significantly or marginally after using mHealth apps.

Some of these findings regarding mHealth technology have a relationship with mHealth literacy requirements, the central research question of this dissertation. Such relationship will be discussed in detail in section 5.3.

4.2 S-Health: The mHealth App Showed to the Participants

The previous section discussed that the final study participants used 31 mHealth apps in total. Although two apps (MyFitnessPal and Apple Health) were used by multiple participants, there was no such app which was used by all 24 participants. This lack of a common app experienced by all participants made it difficult to get a baseline understanding of mHealth literacy requirements more accurately. To achieve this goal, during each interview, the interviewer walked each participant through an mHealth app called "S-Health" (see Figure 15). The interviewer first gave an introduction about S-Health and then showed all the features of this app. Then the interviewer answered all the questions asked by the participants related to this app. Below is a brief introduction provided by the interviewer to each participant about S-Health before starting the walk-through.

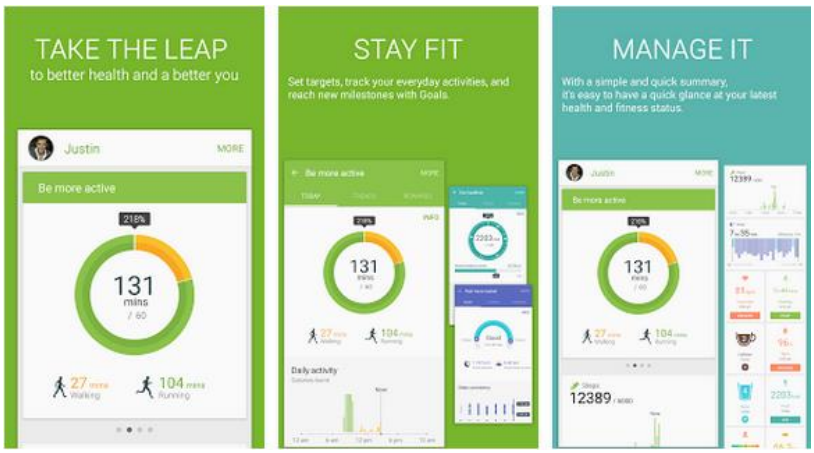

Figure 15: Sample screenshot of S-Health app

> This app comes with Samsung [smartphone]. It is called S-Health[14]. It tracks your movement. You don't have to install this app. It automatically comes with the smartphone. [It shows] how many calories I burned and how much distance I moved. It also shows the treadmill walking, running, and up and down. There is a food tracker, what kind of food you consumed and how many calories you consumed. Exercise mate is a feature which shows how many calories I burned and what all exercises I did. The weight feature tracks weight. The "surroundings" feature is based on your surroundings, especially the humidity and the temperature. – Interviewer

4.2.1 Difference between S-Health and mHealth Apps used by Participants

After walking through the S-Health app, the interviewer asked the following question (question 21 of the final study) to all participants: what are the major differences you have found between these two apps (S-Health and the app you are using)? Participant 2 did not find any significant differences. To quote him:

> They [Google Fit and S-Health] look similar. – P2

According to participant 1, she did not get enough time to successfully compare these two apps. However, she liked the different functionalities provided by S-Health. To quote her:

> This [S-Health] has got a lot of what I have got three apps doing and it's all in one app, so that's nice. You've got exercise monitoring and food tracking. That would be a plus.

[14] https://play.google.com/store/apps/details?id=com.sec.android.app.shealth&hl=en

> I can't think of anything negative. I would have to use it for a couple of weeks but overall it looks like it would be pretty good. – P1

According to five participants (P6, P7, P11, P13, and P21), S-Health was better in terms of functionality compared to the mHealth apps they were using. To quote these participants:

> The app you were showing [S-Health] has many features. Many things I can track, not only sleep. Like how many calories I'm burning and how many steps I'm walking. Apple Health does not provide that. Apple Health just keeps the record, keeps the history. Also, the other part was how you are feeling. The temperature and humidity, that's the other thing [I like about S-Health]. – P6

> One feature [of S-Health I like] is the calorie burned from the step count. The second one is meal consumption and the calorie input per day. I really like that function. And the third point is weight tracking. I normally go to our lab center during the walk and measure my weight. I take two to three times per week. That's [S-Health] a good app for me. If I take the steps, the meal, and the weight that almost is an ideal condition for me. – P7

> You don't have to start this [S-Health] and [it] always goes. It monitors everything. I like the comfort level. I like the fact that if you want to go to another area of health like watching your meals, you won't have to go for another app. It is already there… It shows more in depth with your health, with your exercise, with your meals, and even with your comfort level. I like that. It is kind of covering different aspects of your life on your phone. – P11

> I like that walking mate and comfortability [features of S-Health]. Those two main features attracted me. So if I am burning [calories] by walking and if I see I can walk more, I will just take another walk and just burn more calories. – P13

> "Lose It" [the mHealth I use] focuses more on the food you're eating and nutrition, whereas it [S-Health] does track exercise but it doesn't give as many options within them. So, I feel like "Lose It" is just more basic whereas these [Apple Health and S-Health] are specialized under each category. There are more options. You can track even your vitamins and minerals. I think that's a major difference because it's more holistic as far as your sleep patterns. This [S-health] has your comfort level. So, it offers more features. I think the way S-Health is designed is the most user-friendly and it feels the most natural. Because you have your home screen and then you have your sidebar which is a consistent bar you can go to and click to. I think that's one of my favorite parts of it. Then I like the home screen. I like that and then it shows you your weight at the bottom. Whereas it seems like on the Apple Health, that dashboard is so boring. That's not helpful. – P21

Participant 7 also found that the app she was using [Moves] took more information from the users compared to the information collected by S-Health from the users. To quote her:

> I think I need an app like this [S-Health] that tracks my weight too. I also use one app for weight tracking but they take too much information. – P7

Participant 9 preferred S-Health since it was easy to use. According to him,

> This one [S-Health] runs in the background. For these ones [7 minute workout and WebMD], you have to actually go and seek them out right. This one [S-Health] might

be obviously much easier to use since it's in the background and always running. Whereas these other ones you have to remember to use them, you have to go out of your way, I think that's the biggest difference. – P9

Four participants (P4, P5, P7, and P19) liked the interface of S-Health. To quote these participants:

It [S-Health] is more colorful. The diagram for every day and every month was interesting. – P4

S-Health seems better and user-friendly. – P5

The visualization is good. I like it. The color contrast is also good. Very soothing and refreshing. – P7

It [S-Health] is very clear. You can see how many steps you walked what's the distance you covered and how many calories [you burned]. It's not like in iPhone you have to dig it. It's visually more helpful. It is easy to see what you are doing and then you have the option to look at it by each day. I like this one, the calories for each food. It definitely helps. If you are concerned about your diets, it will make sure you're having the proper diet. The comfort level [a feature of S-Health] is neat. I like it. It is a good app. Compared to Apple Health, it [S-Health] is much better. It's not asking for your blood works. It tracks your food intake, your exercise, your surroundings, and exercise levels. These are the things I will appreciate. It's not like you are collecting your information which you are not comfortable to share with other people. I like it [S-Health]. – P19

However, Participant 3 believed that her app [MyFitnessPal] was better than S-Health. To quote her:

> I like barcode scanner [of MyFitnessPal]. For me, it's very convenient. I don't need to enter anything. It [MyFitnessPal] is easy for me. If it gets the work done and if you are comfortable with it then I think it is fine. – P3

4.2.2 **Challenges to Use S-Health**

The interviewer also asked the following question (question 22 of the final study) to the users: what would be the biggest challenge in using or learning how to use this new app (S-health)? Participants 9 and 13 did not find any particular challenge to use S-Health. To quote these two participants:

> There is no challenge to use this one [S-Health]. If people are using a smartphone in general, I think they would be able to figure it out. And there's nothing really to input much. It is just running in the background they can just check it every once in a while just like they would check any other notification that comes on their phone. – P9

> So far I don't see that much [challenge]. It's pretty easy at a glance. I don't see that much challenge. – P13

However, participant 13 changed his opinion later and pointed out that S-Health might require some initial learning curve. To quote this participant:

> It will take a little while to understand. As you said. Just start the machine and start counting your steps. Maybe other features when you go through, that'll be the learning process. Especially the food tracker and exercise mate. Walking mate is

> fine. The comfortable level is fine. But food tracker, a little bit you have to. I didn't understand what the app was doing. Now I do. Trying the food, taking the calories, then you're burning the calories, it balances out. – P13

Participant 2 thought that S-Health provided too much information which might have an adverse effect for the user. According to him,

> I also think there's a danger in showing most people too many data… This breakdown right here [one feature in S-Health], that is too much information. Why do I care that I've been up and down for I can't even tell how many steps at the bottom of that graph. You get a glimpse but do I really care that I went up and down steps for a little bit? – P2

Participant 11 was skeptical whether users would be able to find the app by themselves since it is automatically installed by Android and always runs in the background. According to her,

> How do you know that it [S-Health] is on your phone? I could have it on my phone and I don't know it. - P11

Participant 7 was skeptical about the calculation process S-Health utilized to convert from step count to calorie. According to her, since people's body structure are different from each other, the same calculation process for each person may give inaccurate information. Moreover, she was concerned about the accuracy of this app since it does not consider the whole body movement of the user. To quote participant 7:

> I don’t like the accuracy about the calorie burnt [measured in S-Health app]. Your step and my step is not similar. How are they calculating the calorie? I am concerned about that. So is it just believe in it? I may want to know. It may be in your pocket. It doesn’t capture the whole body movement. I don’t how many calories they burnt. – P7

Four participants (P10, P16, P19, and P22) were concerned about the time S-Health required to be started. According to them,

> I think my app [Misfit] starts up a little faster, even on my old phone. – P10

> [S-Health is] very slow. – P16

> I think it [S-Health] is a little bit slow. – P19

> It [S-Health] is little slow. – P22

Participant 16 also complained that the interface of S-Health is not intuitive. To quote this participant:

> I think this is not very intuitive. The first thing is, it doesn't tell you what to start and how to start. The second thing is, it seems to me, there is a profile setup and maybe you are setting a target. [But], it is not easy to find… The other thing is, what is walking mate? How should I use it? What is the purpose to use it? So I think it's not very intuitive… For the first time user, it's going to be confusing but eventually probably they may catch up. – P16

4.2.3 **Summary**

All participants were also shown an mHealth app (S-Health) by the interviewer during each part of the interview. Participants highlighted the features that they liked and disliked and

challenges they would face in using S-health. Participants admired the aesthetically pleasing S-Health interface, availability of multiple features including the "comfort level" feature and barcode scanner for food tracking, S-Health's operating process (always runs in the background without interrupting the user), and conversation and presentation of needed information (the way S-Health calculates calories spent from step-count). Although two participants did not consider using S-Health would present any challenge, other participants expressed concerns about S-Health use. These concerns included but were not limited to the response time of S-Health (participants considered it slow), higher learning curve (new users may require to put an extra effort in the initial phases to learn how to best use S-Health), and information overload (participants considered S-Health provided too much information to users). In addition, some participants thought it may be difficult to locate this app in the smartphone since it comes pre-installed and always runs in the background. While the majority of the participants preferred the step count to calorie conversion, a few participants were skeptical about the accuracy of the conversion process. Although participants were using their mHealth apps for a longer period of time, several of them admitted that they were unaware of many features available in their apps.

No direct relationship was found between the findings of this section and the mHealth literacy requirements, the central research question of this dissertation. However, as mentioned earlier, there was no such app which was used by all 24 participants. Hence, to get a baseline understanding of mHealth literacy requirements more accurately, during each interview, the interviewer walked each participant through a common mHealth app

(S-Health). Hence, the findings of this section are crucial even though those are not directly related to the central research question of this dissertation.

Chapter 5 mHealth Literacy Requirements

Chapter 5 reports findings related to mHealth literacy requirements. Final study participants were asked about the skill required to use mHealth apps (questions 23 to 26 of the final study). Their responses were coded using the coding methods discussed in chapter 3. The coding helped to identify two different sets of requirements to achieve mHealth literacy: (a) Requirements for mHealth app users and (b) Requirements for mHealth app developers. This chapter discusses these two categories of requirements in detail. This chapter also discusses how some of the skills are influenced by the participants' backgrounds, current life experiences, and mHealth technology they have used.

5.1 Requirements for mHealth App User

The coding of the final study transcripts and field notes indicated that mHealth app users should have 15 skills. These 15 skills are: Smartphone Literacy, App Literacy, English Literacy, Numeracy, App-centric Health Literacy, Information Literacy, Graph Literacy, Computer Literacy, and Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary.

5.1.1 **Smartphone Literacy**

All participants (N=24) considered two skills as requisite skills to use mHealth apps: Smartphone Literacy and App Literacy. As discussed in chapter 2, according to Rosen (2015), Smartphone Literacy entails two groups of skills: basic skills (e.g., how to turn a smartphone on) and advanced skills (e.g., how to make a smartphone do what a user wants

it to do). The coding of the final study transcripts and field notes revealed that participants cited some of the technical skills mentioned by Rosen. These skills are:

- How to turn a smartphone on
- How to unlock a smartphone
- How to use a touch screen
- How to navigate different features of a smartphone
- How to charge the device
- How to replace the battery

According to some participants, mHealth app users in specific demographic categories (e.g., senior citizens, first-time smartphone users, and users who do not have English Literacy) may experience fear while using a smartphone. The reasoning is that people from these demographic categories may perceive that they do not possess the skills required to successfully use a smartphone. Some users, in addition, may have fear of "breaking" something while using a smartphone. According to participant 13, getting rid of such fear is crucial and should be considered a part of Smartphone Literacy:

> First of all, you have to take care of the fear that I can't [use a smartphone]. – P13

5.1.2 **App Literacy**

The coding and analysis of the final study transcripts and field notes revealed that App Literacy was also considered a required skill by all 24 participants. App Literacy is especially crucial for those users who are using mHealth apps for managing health issues of

a more technical medical nature (e.g., high blood pressure, diabetes, and cancer). Lack of such literacy may cause serious health risks for those users. Participant 12 explained this:

> For diabetes or any other diseases where there is any health issue or risk, I would make sure that they [apps] are secure and they [users] understand the apps before using it to keep track of their things. – P12

Number	Skills required for App Literacy
1.	Knowledge about availability of mHealth apps
2.	Knowledge about the app installation process
3.	Knowledge about the app store
4.	Knowledge about app activation, rediscovering, starting, exiting, and the input process
5.	Knowledge about the app buying process
6.	Knowledge about app data
7.	Knowledge about app features and instructions
8.	Knowledge about an app's negative impact

Table 35: Skills Required for App Literacy

Analysis of the final study transcripts and field notes also identified the set of skills that constitutes App Literacy. Table 35 summarizes these required skills.

1. *Knowledge about the availability of mHealth apps*: Users who use smartphones predominantly for making phone calls or texting messages may simply not be aware of mHealth apps. According to participant 11,

They [users] need to know they [apps] are out there. They need to know they are available. – P11

2. *Knowledge about the app installation process*: mHealth apps might be preinstalled (e.g., S-Health for Android and Apple Health for iOS) or might need to be downloaded before installation. A user should be able to find the app on his or her smartphone if it is preinstalled. Otherwise, s/he should know how to download and install needed mHealth apps.
3. *Knowledge about the app store*: All smartphone apps including mHealth apps are typically available for download and installation through distribution platforms such as Apple's App Store, Google's Play, Microsoft's Windows Phone Store, and Blackberry's App World. mHealth app users should know:
    - How to go to an app store.
    - How to search for an app in an app store.
    - How to find the right app.
    - How to select the best app in case multiple high-quality apps are available. This could entail trying several apps before finalizing their selection. According to participant 2,

      You have to try several of them [mHealth apps] to see what works for you. There are lots of apps for a reason. Everybody looks at the problem in a different way. – P2

4. *Knowledge about app activation, rediscovering, starting, exiting, and the input process*: An activation process involving registration and the creation of a username and

password may be required for some mHealth apps. After downloading and installing it, a user should be able to activate the app. An app might be hidden from a user's smartphone for several reasons, such as unintentional uninstallation or deletion from the home screen. mHealth app users should know how to find an installed app in a smartphone if it is missing. mHealth app users should also be comfortable with starting and exiting from an app. Many apps do not require explicit start command and always runs in the background or whenever the phone is on. Users need to know how to exit from such apps. At the same time, users need to know if they have to actively start an app to work it properly (e.g., tracking step counts). Based on the app's requirements, mHealth app users should be able to provide input via a touchscreen-based keyboard. This may seem trivial for some users. However, participant 7 observed that her mother had difficulties doing this:

> If I give input and show her [my mother] the result, she will understand; but how to give input, that is the most difficult for her. – P7

5. *Knowledge about the app buying process:* Although mHealth app users prefer free apps, they are willing to pay for apps if they consider them useful. Participant 13 shared her personal experience in this regard:

> I go through and look at the different apps and I like the free ones…. Maybe one or two dollars are OK but sometimes apps can be pretty expensive. – P13

If users decide to buy mHealth apps, they should be familiar with the payment process.

6. *Knowledge about app data:* mHealth apps provide health-related data in different ways. For instance, an app may show results in a concise manner to help users to get a holistic

view. Hence, mHealth app users should know how to get final results and summary. According to participant 7, many users struggle with such skill.

> But how to get that [final] summary, that is a difficult task. – P7

In addition, knowing how to get summarized data is important but not sufficient. mHealth app users should have the ability to correctly interpret the results and act accordingly. Participant 11 shared her experience:

> You have to know what it means when you want to know the results. I didn't know what Kcal meant. I was looking at my result, but I don't know what it means. I had 80 Kcal [and 1018 total calories], I don't know what it means and what "1018 total calories" mean. I don't know the difference…. I thought a calorie is a calorie. – P11

Since mHealth apps store data either in smartphones or in the clouds, final study participants agreed that mHealth app users should know how to find data and share it with others such as doctors, family members, and friends if needed.

7. *Knowledge about app features and instructions:* A majority of mHealth apps share some typical features (e.g., menu bar, scroll bar). However, some apps may include atypical features (e.g., barcode reader or camera for inputting data). Participant 2 implied that understanding both common and unique features of mHealth apps is important. He found that some common features were very cumbersome to use and hence suggested switching to alternate features:

> Adding calories to MyFitnessPal, that's more complicated. You really have to use the camera or punch the numbers. I use barcode reader. – P2

mHealth apps usually come up with instructions and guidelines (e.g. manual, audio tutorial, and video tutorial). Users should be able to follow those instructions.

> Some mHealth apps need to be synced up with particular devices (e.g., the Fitbit app with the Fitbit device). The syncing process is potentially very tedious, cumbersome, and error-prone. Hence, some participants pointed out that users should be comfortable with the synchronization process.

8. *Knowledge about an app's negative impact:* Some mHealth apps may have a negative impact on smartphones (e.g., higher memory consumption, lower processing speed, and higher power depletion). Any such negative consequences may discourage users to continue using mHealth apps in general. Hence, users should be fully aware of such impacts. Participant 13 described its importance:

> There are so many apps. [You should know] if the app is harmful to your phone or not. They [apps] might take space of your memory, slow you down, keep feeding ads. So you need some reliable company name that you can trust, who sold the app. My insurance company is United Healthcare and I can download their app. I know they will not drag me down or they will not take more space. But for blood pressure monitor, you have to take a risk [to use the app). – P13

5.1.3 **English Literacy**

The coding and analysis of the final study transcripts and field notes reflected that the need for English Literacy was mentioned by all 24 participants during interviews. However, the participants expressed three different opinions regarding its importance: (a) English Literacy is a required skill (N=14), (b) English Literacy is required if the mHealth app is not

available in users' native/local languages (N=9), and (c) English Literacy is optional (N=1) (see Table 36).

English Literacy	**N**	**%**
Required	14	58.3
Required if app is not available in user's local language	9	37.5
Optional	1	4.2
All	24	100

Table 36: Requirement of English Literacy for using mHealth Apps

1. **English Literacy is a required skill**: A majority of the mHealth apps are available in English only. Hence, 14 participants (58.3%) considered English Literacy as an absolute necessity for the successful use of mHealth apps. Some comments from the participants are worth mentioning here:

> Of course, understanding basic English is very important. All apps are in English. – P3
>
> Somehow [knowing English] is mandatory. Because if you need more information, what does it mean? If you need to go back to the Internet to find out, you must have some documentation in [native] language and the quantity [of documentation in a language other than English] is not enough. There are few [documents in other than the English language] but English is the ocean [in terms of availability of documents]. – P7

> If the smartphone is in English, they [users] will have to have some English knowledge. Most user interfaces of the phone and the system itself may be in the native language, but lots of the apps are not [in the user's native language]. – P9

Participant 12 explained the importance of English Literacy from a different perspective. According to her, lack of English knowledge poses a potentially serious health concern:

> If you have someone who has trouble reading or doesn't know the language well, and they are trying to utilize apps for health benefit, it would get me little nervous because I would not want them to misread and misunderstand their results. If it is something that was like medically not "life or death" but you know "their health is in the balance," it would get me nervous. – P12

Furthermore, the participants differed in terms of the required level of English Literacy. Participant 1 contended that "4th grade English knowledge" would suffice while participant 2 was advocating for advanced English knowledge:

> You should present everything at a 4th-grade level. I was in the newspaper business and I was required to write everything considering the 4th-grade level readers. It means elementary school. – P1

> For MyFitnessPal app, if you are not capable of understanding lots of complicated English words, you will have a problem. – P2

2. **English Literacy is required if the app is not available in user's local language**: Some mHealth apps are available in multiple languages. In light of this, nine participants (37.5%) argued that users would be able to use mHealth apps without

knowing English if those apps are available in users' native languages. According to participant 5:

> If the number is in local language then anyone will love it. They will think that that is their own property. Obviously, the mother tongue will be the first preference. – P5

(C) **English Literacy is optional**: Participant 10 made an interesting observation regarding the importance of English Literacy with regard to mHealth apps. He had been using a smartphone for 11 years and an mHealth app for three and was one of the most experienced and frequent mHealth app users among the 24 participants. He believed that users may experience difficulty in using an mHealth app without adequate English Literacy. However, he also believed that mHealth apps with excellent graphical interfaces have the potential to reduce or eliminate this dependency on English Literacy. This observation led him to believe that English Literacy was an optional skill provided the app contains an intuitive graphical representation of information. To quote P10,

> It is much more difficult if the app is not in your language…. [However], I think it [a need for English Literacy] depends on the app. A lot of them have a graphical display. Misfit [an mHealth app] just shows a dial, even if you can't read the numbers, you know you get a certain percentage and you can tell how it is supposed to go all around. So I have not done all the exercise today. You might not get exactly what you might want to get but you understand some information. – P10

5.1.4 **Numeracy**

The coding and analysis of the final study transcripts and field notes indicated that 12 participants (50%) considered Numeracy as being of the utmost importance, whereas the

other 12 (50%) did not have any comment on it (see Table 37). Many mHealth apps provide results and summary using numerical values and understanding these numbers are imperative for successful app use. Participant 12 noted:

> I have not thought about that [Numeracy] before, but yeah, [you have to understand numbers]. – P12

Numeracy	**N**	**%**
Required	12	50
Not reported or mentioned	12	50
All	24	100

Table 37: Requirement of Numeracy for using mHealth Apps

To explain the importance of Numeracy, participant 8 focused on data interpretation. He contended that it is very important for mHealth app users to interpret numerical data correctly and act accordingly. According to him:

> Data interpretation is very important. S-health [an mHealth app for Android] is showing some trends. Apple Health [an mHealth app for iOS] is showing [trends] in another way. They are representing something. For instance, "all-time record" [a feature of the app], what does it mean? At first, it may not make sense to them…. Some of the new features of the new apps are self-explanatory, some of them are not. I think they [users] should understand this difference. – P8

5.1.5 **App-Centric Health Literacy**

App-Centric Health Literacy	N	%
Required	22	91.7
Not reported or mentioned	2	8.3
All	24	100

Table 38: Requirement of App-centric Health Literacy for using mHealth Apps

The coding and analysis of the final study transcripts and field notes found that 22 out of 24 participants (91.7%) considered App-centric Health Literacy to be a required skill (see Table 38). Different apps focus on different health aspects (e.g., activity tracking, stress management) and as a result, contain features that are only related to the respective health problem. In addition, apps that focus on addressing same or similar health problems may focus on different strategies and as such can have very different functionality and look and feel. As a result, the participants believed that experience with one mHealth app may not be sufficient for successful use of another mHealth app. For example, an experienced user of diabetes management app may find it challenging to use a stress management app. Some participants noted:

> [If they use food related app], from nutritional point of view, they should understand calorie; how calorie-burning and calorie consumption affect weight loss and why do they need to do it, how much carbohydrate, protein, all from dietitian point of view. – P3

> For a diabetic patient, she must maintain a level of diabetes and must maintain a food chart; which food contributes the higher sugar level, that knowledge is very important. – P7

> I didn't know that a person actually sleeps in cycles. And there is a better way to wake up. Rather than putting the alarm and wishing for the best, there is a smart alarm that can help you to wake up gradually instead of the middle of your sleep cycle. If people don't know about that, they won't even look for the app and use it. They have to know about this sort of phenomenon. I talked to some people about this sleep app, they said, oh really? They don't understand how a person sleeps. – P9

> I think it is important to understand what those terms [health related] mean. Understand where you are in terms of the level of your health. What is your BMI and what [it] is supposed to be. If you don't understand what it is, then you don't know what to be. What is my BMI; I think the knowledge of this is important. – P11

> I just see the measurement but I don't know what it means. So it is good to have the knowledge of what it is, but if you don't know what calories are, how can you use it? – P11

The coding and analysis of the final study transcripts and field notes identified a number of skills to achieve App-centric Health Literacy:

1. mHealth app users should be aware of their health-related goals. Participant 7 said:

> First, we should know the goal [related to health]. – P7

2. After choosing an mHealth app, a user should be able to understand whether the chosen app is helping towards achieving his or her health-related goal. Participant 7 and 8 expressed their views in this regard:

> She also needs to understand whether it [the app] really communicates well with her body need and food chart. – P7

> [A user needs to understand] what is the critical threshold and how step count can help to reduce it below the critical level. – P8

3. A typical mHealth app user might not be able to take the correct action after viewing the mHealth app results. For instance, if an app keeps a log of a user's blood pressure readings and shows a set of non-typical results, the user might not be able to take the right action based on the results she or he observed. Hence, a user should consult a doctor urgently. In summary, a user should know when it is time to make necessary decisions such as visiting a doctor, which was described by participant 6.

> She should know when she should talk to the doctor. – P6

4. mHealth apps typically provide general guidelines or information. However, results may vary from one person to another. A user should understand such differences and act accordingly. The following quotes support this belief:

> One cup of rice may act differently for her [body] than other people from other nation. – P7

> Everybody understands what walking is, but understanding the nutrition of food is hard. It also depends on culture. What you eat daily is vastly different than what I eat daily. Understanding how the cuisine impacts the nutrition is huge. – P2

5. While participants considered mHealth apps useful, they also believed that for serious and chronic health issues such as diabetes and high blood pressure, relying on mHealth apps alone could be dangerous. They believed that for such critical health conditions, mHealth apps can be used as helpers but never should be used as alternatives to doctors. According to participant 12,

> When you mention things like diabetes, to me, those are things like a medically necessary and more of an intense issue. I would get a little concerned. I don't take these [apps] as hundred percent face value. Like my sleep. If I really have sleep problems, I won't utilize it [the app] as my only way, my only knowledge. I would probably also go to my doctor. – P12

5.1.6 **Information Literacy**

Information Literacy	**N**	**%**
Required	22	91.7
Not reported or mentioned	2	8.3
All	24	100

Table 39: Requirement of Information Literacy for using mHealth Apps

Information Literacy, in terms of mHealth apps, refers to a skill to discover the right app from a sea of apps available in the app stores (see section 3.2.2). The coding and analysis of

the final study transcripts and field notes revealed that 22 out of 24 participants (91.7%) considered Information Literacy as a must-have skill (see Table 39). Furthermore, participant 7 and 9 stated that Information Literacy is not an easy skill to acquire. Even an experienced mHealth app user might not have this literacy. They explained:

> There are thousands of apps. I only know 30, 40, or 50 apps. But there are many good apps that can be useful for me. I am actively using a smartphone for four years but I don't know [about those apps]. How can a new person know? – P7

> It's hard [to choose from hundreds of apps]. – P9

However, participant 7 expressed that gaining experience over time might be useful in this regard:

> Initially, a user might have some problems, but if she starts using frequently, she will know where to look, how many documents she needs to read before trusting anything. – P7

The coding and analysis of the final study transcripts and field notes yielded the following recommendations and guidelines for mHealth app users to acquire Information Literacy:

1. To locate the most usable mHealth app, a user ought to try multiple similar apps simultaneously. Picking a single mHealth app, even if it is the most popular app, may lead the user to neglect other great choices. Participant 9 pointed out the challenge in this selection process:

   Sometimes, you might not like the obvious choice, you might like the other one. – P9

According to participants 9 and 11,

> Obviously, you will download the one which has lots of downloads, which has lots of good reviews, which looks polished and which looks better. Sometimes you [should) download multiple apps and try them out to see which one is better. – P9

> I will tell him [a newbie to mHealth app] to choose the first three [among the thousands of apps which come after searching apps in play store]. – P11

2. Sometimes consulting with experts (e.g. doctors) may help with finding the right app. Feedback from participant 9 is worth mentioning here:

> If they [users] have a specific medical condition like diabetes, it would be beneficial if their healthcare providers recommend some apps. Many times they [doctors] would know better what is out there and what is not. Sometimes they might not be in touch with, perhaps, to modern technology; sometimes they are. But many times they can recommend a good app. – P9

3. Some participants emphasized using the Internet to finalize the selection of the right mHealth app. However, considering the contradictory information available on the Internet, participant 7 was skeptical in this regard. More specifically, she was unsure of a typical user's ability to differentiate between accurate and inaccurate information available on the Internet:

> When you read many documents [on the Internet], you will learn that you don't need to trust everything. – P7

It is very important to know the difference between the good and bad information [on the Internet]. If a user doesn't know how to differentiate, it will be a problem. It will make her more panicked. – P7

Therefore, unlike other participants, participant 7 was hesitant to use the Internet for choosing the right app. Rather, she relied upon printed books, as opposed to Internet sources, to get correct information. According to her,

Book usually provides correct information. – P7

5.1.7 **Graph Literacy**

The coding and analysis of the final study transcripts and field notes revealed that seven final study participants (29.2%) considered Graph Literacy as a must-have skill (see Table 40). Graphs are commonly used by many mHealth apps to display results and summary of activity, health trend, and usage and health history. As a result, a lack of understanding of graphs might be costly, as described in the following quote:

I don't know how much they [users] would benefit actually from the tracking [by using an app] if they don't know how to read a graph. – P9

Graph Literacy	**N**	**%**
Optional	15	62.5
Required	7	29.2
Not reported or mentioned	2	8.3
All	24	100

Table 40: Requirement of Graph Literacy for using mHealth Apps

Participant 10 believed that Graph Literacy was bound up with the purpose of the app usage:

> It [understanding the graphs] really depends on the purpose. If you are only doing it since doctors say to track your blood pressure, that's the purpose. Do it and show [the graph] to the doctor. I think most people want to understand the graph. But it really depends on why you are doing it. – P10

However, Table 40 also highlights that 15 final study participants (62.5%) considered Graph Literacy as an optional skill. They argued that even without it, a person could make appropriate use of mHealth apps. A few participants mentioned that having Numeracy skill can compensate for a lack of Graph Literacy:

> They [users] can gain from the app if they can use one or the other [numbers or graphics]. – P11

> Personally, I think the graph is an additional way for me to look at the results. It is not a necessity, I would think. – P12

> The graph is just an extra visual feature. It is not mandatory [to understand graphs]. It just provides a quick glance what is going on. The number matters when you put them and when you get back the results. The graph is a quick thing which you can see visually. – P13

Some participants also considered using graphs as problematic as they require additional skills to interpret the results. For instance, participant 3, who considered Graph Literacy as an optional skill, was against the use of sophisticated graphs (e.g., pie chart). She thought

they could become problematic not only for a nontechnical person but also for a technical person:

> From my point of view, it [graph] is an overkill. Why do I need to know the percentage of food in breakfast, lunch etc.? MyFitnessPal app has a feature where I can say, "I want to eat 30% carb, 50% of protein and rest is fat." The app will automatically convert it to grams for each [and show it in a pie chart] and if I exceed it, it will automatically show the red mark. I don't need to see a big pie chart. – P3

Participant 5 was skeptical whether the majority of users have enough Graph Literacy:

> I don't know how many percentages of people will understand the graphs. – P5

Participant 2 also raised a question of the importance of Graph Literacy, expressing a preference for visualization (represent of data as intuitive images instead of graphs):

> Understanding visualization is important but not x, y chart. – P2

5.1.8 **Computer Literacy**

The coding and analysis of the final study transcripts and field notes indicated that 10 out of 24 participants (41.7%) expressed their opinions regarding Computer Literacy (see Table 41). Three participants (P16, P18, and P23) emphasized its significance because of the strong commonalities between computers and smartphones. They argued that a smartphone is a computer and hence the lack of Computer Literacy may prevent people from making appropriate use of mHealth apps. Another three participants (P14, P15, and P19) characterized Computer Literacy as an optional skill. According to them, having Computer Literacy would be helpful, but a user should be able to use mHealth apps without

it. Four participants (P20, P21, P22, and P24) did not consider Computer Literacy as a required skill at all for using mHealth apps. They rationalized by providing examples of people in underdeveloped countries who were able to use smartphones and relevant apps smoothly without any prior experience with computers.

Computer Literacy	**N**	**%**
Optional	3	12.5
Required	3	12.5
Not Required	4	16.7
Not Reported or Mentioned	14	58.3
All	24	100

Table 41: Requirement of Computer Literacy for Using mHealth Apps

5.1.9 **Web Literacy**

Although the Internet and the web are two separate entities, the coding and analysis of the final study transcripts and field notes revealed that participants used these two terms interchangeably. However, when participants explained the term "Internet," they meant the web. Sixteen out of 24 participants (66.7%) shared their opinions about the need for Web Literacy for using mHealth apps (see Table 42). Fourteen (58.4%) considered Web Literacy a required skill for the successful use of mHealth apps. Participant 9 stated,

> Of course, they [users] have to know how to use the Internet [or web]. – P9

Participant 1 and participant 11 went into greater detail:

Not lots of documentation [is available] on the phone; you have to go to online to find. Somebody has to be aware of the other sources of information. The app store has a little description. – P1

Definitely, they [users] have to [know how to use the web or the Internet]. How do they know the information if they don't Google [it]? – P11

Web Literacy	**N**	**%**
Required	14	58.4
Not Required	2	8.3
Not reported or mentioned	8	33.3
All	24	100

Table 42: Requirement of Web Literacy for using mHealth Apps

On the other hand, two participants were hesitant to characterize Web Literacy as a "must-have skill." For instance, participant 7 mentioned the importance of Web Literacy in the following way:

[Understanding how to use the web or the Internet] is greater than nice to have but less than must. – P7

5.1.10 **Privacy Awareness**

By "privacy," this dissertation means data privacy, defined in the following way:

Data privacy, also called information privacy, is the aspect of information technology (IT) that deals with the ability an organization or individual has to determine what data in a computer system can be shared with third parties.[15]

Privacy Awareness	N	%
Required	11	45.8
Optional	2	8.4
Not reported or mentioned	11	45.8
All	24	100

Table 43: Requirement of Privacy Awareness for using mHealth Apps

According to the International Association of Privacy Professionals (IAPP):

> Information privacy is the right to have some control over how your personal information is collected and used.[16]

IAPP also explained the importance of information privacy in the following way:

> With speed-of-light technological innovation, information privacy is becoming more complex by the minute as more data is being collected and exchanged. As the technology gets more sophisticated (indeed, invasive), so do the uses of data. And that leaves organizations facing an incredibly complex risk matrix for ensuring that personal information is protected. As a result, privacy has fast emerged as perhaps

[15] http://searchcio.techtarget.com/definition/data-privacy-information-privacy

[16] https://iapp.org/about/what-is-privacy/

> the most significant consumer protection issue—if not citizen protection issue—in the global information economy.

By privacy awareness, this dissertation means "the awareness users should have to protect their sensitive and private information from being accessible by any third parties."

mHealth apps typically collect users' private and health-related information. Once collected, this information may be stored on users' smartphones or in the cloud or in both places. A security breach of the app may make users' sensitive information vulnerable. Hence, it is important for users to be privacy aware while using mHealth apps. Not being so may make such sensitive information accessible to unwanted parties.

The coding and analysis of the final study transcripts and field notes found that 11 participants considered privacy awareness as a must-have skill (see Table 43). Some of them explained the reasoning to be privacy-aware.

> A lot of people are going to be real concerned about privacy. – P1

> Actually, I was interested in one app that will track my diet. But the problem that I face that they collected my text messages, my social media information, my logs, and contact information… I don't feel comfortable [to share these data]… I don't know what they will do with my data. – P7

> They [apps] record everything. I don't want them to record everything. – P13

> My main concern is how secure is this data [which I am sharing in the app]. Is somebody going to use this data? – P19

> The first thing I am going to check is that if it [the app] is sharing my information…My privacy is very important [to me]. – P20
>
> So I am leery of new apps because I don't trust them. So I think that's probably a big deal because with the internet age and everything going on, you always feel that apps and companies are trying to get your information… A lot of people are feeling like it's invasive and so they don't trust many apps. – P21

In contrast, two participants (participants 8 and 24) were not interested in tagging "privacy awareness" as a must-have skill. However, they did not deny its significance either:

> [Becoming privacy aware] is not a must but important [to have]. Because they [users] might be caught [up] by something else if they are not aware of [privacy]. – P8

Interestingly, participant 8 recommended considering privacy as one of the selection criteria for choosing an mHealth app:

> Two apps may give the same type of utility but one app is expecting less amount of private information. This can also be one criterion [to select one app over another]. – P8

5.1.11 **Awareness of Negative Impact of mHealth Apps**

Some mHealth apps may impact the operating condition of the smartphones negatively. According to Participants 13 and 19, mHealth app users should be aware of whether the apps they are using have any negative impact.

> Nowadays so many apps have come out. Is it [the app] harmful for your phone? They might take large memory space that slows your app down. – P13

> Are there any other negative parts of using that app? If I am using it all the time for my health reason, are there any other negative outcome? So these things need to be clear at the very beginning. – P19

5.1.12 **No Fear of Technology**

Many people, especially senior citizens, are afraid of using technology. According to participant 9,

> Older generations don't want to break some things. They are afraid. – P9

Several participants highlighted the importance of removing a user's "fear of technology". Participant 13 and participant 23 provided some suggestions to remove or reduce such fear

> First of all, remove the fear [from the trainees] that I can't do it. And let them know that, when you need any help, help will be provided. – P13

> When I was in school, I didn't know how to use a computer. I went to my school teacher. She told me that why don't you do it by yourself? Go ahead and do everything that you find on your screen…The main thing is fear, go ahead and do it. You'll come to know. – P23

5.1.13 **Strong Desire to use mHealth Apps**

Without having a strong desire to use mHealth apps, no one will be able to use mHealth app successfully. According to participant 23,

> First of all, [user should have] interest [to use apps]. – P23

5.1.14 **Consistency in using mHealth Apps**

Participant 3 found that many users are not consistent to use mHealth apps.

> I've seen a lot of people who just quit on it after one week or ten days. – P3

Participant 1 emphasized that a user should be consistent to use mHealth apps to receive health benefits.

> A big part of getting health benefit is using it all regularly. – P1

5.1.15 **Willingness to Consult a Doctor whenever Necessary**

Users should not solely rely upon mHealth apps. For serious health issues such as diabetes, an mHealth app user should know when to consult a doctor while using an mHealth app. According to participant 6,

> She [user] should know in which level she should talk with the doctor if she is tracking by herself. – P6

5.2 Requirements for mHealth App Developer

As discussed earlier, the concept of health literacy evolved around individuals. However, the concept has shifted and health literacy is now considered a complex concept that

involves not only the users but also families, healthcare professionals, and communities, and health care system. Interestingly, from mHealth literacy point of view, several participants also expressed that mHealth literacy should not be thought as user's responsibility but also app developers should share the same, if not more, responsibilities. While answering the questions on mHealth Literacy requirements (questions 23 to 26 of the final study), several participants expressed a concern that a poorly designed mHealth app might be unusable even for an expert mHealth app user. Participants 2 and 9 described this in depth:

> Computer Scientists run this danger all the time. They do this all the time. They show what they want, not what the person should have. – P2

> Unfortunately, many apps are developed by engineers who perhaps don't understand the user experience. And they developed it as an engineer, keeping themselves in mind. When in fact, an engineer is not going to use it. This is the problem across the industry, not only in the apps. The engineer knows how to program, but when user experience, you need a totally different team. Yes, definitely, this is a huge point. The burden is now on the app developer to design something smooth, intuitive. And that's a whole different science. You have to put in psychology, perception, graph refinement, and tell a story. – P9

As a result, 13 recommendations have been developed, all drawn from participants' experiences and reflections, for the design of mHealth apps. Other researchers recently investigated this issue and suggested guidelines for designing accessible and inclusive mHealth apps (keeping low-literacy people in mind as mHealth app users). This section will

first discuss the five design recommendations provided by the participants which overlapped with the guidelines provided by researchers in different health-related domains. This section will also discuss the remaining eight intuitive yet insightful design recommendations which were provided by the participants only.

5.2.1 **Design Recommendation Supported by Existing Research**

Nine participants (P2, P3, P5, P7, P13, P18, P20, P21, P23) provided five recommendations for designing better mHealth apps. These recommendations were also supported by existing researchers. These five recommendations are as follows:

1. An mHealth app should be simple and easy to use in order to be accessible to people with limited mHealth Literacy.
2. A balance between the screen size and the number of touchscreen buttons is important.
3. Images, pictures, and visualizations should be used.
4. Health-related terms should be explained in an easy and simple manner.
5. Minimum user involvement, especially when it comes to entering input, is highly encouraged.

Simple and Easy to Use:

An mHealth app may possess several good features and yet be considered troublesome to use due to its complex interface design. Simple, intuitive interfaces with fewer features are preferred over feature-rich apps with complex interfaces. Researchers have been arguing for simple mHealth app design. For instance, Broderick et al. (2014) discussed multiple

tactics for developing mHealth apps that might be useful for people with low-health-literacy. According to them, one of the critical design strategies should be to keep the mHealth apps simple. Simple, known interactions are also preferred by the participants. To quote some participants:

> I like Google Fit for its simplicity. You basically hit the big button at the top and it shows you four things and that's it. – P2
>
> Keeping it [the mHealth app] simple and accurate would be the main thing. – P3
>
> [App developers] need to make things [the app] easier. Tap it and get it [the results]. – P5
>
> If the designer can make this app as user-friendly as possible, [that would be great]. – P5
>
> Mostly, in the app, I look for simplicity and usability of the product. How simple it is and how useful it is for my purpose and for my need. – P13
>
> First of all, it [mHealth app] has to be simple. Within two to three steps, you should get the results. If you have [to take] four or five steps that means you are getting more steps, and it will lose their [users'] interests. – P13
>
> I'm pretty sure that there is a complicated algorithm behind what I see, the calculation of distance based on GPS data. I don't want to see that kind of things. – P20
>
> The app should not be complicated to understand. – P23

Accommodation in Small Screen Size

App developers face the challenge of "fitting everything on a smaller mobile screen" and "keeping touch screen buttons as few as possible." Participant 7 laid out the dilemma:

> Because we [users] don't want more buttons and we want more functionalities, so the app developer really has a dilemma. Because more features mean more buttons, but more buttons make us confused. That's why they [app developers] try to compact more information in few buttons or tabs. – P7

To solve this problem, the same participant suggested that there should be a balance between screen size and number of on-screen buttons. However, no suggestion was offered by the participant on how to achieve such a balance. Along the same lines, Broderick et al. (2014) suggested displaying app contents clearly by using a typical font with at least 12-point font size. They also suggested to enlarge buttons and to simplify on-screen controls.

Images, Pictures, and Visualization

Broderick et al. (2014) also advocated for using images to develop mHealth apps for people with low health literacy, which resonate with the suggestions provided by several participants. To quote some participants:

> They [mHealth app developers] should use more pictures to convince people [mHealth users] that you have to do this. – P18

> I prefer pictures over something I have typed because it is fast and I can track it easily. It's good to look over [too]. – P21

Arcia et al. (2013) discussed different visualization techniques for people considering that they might have different levels of health literacy. For instance, they mentioned that simple bar chart, icon array, and iconographic bar chart can be useful for showing weekly vegetable consumption, Body Mass Index (BMI) can be represented using Reference Range Number Line, and blood pressure number can be visualized using Reference Range Double Number Lines, etc. However, the authors did not discuss whether and how these visualization techniques will be applicable for mHealth apps. As mHealth apps also include these types of data and participants prefer to use picture and images, these visualization techniques can also be applicable to the design of successful mHealth apps.

Health Terms Should Be Explained in a Simple Manner

As discussed earlier, App-centric Health Literacy is imperative for the successful use of mHealth apps. Unfortunately, in many instances, health terms are not clearly explained, rendering them unintelligible even for skilled users. Participant 5 remarked,

> A graduate [with bachelor's degree] might also feel uncomfortable with these [health and medical] terms because some terms [are] for some specific people. – P5

Broderick et al. provided (2014) a simple guideline in this context which shows that to design mHealth apps, undefined technical or medical terms should be avoided and should be replaced with common, everyday words.

Less is More

Asking for too much information from users might put them off from using an mHealth app. Hence, minimum user involvement, especially when it comes to entering input, is highly

encouraged. Participant 13 shared an example of another type of app to illustrate this point:

> I was looking for a banking app [to monitor my] savings. I am getting 100 dollars and saving 50 dollars. That are the only numbers I needed. But if you [user] have to put your bank information and frequency of your savings then you are asking too much information. At the end, you [the user] lose the interest. So it doesn't serve your purpose. – P13

The same participant was also concerned about the amount of information required and provided by the apps. He believed that too much information may discourage elderly people from using these apps.

> Too much information is always bad. It's very very bad. They [senior citizens] will not [be able to] handle it. Once they lose the interest, you can't return them back. It should be very very simple. If it is complicated, they won't go back and they will rely on something else. – P13

Also, requiring less interaction and less effort from the users will reduce user burden and may encourage more use. As a result, participants advocated for less user burden when designing mHealth apps. To quote participant 2:

> My goal is to minimize the effort [needed] to use this app. Least amount of necessary effort is probably good. – P2

> There is something [in the apps] which is universal. Less interaction is better. – P2

A similar suggestion was provided by Broderick et al. (2014) where they explained that interactive contents can be included in mHealth apps but such type of content should be limited to avoid burden.

5.2.2 Design Recommendation Suggested by Participants Only

Eight additional intuitive yet insightful design recommendations were recommended by 17 final study participants. These recommendations are as follows:

- An mHealth app should be personalized.
- Social aspects should be incorporated without breaching a user's privacy.
- Accuracy, quick response, and less battery power consumption are vital.
- An mHealth app should be motivating to use.
- Smart tutorial and preview are useful.
- Minimal dependency on English Literacy is important.
- Switching between one mHealth app and another similar one should be seamless.
- Training in how to use an mHealth app is very important.

Personalized mHealth App

Typically, mHealth app developers follow the "*an app for everyone*" design approach to reach more people through their mHealth apps. According to study participants, such design philosophy is ineffective in this context and mHealth apps should be customizable based on users' preferences and skills. Some participants expressed the opinion that a popular and highly-rated mHealth app does not guarantee that every user will gain equal benefit from using it. They believed that personalization is imperative as users vary in their

health needs, experience with smartphones and mHealth apps, technical expertise, and even their motivation for using these apps. Participant 13 shared his experience:

> I have seen many apps that have been downloaded 100,000 times but not good at all. You can't use them. The app is not good enough. – P13

Participants 2, 6, and 10 described the reason:

> Everybody looks at the problem in a different way. Maybe it is motivated by corporate interest or maybe it is motivated because they think they have a better solution. What [is] right for you is not necessarily right for me. – P2
>
> All users are not regular users. – P6
>
> Everybody is different. – P10

Some users are not patient enough to spend enough time to choose the right app, which was vividly described by participant 3:

> For me, I started using MyFitnessPal since I wanted to start from somewhere. I did not waste too much time doing research. There were dozens of apps and I opened two or three of them. I liked it [MyFitnessPal] since the user interface was very clean. I like the color blue. I wanted to start from somewhere. So how does it matter? Let's start with it. – P3

Participant 3's remark raises the important question of whether a user will be able to find the app that is right for her or him. Another comment by this participant shows that, perhaps, MyFitnessPal was not the best app for her:

> MyFitnessPal has lots of features that are not required by me. – P3

She was also worried about the capability of a non-technical person like her mother trying to use the app:

> My mom might be overwhelmed with so many features [of MyFitnessPal]. She might not take part in the community or blog. Even you go to the [MyFitnessPal] website, there are too many options in the menu. Then how can my mom decide whether she needs this feature but not the [features of] community and recipe? – P3

To design personalized mHealth apps, one needs to understand a person's skill and comfort level with technology. Participant 7 shared an example from the "understanding graphs" point of view. Depending on users' skill level in this domain, the choice of the app should be customizable. To quote participant 7,

> How strong you are in [understanding graph and visualization]? If you give 4 stars to yourself then you will use the visualization. If you give 1 star then you will use the basic functions. – P7

Participant 1 expressed a similar view:

> A big part of getting health benefit is using it [mHealth app] regularly. Everyone doesn't want to use on a regular basis. Everyone is busy. Also, [health benefit] depends on the level of comfort on technology. – P1

In summary, mHealth apps should be personalized based on the user's preferences and skills. Personalized mHealth apps will help the users to successfully use mHealth apps to gain health benefits.

Social Aspects

Some participants mentioned that they started using mHealth apps after getting the recommendations from people of their social circles (e.g., family, friends, and colleagues). Here are some quotes from the participants:

> My friend told me that this [app] is very cool. A group of my friends was talking about the apps. I decided to use them. They were useful for me so I kept using them. – P4

> One of my friends told me that you can download it [the app]. He sent me the name [of the app] on Facebook. Then I started using it. – P5

> Initially, it's better to talk with the friends or family or any other person who use this kind of thing [app] to know their experiences. – P6

> For some people motivation [to use mHealth apps] needs to come from the family members. – P16

> I personally just follow everything like my friend told me. – P23

> If you're not doing anything and your colleague is doing a lot of exercises, then you'll be motivated to do the same. – P24

Hence, incorporation of a social aspect was highly supported by participants. Surprisingly, most of the participants never used the "social" or "community" feature provided by the mHealth apps that they were using. One of the reasons was the fear of breaching one's privacy. Thus it is crucial that a social aspect to the mHealth apps be incorporated while maintaining users' privacy.

Accuracy, Quick Response, and Less Battery Power Consumption Are Vital

According to study participants, mHealth app users typically consider the results from their mHealth apps accurate and act upon the information the apps provide. Unfortunately, since many developers did not follow established healthcare guidelines in designing their mHealth apps, it may be risky for people to rely solely on these apps for their health needs, especially for health issues of a more technical medical nature (e.g., high blood pressure, diabetes, and cancer). In addition, it is nontrivial for typical users to validate the accuracy of the results provided by their apps. Thus participants suggested that the highest precaution should be taken regarding the accuracy of the results provided by mHealth apps. Otherwise, inaccurate results may cause serious health issues. Getting a quick response from an mHealth app is not as critical as accuracy. However, people of the current digital world are accustomed to swift responses and a lack of quick responsiveness may lead to user frustration. Some participants suggested that app developers should consider responsiveness as one of the key features when designing the app. According to participant 2 and participant 8:

> I am very impatient with the computers. They [apps] should work what they intend to [do] and quickly. If they don't then it's time to reconsider that option. Kind of Steve Jobs mentality about UI. Everything should be just right. – P2

> One reason [that most of the apps are not successful] is [lack of] accuracy. If I see that I did an activity and I didn't see that it has been reflected, it can create frustration. – P8

Another important factor related to mHealth app use is an app's battery power requirement. Some mHealth apps (e.g., Moves) use GPS, Bluetooth, or Wi-Fi and consume excessive battery power. Such mHealth apps impact users' overall experience with the smartphone as they need to charge their phones more often and experience less than optimal functionality from other apps. As a result, users may not be interested in using such apps, even when they are very accurate and provide results in a split second. Participant 8 expressed this concern:

> If a user uses more apps, the battery life goes down. This is why sometimes they might not be interested in installing these apps. This is one challenge. – P8

User Motivation is Imperative

Despite an mHealth app being simple, accurate, and responsive, highly skilled users, let alone newbies, may not use it if they do not feel driven to do so. Several users mentioned starting to use mHealth apps with great enthusiasm, but having quickly lost interest. Participant 1 shared her experience:

> I was recording all my food on a regular basis about a month and something happened one day and I got too busy to do it and I couldn't do it and I never get back to do it. That kind of thing happens. – P1

If users are not motivated to use mHealth apps regularly and adhere to the guidelines, no benefit will be gained by having access to them. As a result, keeping the user motivated to use the app regularly and for the longer term should be an important design consideration. Participant P3 explained it nicely:

> A big part of getting health benefit is using it all regularly. Everyone doesn't want to use on a regular basis…. Even to use the app, no matter how simple it is, how intuitive it is, the person needs her motivation to stick with it. – P3

Smart Tutorial and Preview Can Be Useful

Each mHealth app usually comes with both standardized and unique features. As a result, some participants advocated for smart tutorials and good previews for new users, especially for the novel features. Participants also highlighted the need for simple tutorials containing lots of audios and videos. According to participants 1, 5, 12, and 23,

> A tutorial would be good. - P1
>
> If there is an audio instruction that will be helpful. – P5
>
> Some kind of tutorial would help initially. A video tutorial would probably be the best because it will show how to do it. Just like YouTube video or something, a small quick tutorial. – P12
>
> I think it [the app] should have videos. Yeah, it should have videos. When the app gets started, it should have video. – P23

Also, having a good preview can be very useful and is even considered by some participants a must-have for an mHealth app. Many people like to "try out" apps before deciding to use them. For apps, especially apps that require money, users considered previews imperative as it will enable users to get a feel for the actual app before purchasing it. Participant 2 stated:

> There are paid apps without previews. I won't do if I have to buy without seeing it first. It used to be pretty common in iTunes. Lots of people realized that that is a bad business model. So they [iTunes] have a preview edition [now]. – P2

Since people love to learn by playing games, some participants advised that game-like features be incorporated into the tutorials.

Need to Reduce Dependency on English Literacy

The majority of the mHealth apps are available only in English. It is unrealistic to expect people all over the world will start learning English in order to use these apps. This aspect should be taken into account by the app developers. To quote a participant 1:

> [The app] developer should know the audience…. Learning English can be a barrier. The developer should take this [some person might not understand English very well] into account. – P1

Participant 8 stressed the importance of designing apps in the local language:

> Local language can be very useful for them [users]. We don't expect that everyone understands English. It is really rare. In our country [Bangladesh], the literacy rate is very low. Most of them may not understand English at all. – P8

Seamless Switching between Apps

Many people are averse to updating their apps even if the changes bring positive changes. Participants felt that if an update is required, it should be very easy and smooth. In addition, when similar but better mHealth apps become available, participants felt that they should be able to switch to the new app without much manual effort. As many current

mHealth apps do not talk to each other, users run the risk of losing their historical data if the transition to the new app occurs. According to participant 3:

> I am sticking to MyFitnessPal. Probably there are better apps out there. But I am sticking with it because it has the whole record for three years and it has all the details. And I can access it. For another app, I have to start from the beginning and I will lose all these records. And I don't want that. – P3

Importance of User Training

Few participants described how training can be beneficial to use mHealth app. Many users have fear of using new technology and training may help to alleviate this fear. This is especially true for unskilled or non-technical users, who may find testing the app features without any guidance intimidating. To quote participant 9 and participant 20:

> We need to walk them [older generations] through. Look, as long as you are not going here, you are fine. You can't break the phone if you are doing this. – P9

> Computers are scary for people who have not used them because they might get scared of fraud, losing money, and giving away information. Cell phones are like them. So you have to teach them what they do and what they do not do. It's a very important thing. Because when you start giving information about cellphones or applications to some people, if they are scared of using these kinds of applications, you should tell them what to do and what not to do to get into a trouble. – P20

Participant 10 was very detailed in suggesting what the characteristics of the training procedure should be:

> I think rather than just showing them [trainees] those things [in sleep app], what would be important is that, slowly over time, ask them questions about it [app], give them few days and then ask, oh well, how was your sleep last night? Can you go to the sleep function to show me how to do that? And they can see what sleep like [by themselves] and if they don't remember then you [trainer] show them that, oh, you pressed this button and this one [happens] and [pressed] that button and that one [happens]. [Ask] other questions also. What are the highest steps you reached this week? If they use the food tracker on the same one, then what's your calorie intake versus exercise? How is that looking? Ask them what they used it rather than go to the calorie count which doesn't seem effective. – P10

5.3 Relationships among Users, mHealth Technology, and mHealth Literacy

As mentioned earlier, all participants (N=24) considered two skills as requisite skills to use mHealth apps: Smartphone Literacy and App Literacy. However, some of the remaining skills are influenced by the participants' backgrounds, current life experiences, and mHealth technology they have used. This section investigates the interplay of these factors. Since the number of participants of this study is relatively small (N=24), this section is exploratory, looking for potential relationships.

5.3.1 Relationship between mHealth App Users and mHealth Literacy

Relationship between mHealth App Users and English Literacy

As discussed earlier, the coding and analysis of the final study transcripts and field notes revealed that the 24 participants expressed different opinions in terms of the necessity of

English Literacy for using mHealth apps. The association (or lack of association) of specific components of participants' demographic profiles with their views on English Literacy is shown in Table 44 to Table 50.

Table 44 shows that a majority (61.1%) of the younger participants (age<40) considered English Literacy a required skill for using mHealth apps. However, older participants (age>=40) were equally divided among two choices: 50% considered English Literacy a required skill, while the remainder considered English Literacy a required skill only if mHealth apps are not available in a user's local language.

Age	**English Literacy**		
	Required (%)	**Required if app is not available in local language (%)**	**Optional (%)**
20–29 (N=7)	57.1	42.9	0.0
30–39 (N=11)	63.6	27.3	9.1
40–49 (N=5)	40	60	0.0
50+ (N=1)	100	0.0	0.0

Table 44: Relationship between Participant's Age and English Literacy

Table 45 shows that a majority (81.8%) of the female participants considered English Literacy a required skill, while more than half of the male participants (53.8%) considered English Literacy a required skill only if mHealth apps were not available in a user's local language.

Table 46 shows that participants with relatively lower levels of education (e.g., two year's college degree, associate degree, or bachelor's degree) and participants with the highest

education degree (e.g., Ph.D.) considered English Literacy a required skill for using mHealth apps. Participants with a master's degree, on the contrary, were mainly divided into two categories on the importance of English Literacy: 42.9% considered it a required skill while 50% considered it a required skill only if mHealth apps were not available in a user's local language.

Gender	**English Literacy**		
	Required (%)	**Required if app is not available in local language (%)**	**Optional (%)**
Men (N=13)	38.5	53.8	7.7
Women (N=11)	81.8	18.2	0.0

Table 45: Relationship between Participant's Gender and English Literacy

Educational Level	**English Literacy**		
	Required (%)	**Required if app is not available in local language (%)**	**Optional (%)**
Two year's College/ Associate Degree (N=2)	100	0.0	0.0
Bachelor's degree (N=7)	71.4	28.6	0.0
Master's Degree (N=14)	42.9	50	7.1
Ph.D. degree (N=1)	100	0.0	0.0

Table 46: Relationship between Participant's Education and English Literacy

Table 47 highlights the relationship between participants' ethnicity and the need for English Literacy. This table shows that a majority (70%) of the participants with non-Asian

(European – 66.7%, African-American – 66.7%, and Asian-American – 100%) ethnicity considered English Literacy a required skill. Asian participants (N=14), however, were equally divided between two choices: English Literacy is a required skill (50%) and English Literacy is a required skill only if mHealth apps were not available in a user's local language (50%).

Ethnicity	English Literacy		
	Required (%)	Required if app is not available in local language (%)	Optional (%)
Asian (N=14)	50	50	0.0
European (N=6)	66.7	16.7	16.7
African American (N=3)	66.7	33.3	0.0
Asian American (N=1)	100	0.0	0.0

Table 47: Relationship between Participant's Ethnicity and English Literacy

Table 48 shows that three-fourths of the participants at the beginner level of app expertise considered English Literacy a required skill for the successful use of mHealth apps. Participants at the expert level of app expertise were equally divided between two choices: English Literacy is a required skill (44.4%) and English Literacy is a required skill only if mHealth apps were not available in a user's local language (44.4%). However, participants at the intermediate expertise level were divided between two choices: English Literacy is a required skill (42.9%) and English Literacy a required skill only if mHealth apps were not available in a user's local language (57.1%).

App Expertise Level	English Literacy		
	Required (%)	Required if app is not available in local language (%)	Optional (%)
Beginner (N=8)	75	25	0.0
Intermediate (N=7)	42.9	57.1	0.0
Expert (N=9)	44.4	44.4	11.1

Table 48: Relationship between Participant's App Expertise and English Literacy

Sources of Talk about App Use	English Literacy		
	Required (%)	Required if app is not available in local language (%)	Optional (%)
Friends (N=15)	53.3	40	6.7
Family members (N=13)	53.8	38.5	7.7
Colleagues (N=3)	33.3	66.7	0.0
No one (N=3)	66.7	33.3	0.0

Table 49: Relationship between Participant's Sources of Talk about App Use and English Literacy

Table 49 shows that a majority (54.8%) of the participants who talked to their friends or family members or no one about their mHealth app use considered English Literacy a required skill. Participants who talked to their colleagues typically considered English

Literacy a required skill only if mHealth apps were not available in a user's local language (66.7%).

Table 50 shows that a majority (65.2%) of the participants who received help from their friends, family members, or no one considered English Literacy a required skill. However, the participants who received help from colleagues (N=2) or from online sources (N=2) were equally divided between two choices: English Literacy is a required skill (50%) and English Literacy is a required skill only if mHealth apps were not available in a user's local language (50%).

Table 51 summarizes the relationship between participants' demographics and English Literacy. Since a majority of the participants chose one of two options (English Literacy is a required skill; English Literacy is a required skill only if mHealth apps were not available in a user's local language), the table lists these two options only.

Sources of Help with App Use	**English Literacy**		
	Required (%)	**Required if app is not available in local language (%)**	**Optional (%)**
No one (N=12)	58.3	33.3	8.3
Friends (N=8)	75	25	0.0
Online (N=2)	50	50	0.0
Family members (N=3)	66.7	33.3	0.0
Colleagues (N=2)	50	50	0.0

Table 50: Relationship between Participant's Sources of Help with App Use and English Literacy

	Participants who considered English Literacy a required skill (N)	Participants who considered English Literacy as a required skill if app is not available in local language (N)
Age	**Age < 40 or Age >= 50 (12)**	**40 <= Age < 50 (3)**
Gender	**Female (9)**	**Male (7)**
Education Degree	**Degree other than a master's (8)**	**Master's degree (7)**
Ethnicity	**No pattern (14)**	**Asian (7)**
Expertise Level	**Beginner (6)**	**Intermediate or expert (8)**
Sources of Talk about App Use	**Friends, family members, or no one (17)**	**Colleagues (2)**
Sources of Help with App Use	**Friends, family members, or no one (15)**	**No pattern (9)**

Table 51: Relationship between Participant's Demographics and English Literacy

Relationship between mHealth App Users and Graph Literacy

The coding and analysis of final study transcripts and field notes revealed that 22 out of 24 participants expressed opinions about the need and importance of Graph Literacy. The impacts of participants' demographic profiles on Graph Literacy are shown in Table 52 to Table 56.

Table 52 highlights that a majority (75%) of the participants over the age of 30 considered Graph Literacy an optional skill for using mHealth apps. However, the younger participants (age<30) were equally divided between two choices: Graph Literacy is a required skill (50%) and Graph Literacy is an optional skill (50%). Table 53 highlights that at least two-thirds of both male (66.7%) and female (70%) participants considered Graph Literacy as an optional skill. Table 54 indicates that a majority (76.9%) of the participants with a master's degree considered Graph Literacy an optional skill. Participants with a bachelor's degree were equally divided between the two choices. All participants with a two year's

college degree or an associate degree considered Graph Literacy an optional skill, and the only participant with a Ph.D. degree considered Graph Literacy a required skill.

Age	Graph Literacy	
	Required (%)	Optional (%)
20-29 (N=6)	50	50
30-39 (N=10)	30	70
40-49 (N=5)	0	100
50+ (N=1)	100	0

Table 52: Relationship between Participant's Age and Graph Literacy

Gender	Graph Literacy	
	Required (%)	Optional (%)
Men (N=12)	33.3	66.7
Women (N=10)	30	70

Table 53: Relationship between Participant's Gender and Graph Literacy

Educational Level	Graph Literacy	
	Required (%)	Optional (%)
Two year's College/Associate Degree (N=2)	0	100
Bachelor's degree (N=6)	50	50
Master's Degree (N=13)	23.1	76.9
Ph.D. degree (N=1)	100	0

Table 54: Relationship between Participant's Education and Graph Literacy

Table 55 shows that a majority (81.2%) of the non-European participants considered Graph Literacy an optional skill (Asian–75%, African-American–100%, and Asian-American–100%). However, two-thirds of the European participants considered Graph Literacy a required skill.

Ethnicity	**Graph Literacy**	
	Required (%)	**Optional (%)**
Asian (N=12)	25	75
European (N=6)	66.7	33.3
African American (N=3)	0	100
Asian American (N=1)	0	100

Table 55: Relationship between Participant's Ethnicity and Graph Literacy

Table 56 shows that a majority (85.7%) of the participants at both the beginner level of app expertise and the expert level of app expertise (66.7%) considered Graph Literacy an optional skill. However, participants who have intermediate expertise with mHealth apps were equally divided between the two choices. Table 57 indicates that a majority (71%) of the participants, irrespective of the social circles with whom they talked about their mHealth apps, considered Graph Literacy an optional skill. Table 58 shows that a majority (78.3%) of the participants who received help with mHealth apps from their family members, friends, colleagues, or no one considered Graph Literacy an optional skill. However, the participants who received help from online sources (100%) considered Graph Literacy a required skill. Table 59 summarizes the relationship between participants' demographic profiles and Graph Literacy.

App Expertise Level	Graph Literacy	
	Required (%)	Optional (%)
Beginner (N=7)	14.3	85.7
Intermediate (N=6)	50	50
Expert (N=9)	33.3	66.7

Table 56: Relationship between Participant's App Expertise and Graph Literacy

Sources of Talk about App Use	Graph Literacy	
	Required (%)	Optional (%)
Friends (N=14)	35.7	64.3
Family members (N=12)	25	75
Colleagues (N=3)	33.3	67.7
No one (N=2)	0.0	100

Table 57: Relationship between Participant's Sources of Talk about App Use and Graph Literacy

Sources of Help with App Use	Graph Literacy	
	Required (%)	Optional (%)
No one (N=11)	27.3	72.7
Friends (N=7)	28.6	71.4
Online (N=2)	100	0.0
Family members (N=3)	0.0	100
Colleagues (N=2)	0.0	100

Table 58: Relationship between Participant's Sources of Help with App Use and Graph Literacy

	Participants who considered Graph Literacy as a required skill (N)	Participants who considered Graph Literacy as an optional skill (N)
Age	**Age<30 (3)**	**Age>=30 (12)**
Gender	**No pattern (7)**	**No pattern (15)**
Education Degree	**No pattern (7)**	**Two year's College/Associate Degree or Master's degree (12)**
Ethnicity	**European (4)**	**African American, Asian, or Asian American (13)**
Expertise Level	**No pattern (7)**	**Beginner or Expert (12)**
Sources of Talk about App Use	**No pattern (9)**	**Family members, friends, colleagues, or no one (22)**
Sources of Help with App Use	**Online (2)**	**Family members, friends, colleagues, or no one (18)**

Table 59: Relationship between Participant's Demographic Profile and Graph Literacy

Relationship between mHealth App Users and Computer Literacy

As discussed earlier, the coding and analysis of the final study transcripts and field notes revealed that 10 out of 24 participants (41.7%) expressed opinions regarding the necessity of Computer Literacy for using mHealth apps. These opinions fell into three categories: Computer Literacy is a required skill (N=3), Computer Literacy is not required (N=4), and Computer Literacy is an optional skill (N=3). The influence of participants' demographic profiles on Computer Literacy is shown in Table 60 to Table 64.

Table 60 shows that a majority (80%) of the participants over the age of 30 considered Computer Literacy as an optional or non-required skill. However, the younger participants (age<30) were divided among three options: Computer Literacy is a required skill (40%), Computer Literacy is not required at all (40%), and Computer Literacy is an optional skill (20%).

Age	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
20–29 (N=5)	40	40	20
30–39 (N=2)	0	100	0
40–49 (N=3)	33.3	0	66.7

Table 60: Relationship between Participant's Age and Computer Literacy

Table 61 shows that 40% of both male and female participants considered Computer Literacy is not required at all to use mHealth apps. However, they differed with regard to the two other options: Computer Literacy is a required skill (40% male and 20% female) and Computer Literacy is an optional skill (20% male and 40% female). Table 62 shows that 50% of the participants with a master's degree considered Computer Literacy not to be a requirement to use mHealth apps, while a majority of the participants with a bachelor's degree (66.7%) considered that it was. The only participant with an associate's degree considered it an optional skill.

Gender	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
Men (N=5)	40	40	20
Women (N=5)	20	40	40

Table 61: Relationship between Participant's Gender and Computer Literacy

Educational Level	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
Associate Degree (N=1)	0.0	0.0	100
Bachelor's degree (N=3)	66.7	33.3	0.0
Master's Degree (N=6)	16.7	50	33.3

Table 62: Relationship between Participant's Education and Computer Literacy

Table 63 shows that non-Asian participants (European and African American) did not consider Computer Literacy a required skill. The Asian participants, by contrast, were divided among three opinions: Computer Literacy is a required skill (42.9%), Computer Literacy is not required at all (42.9%), and Computer Literacy is an optional skill (14.2%).

Table 64 shows that the 10 participants who expressed their opinions regarding the necessity of Computer Literacy were either at the beginner or expert level in terms of using mHealth apps. This table also shows that 40% of both groups considered Computer Literacy to not be required at all to use mHealth apps. However, they varied in terms of the two other options: Computer Literacy is a required skill (40% beginner and 20% expert) and Computer Literacy is an optional skill (20% beginner and 40% expert).

Ethnicity	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
Asian (N=7)	42.9	42.9	14.2
European (N=1)	0.0	100	0.0
African American (N=2)	0.0	0.0	100

Table 63: Relationship between Participant's Ethnicity and Computer Literacy

App Expertise Level	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
Beginner (N=5)	40	40	20
Expert (N=5)	20	40	40

Table 64: Relationship between Participant's App Expertise and Computer Literacy

Sources of Talk about App Use	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
Friends (N=7)	14.3	57.1	28.6
Family members (N=1)	0.0	0.0	100
Colleagues (N=2)	0.0	50	50
No one (N=3)	66.7	0.0	33.3

Table 65: Relationship between Participant's Sources of Talk about App Use and Computer Literacy

Table 65 shows that a majority (57.1%) of the participants who talked to their friends considered Computer Literacy to not be required at all for using mHealth apps. All participants (100%) who talked to family members about their mHealth apps considered Computer Literacy an optional skill. Participants (66.7%) who never talked to anyone about their mHealth apps considered Computer Literacy a required skill. Participants who talked to their colleagues were equally divided between two options: Computer Literacy is not required (50%) and Computer Literacy is an optional skill (50%).

Sources of Help with App Use	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
Friends (N=3)	33.3	33.3	33.3
Family members (N=2)	0.0	0.0	100
Colleagues (N=2)	0.0	0.0	100
No one (N=4)	50	50	0.0
Online (N=1)	0.0	100	0.0

Table 66: Relationship between Participant's Sources of Help with App Use and Computer Literacy

	General pattern of participants who considered Computer Literacy a required skill (N)	General pattern of participants who did not consider Computer Literacy a required skill (N)	General pattern of participants who considered Computer Literacy an optional skill (N)
Age	**No pattern (3)**	**Age<40 (4)**	**Age>=40 (2)**
Gender	**No pattern (3)**	**No pattern (4)**	**No pattern (3)**
Educational Level	**Bachelor's degree (2)**	**Master's degree (3)**	**Associate degree (1)**
Ethnicity	**No pattern (3)**	**European (1)**	**African American (2)**
App Expertise Level	**No pattern (3)**	**No pattern (4)**	**No pattern (3)**
Sources of Talk about App Use	**No one (2)**	**Friends (4)**	**Family members (1)**
Sources of Help with App Use	**No pattern (3)**	**Online (1)**	**Family members or colleagues (4)**

Table 67: Relationship between Participant's Demographic Profile and Computer Literacy

Table 66 shows that all participants (100%) who received help with mHealth apps from their family members or colleagues considered Computer Literacy an optional skill. Participants who received help from their friends were equally divided among three options: Computer Literacy is required (33.3%), Computer Literacy is not required (33.3%) and Computer Literacy is an optional skill (33.3%). Participants who received help from no one were equally divided between two options: Computer Literacy is required (50%) and Computer Literacy is not required (50%). The participant who received help from an online source considered Computer Literacy is not required (100%). Table 67 summarizes the relationship between participant's demographic profile and Computer Literacy.

Relationship between mHealth App Users and Web Literacy

The coding and analysis of the final study transcripts and field notes revealed that 16 out of 24 participants (66.7%) expressed their opinions about Web Literacy. The impacts of participants' demographics on Web Literacy are shown in Table 68 to Table 74. These tables highlight that a majority of the participants, irrespective of age, gender, education, ethnicity, expertise level, and social circle, considered Web Literacy a required skill.

Age	**Web Literacy**	
	Required (%)	**Not Required (%)**
20–29 (N=6)	83.3	16.7
30–39 (N=5)	80	20
40–49 (N=4)	100	0.0
50+ (N=1)	100	0.0

Table 68: Relationship between Participant's Age and Web Literacy

Gender	Web Literacy	
	Required (%)	Not Required (%)
Men (N=7)	85.7	14.3
Women (N=9)	88.9	11.1

Table 69: Relationship between Participant's Gender and Web Literacy

Education	Web Literacy	
	Required (%)	Not Required (%)
Two year's College/Associate Degree (N=2)	100	0.0
Bachelor's Degree (N=5)	80	20
Master's Degree (N=9)	100	0.0

Table 70: Relationship between Participant's Education and Web Literacy

Ethnicity	Web Literacy	
	Required (%)	Not Required (%)
Asian (N=9)	88.9	11.1
European (N=3)	66.7	33.3
African American (N=3)	100	0.0
Asian American (N=1)	100	0.0

Table 71: Relationship between Participant's Ethnicity and Web Literacy

App Expertise Level	Web Literacy	
	Required (%)	Not Required (%)
Beginner (N=6)	83.3	16.7
Intermediate (N=2)	100	0.0
Expert (N=8)	87.5	12.5

Table 72: Relationship between Participant's App Expertise and Web Literacy

Sources of Talk about App Use	Web Literacy	
	Required (%)	Not Required (%)
Friends (N=11)	81.8	18.2
Family members (N=6)	100	0.0
Colleagues (N=3)	100	0.0
No one (N=3)	100	0.0

Table 73: Relationship between Participant's Sources of Talk about App Use and Web Literacy

Sources of Help with App Use	Web Literacy	
	Required (%)	Not Required (%)
No one (N=6)	66.7	33.3
Friends (N=5)	100	0.0
Online (N=2)	100	0.0
Family members (N=2)	100	0.0
Colleagues (N=2)	100	0.0

Table 74: Relationship between Participant's Sources of Help with App Use and Web Literacy

Relationship between mHealth App Users and Other Skills

No clear influence of participants' backgrounds and lives on the other nine skills (Numeracy, App-centric Health Literacy, Information Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary) was observed based on the coding and analysis of the final study transcripts and field notes. App-centric Health Literacy and Information Literacy were considered important by 22 participants but were not mentioned by the other two. A similar observation could be made regarding Numeracy, as 12 participants mentioned its importance and 12 made no mention of it at all. Thirteen participants considered privacy awareness a required skill for using mHealth apps and two considered it an optional skill. Despite the high number of participants who considered these skills important, there was no clear demographic preference. It held true across all groups.

Only two participants (P13 and P19) discussed the importance of awareness of negative impact to using mHealth apps. The remaining four skills (No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary) was also endorsed by few participants.

5.3.2 **Relationship between mHealth Technology and mHealth Literacy**

This section summarizes the relationship between mHealth Technology and mHealth Literacy.

Relationship between Smartphone OS and mHealth Literacy

Table 75 indicates that a majority of the participants with Android-based (63.6%) and iOS-based (53.8%) smartphones considered English Literacy a required skill. The coding and analysis of the final study transcripts and field notes revealed that 22 out of 24 participants (91.7%) expressed opinions about Graph Literacy. Table 76 shows that nine participants who used Android-based smartphones (90%) considered Graph Literacy an optional skill. However, participants with iOS-based smartphones were equally divided between two choices: Graph Literacy is a required skill (50%) and Graph Literacy is an optional skill (50%).

Smartphone OS	**English Literacy**		
	Required (%)	**Required if app is not available in local language (%)**	**Optional (%)**
Android (N=11)	63.6	36.7	0.0
iOS (N=13)	53.8	38.5	7.7

Table 75: Relationship between smartphone OS used and English Literacy

Smartphone OS	**Graph Literacy**	
	Required (%)	**Optional (%)**
Android (N=10)	10	90
iOS (N=12)	50	50

Table 76: Relationship between Smartphone OS Used and Graph Literacy

Smartphone OS	Computer Literacy		
	Required (%)	Not Required (%)	Optional (%)
Android (N=4)	0.0	50	50
iOS (N=6)	50	33.3	16.7

Table 77: Relationship between Smartphone OS Used and Computer Literacy

Smartphone OS	Web Literacy	
	Required (%)	Not Required (%)
Android (N=7)	85.7	14.3
iOS (N=9)	88.9	11.1

Table 78: Relationship between Smartphone OS Used and Web Literacy

	Android-based Smartphone User	iOS-based Smartphone User
English Literacy	Required	Required
Graph Literacy	Optional	Required or optional
Computer Literacy	Not required or optional	Required
Web Literacy	Required	Required

Table 79: Relationship between Smartphone OS Used and mHealth Literacy

As discussed earlier, the coding and analysis of the final study transcripts and field notes revealed that 10 out of 24 participants (41.7%) expressed opinions regarding the necessity of Computer Literacy for using mHealth apps, which fell into three categories: Computer Literacy is a required skill, Computer Literacy is not required, and Computer Literacy is an optional skill. Table 77 shows that 50% of participants who used iOS-based smartphone considered Computer Literacy a required skill for using mHealth apps. However, participants with an Android-based smartphone were equally divided between the two other options: Computer Literacy is not required (50%) and Computer Literacy is an

optional skill (50%). Table 78 shows that a majority of the participants with Android-based (85.7%) and iOS-based (88.9%) smartphones considered Web Literacy a required skill.

No relationship was found between Smartphone OS used by participants and other 11 skills (Smartphone Literacy, App Literacy, Numeracy, App-centric health literacy, Information Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary). Table 79 summarizes the relationship of the smartphone OS used by participants and mHealth Literacy.

Relationship between mHealth Apps and mHealth Literacy

As mentioned earlier, the final study participants used 31 mHealth apps. 14 participants (P1, P2, P3, P4, P7, P9, P10, P12, P14, P15, P17, P21, P22, and P23) used more than one mHealth apps. On the contrary, six mHealth apps (MyFitnessPal, Apple Health, Moves, Fitbit, MapMyRun, and WebMD) were used by multiple participants. While trying to find a relationship between mHealth apps and mHealth literacy, no specific pattern was found. For instance, MyFitnessPal was used by eight participants (P2, P3, P4, P7, P10, P12, P15, and P17). Among them, five participants considered English literacy a required skill, one participant considered English literacy an optional skill and the remaining two participants considered it a required skill only if mHealth apps were not available in a user's local language. For the other popular app (Apple Health) which was used by five final study participants (P1, P16, P19, P23, and P24), two participants considered it as a required skill while the remaining three considered it a required skill only if mHealth apps were not available in a user's local language.

As discussed earlier, 16 out of 24 participants expressed opinions regarding the necessity of Web Literacy for using mHealth apps. Except two (P20 and P21), the remaining 14 participants considered Web Literacy as a required skill to use mHealth apps. P20 was using one mHealth app (MapMyRun) and P21 was using three different mHealth apps (Lose it!, Nike Fit, and P Tracker) while the interviews were conducted. No significant relationship was discovered between mHealth apps used by the participants and Web literacy.

No clear influence of mHealth apps on the other 13 skills (Smartphone Literacy, App Literacy, Numeracy, App-centric health literacy, Information Literacy, Graph Literacy, Computer Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary) was observed based on the coding and analysis of the final study transcripts and field notes.

In summary, no relationship was found between mHealth apps used by the participants and mHealth literacy.

Relationship between Information Sources about mHealth Apps and mHealth Literacy

Coding and analysis of the final study transcripts and field notes revealed that three participants (P19, P23, and P24) who found their mHealth apps while exploring their smartphones and two participants (P8 and P12) who got the information from their colleagues considered English literacy a required skill only if mHealth apps were not available in a user's local language. However, no additional distinctive pattern was revealed from the analysis. For instance, five participants (P3, P6, P10, P13, and P17) got their app

information from the Internet. Three of them (P3, P13, and P17) considered English Literacy as a required skill, one of them (P6) considered English Literacy a required skill only if mHealth apps were not available in a user's local language, and the remaining participant (P10) considered English literacy an optional skill.

In terms of Graph Literacy, three participants (P5, P20, and P22) who used app stores to find their mHealth apps, considered Graph Literacy an optional skill. However, for the other participants, who used different other information sources, no particular relationship was found.

For the remaining skills (Smartphone Literacy, App Literacy, Numeracy, App-centric health literacy, Information Literacy, Computer Literacy, Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary), no significant relationship was found as well.

Relationship between Motivations for using mHealth Apps and mHealth Literacy

Among 24 final study participants, only six (P4, P7, P9, P10, P11, and P23) discussed their motivations to use mHealth apps. Due to very few number of participants, no relationship was found between motivations for using mHealth Apps and mHealth Literacy.

Relationship between App Selection Process and mHealth Literacy

As mentioned earlier, 12 final study participants discussed their app selection process. Except participant 10 who followed "trial and error" technique, the other 11 participants

considered App-Centric Health Literacy and Information Literacy required skill to use mHealth apps.

Six participants (P6, P9, P11, P20, P21, and P22) selected their apps based on the app rating (e.g., the users' review about the app, the number of downloads, and the number of stars given to the app). Three of them (P9, P20, and P22) considered English Literacy a required skill to use mHealth apps while the remaining three considered English Literacy a required skill only if mHealth apps were not available in a user's local language. Similarly, no distinct relationship was found between other selection processes (Trial and error, recommendation from others, user interface, curiosity, and multiple techniques) and English Literacy.

No relationship was found between app selection process and other skills (Smartphone Literacy, App Literacy, Numeracy, Graph Literacy, Computer Literacy, Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary).

5.4 Summary

Based on coding and analysis of the final study transcripts and field notes, this chapter identified two different requirements to achieve mHealth literacy: requirements for mHealth app users and requirements for mHealth app developers. In terms of the requirements for mHealth app users, this chapter identified that mHealth app users should have 15 skills. These 15 skills are: Smartphone Literacy, App Literacy, English Literacy, Numeracy, App-centric Health Literacy, Information Literacy, Graph Literacy, Computer

Literacy, Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary. In terms of requirements for mHealth app developers, this chapter provided the details of a set of mHealth app design recommendations, all drawn from participants' experiences and reflections, for mHealth app design. Some recommendations overlapped with the guidelines provided by existing research while the participants of the final study also offered several novel insights. Finally, the influence of participants' backgrounds, living, and experience with mHealth technology use on mHealth literacy requirements was also discussed in this chapter.

Chapter 6 Discussion and Conclusion

The research question of this dissertation is: **what skills does a user need to use a health-related app on a smartphone?** In this dissertation, the term "mHealth Literacy" is coined to refer to the answer to this question.

Some researchers have devoted considerable attention to revealing how users have been using mHealth apps for their health and disease management. It has been assumed that there are no barriers to the uptake of this technology. But do all potential users have the necessary skills to do so? Furthermore, what do those skills consist of? A person lacking the relevant skills will not be able to use these mHealth apps, even those with the most foolproof designs. This dissertation fills that gap.

On the contrary, some researchers assumed that a poorly designed mHealth app might be unusable even for an expert mHealth app user. Hence, they recommend some guidelines to design mHealth apps for people with low health literacy. This dissertation also acknowledges such contributions and examines how to design mHealth apps that can contribute to effective use of mHealth apps.

6.1 Dissertation Summary

Chapter 1 introduced this dissertation's research question and key concepts, along with setting forth the importance and the uniqueness of the research question. The domain of mHealth revolves around several aspects of mobile technology; this dissertation focused on mHealth apps only. In the final section of chapter 1, the argument for choosing mHealth apps among all these existing mHealth tools was presented. Chapter 2 presented the

findings from the disciplines of Literacy, Health Literacy, and eHealth Literacy. Chapter 3 discussed the dissertation's research design, which has two parts: a pilot study and a final study. Next, the user recruitment process, the demographics of the users, the interview questions, the measures used in the final study, and the data analysis techniques were discussed in chapter 3. Chapter 4 discussed the findings regarding mHealth app users and mHealth technology. Chapter 5 discussed the mHealth literacy requirements. Since the skills needed to use mHealth apps depend in part on the design of the apps themselves, users were asked about the functionality of the apps they used and of an app selected by the researcher. As a result, a set of recommendations were developed, all drawn from participants' experiences and reflections, for mHealth app design.

6.2 Recapitulation of the Final Study Findings

Findings from the final study (chapter 4 and chapter 5) are summarized below.

The coding of the final study transcripts and field notes helped to identify 15 skills which are required to use mHealth apps. These 15 skills are: Smartphone Literacy, App Literacy, English Literacy, Numeracy, App-centric Health Literacy, Information Literacy, Graph Literacy, Computer Literacy, Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary. Each of the 24 participants reported or mentioned two skills (Smartphone Literacy and App Literacy) as necessary for effective use of an mHealth app. The remaining 13 skills were reported by some (not all) of the participants.

Four skills (English Literacy, Graph Literacy, Computer Literacy, and Web Literacy) appeared to be a function of the participants' backgrounds and lives. In other words, certain types of participants mentioned certain skills. For instances, 81.8% of female participants considered English Literacy a required skill while 53.8% of male participants considered English Literacy a required skill only if mHealth apps are not available in user's local language. A majority (81.2%) of the non-European participants (Asian, African-American, and Asian-American) considered Graph Literacy an optional skill while 66.7% of the European participants considered Graph Literacy a required skill. Fifty percent of the participants with a master's degree considered Computer Literacy to not be a required skill for the use of mHealth apps, while 66.7% of the participants with a bachelor's degree felt that it was required.

Several participants of this study expressed a concern that a poorly designed mHealth app might be unusable even for an expert mHealth app user who possesses all the 15 skills, a sentiment shared by several researchers (Broderick et al. 2014; Arcia et al. 2013), Hence, according to those participants, it is not only the user's responsibility to learn the 15 skills to be mHealth literate but also mHealth app developers should share the same, if not more, responsibilities. As a result, a set of design principles were developed, all drawn from participants' experiences and reflections, for the design of mHealth apps. Among these design principles, the followings are also identified/recommended by other researchers:

1. An mHealth app should be simple and easy to use in order to be accessible to people with limited mHealth Literacy.
2. A balance between the screen size and the number of touchscreen buttons is important.

3. Images, pictures, and visualizations should be used.
4. Health-related terms should be explained in an easy and simple manner.
5. Minimum user involvement, especially when it comes to entering input, is highly encouraged.

The following eight suggestions were provided by the participants only:

1. An mHealth app should be personalized.
2. Social aspects should be incorporated without breaching a user's privacy.
3. Accuracy, quick response, and less battery power consumption are vital.
4. An mHealth app should be motivating to use.
5. Smart tutorial and preview are useful.
6. Minimal dependency on English Literacy is important.
7. Switching between one mHealth app and another similar one should be seamless.
8. Training in how to use an mHealth app is very important.

6.3 Implications

6.3.1 **Implications for Health Literacy**

The issue of inadequate Health Literacy is critical not only in the USA but also around the world. A person with limited Health Literacy experiences difficulties with regular health tasks, such as following instructions on a prescription drug label (Kutner et al., 2006). In the USA alone, more than one-third of the adult population can be characterized as having inadequate Health Literacy.

With the emergence of information technology, the focus of Health Literacy has been extended from the 'physical world' to the 'cyber world.' Norman and Skinner (2006b) captured this extension by coining the term "eHealth Literacy."

This dissertation moves research in this area one step further by integrating mobile technology. Figure 16 shows how this dissertation extends the domain of Literacy and Health Literacy research.

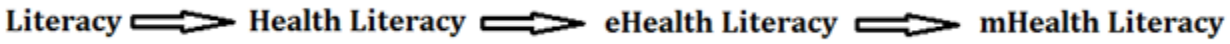

Figure 16: From Literacy to mHealth Literacy

Health Literacy vs mHealth Literacy

Although mHealth is a subset of health in general, the skill set that mHealth Literacy requires has more components than the skill set necessary to be considered health literate. As discussed in chapter 4, Health Literacy is one skill, among 14 other skills needed to achieve mHealth Literacy. However, the original, broader definition of Health Literacy (see section 2.2.1) was not used in this case. Rather, App-centric Health Literacy was adopted. As defined earlier, App-centric Health Literacy refers to the aspect of Health Literacy pertaining to the use of mHealth apps and is a prerequisite to achieving mHealth Literacy.

There exists an interesting similarity between Health Literacy and mHealth Literacy. Health Literacy is the province of patients, consumers, and healthcare system. Similarly, mHealth Literacy is not only the user's responsibility; the app developer and app industry can and should contribute to the literacy acquisition process.

eHealth Literacy vs mHealth Literacy

As discussed earlier, the research question of this dissertation was inspired by the concept of eHealth Literacy. Due to the use of smartphones and mHealth apps by millions of people all over the world, mHealth Literacy extends the focus of eHealth Literacy by including mobile technology.

As discussed in section 2.3.1, eHealth Literacy introduced the Lily Model, which incorporates six literacies: Traditional Literacy, Information Literacy, Media Literacy, Health Literacy, Computer Literacy, and Scientific Literacy. However, the Lily Model was not backed up with any empirical studies. In contrast, this dissertation introduced the concept of mHealth Literacy based on findings from a pilot study followed by a final study with 24 mHealth app users.

Since definitions of eHealth Literacy are up to this point based on theory, not empirical work, this study advances our understanding of eHealth Literacy with regard to mobile devices and their applications, through which a sizeable portion of the world's exposure to eHealth occurs.

While eHealth Literacy incorporates six literacies, mHealth Literacy incorporates 15 skills (Smartphone Literacy, App Literacy, English Literacy, Numeracy, App-centric Health Literacy, Information Literacy, Graph Literacy, Computer Literacy, Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary). Some skills are common to both eHealth Literacy and mHealth Literacy, and some are unique to eHealth Literacy and mHealth Literacy.

Common Skills: Two skills, Information Literacy and Computer Literacy, were common to both eHealth Literacy and mHealth Literacy.

For Traditional Literacy, eHealth Literacy combined both English Literacy and Numeracy. However, based on responses from the participants, mHealth Literacy separates these two skills.

For Health Literacy, eHealth Literacy adopted the definition of Health Literacy provided by the American Medical Association, which encompasses the traditional definitions discussed in detail in section 2.2. However, mHealth Literacy, rather than focusing on generic Health Literacy, focuses on App-centric Health Literacy.

Skills pertaining to eHealth Literacy only: Two literacies (e.g., Media Literacy and Scientific Literacy) were identified by eHealth Literacy only. mHealth Literacy did not identify these two literacies. The definitions of these two literacies are as follows:

> Media Literacy is a skill that enables people to place information in a social and political context and to consider issues such as the marketplace, audience relations, and how media forms in themselves shape the message that gets conveyed.
>
> Scientific Literacy places health research findings in appropriate context, allowing consumers to understand how science is done, the largely incremental process of discovery, and the limitations—and opportunities—that research can present. (Norman & Skinner, 2006b, p. 6)

Neither the pilot study participants nor the final study participants expressed any opinion about the need for Media Literacy. Perhaps, they did not find any relevance of the

"marketplace, audience relations, and how media forms in themselves shape the message that gets conveyed" to mHealth apps.

In terms of Scientific Literacy, Norman and Skinner (2006b, p.6) expressed their concerns in the following way: "For those who do not have the educational experience of exposure to scientific thought, understanding science-based online health information may present a formidable challenge." This concern may have arisen due to the fact that any person with a low level of web familiarity can upload any kind of health-related information. This is not common in relation to mHealth apps, since designing mHealth apps requires specific skills, skills that only a small number of people possess. This may be why no participant in the final study expressed an opinion about Scientific Literacy.

Skills pertaining to mHealth Literacy only: 10 skills were identified as components of mHealth Literacy that were not components of eHealth Literacy: Smartphone Literacy, App Literacy, Graph Literacy, Web Literacy, Privacy awareness, Awareness of negative impact of mHealth apps, No fear of technology, Strong desire to use mHealth apps, Consistency in using mHealth apps, and Willingness to consult a doctor whenever necessary. Smartphone Literacy and App Literacy are unique to mHealth literacy since mHealth is related to smartphones and apps. However, Web Literacy or in general Internet Literacy should be considered important for eHealth Literacy. Since eHealth Literacy is focused on Internet-based health information only, it may be the case Norman and Skinner considered it to be a prerequisite and hence did not include it as a separate skill.

With the increasing use of mobile phones, the protection of private information has become a major challenge. When eHealth Literacy was first introduced in 2006, this was not much

of a concern. Hence, Norman and Skinner did not consider it significant. Unfortunately, when Norman proposed that eHealth Literacy should be reevaluated in the light of Web 2.0 domain, privacy awareness was still ignored in his proposal. However, the participants of this dissertation explicitly mentioned the importance of privacy awareness for mHealth literacy.

6.3.2 Implications for the App Industry, App Developers, Policymakers, and Doctors

The coding and analysis of the final study transcripts and field notes revealed that mHealth Literacy is not the sole responsibility of users. The app industry (e.g., Apple, Google, and Microsoft) and app developers bear some responsibility as well.

The coding and analysis also revealed the importance of user-centered mHealth app design, as participants suggested developers should involve mHealth app users more actively in the design process. App stores should play a prominent role in this context. Rather than allowing any mHealth app to be uploaded in an app store without going through a quality control screening, the app industry should impose standards and evaluate apps using these standards to make sure that developers adhere to a user-centered design process.

According to a report published by Research2Guidance, the market size of mHealth app industry was USD$10.2 billion.[17] Google declared 2014 the year of health and fitness apps,

[17] http://research2guidance.com/2016/02/09/the-2016-mhealth-app-developer-economics-study-has-been-launched-take-part-today/

which clearly reflects the popularity and extensive growth of the mHealth app industry.[18] Similar findings were also reported by the participants of this study. Some commented that more users will use mHealth apps extensively in the near future since these apps are helping them to become healthier:

> Technology is improving and people are becoming aware and conscious about smartphone app to manage their behavior, health, and how everything is correlated. Now Internet of things becomes a new term in the research field. It is obvious that in future people will be used to this kind of apps. And over time, even from the environment, they will learn how to use them. Someone learning from their family members, someone learning from a television advertisement. Buying Fitbit and using the Fitbit app, how much quality of sleep you are having? This kind of knowledge is passing from all directions. So, I am hopeful that people will use these apps more [in future]. – P8

> Knowledge is power. You know how much you are eating and putting in. Some people eat unconsciously, they put everything together; they do not keep track or so. Obviously, the app helps them to keep track, it changes your perspective how you are living your life. – P9

By the last quarter of 2015, 165,000 mHealth apps had been downloaded 3 billion times; however, only 36 made up nearly 50% of downloads and 12% accounted for 90% of the

[18] http://www.digitaltrends.com/mobile/google-play-store-2014-most-downloaded-apps/

total downloads.[19] The same report also highlighted that 40% of the available apps were downloaded fewer than 5000 times. The findings of this dissertation may help to improve this disparity and bring positive changes to the mHealth app industry.

The coding and analysis of the final study transcripts and field notes revealed one of the major reasons contributing to this large disparity in the number of downloads. There is a huge disconnect between users' need and the skills that they have and appropriate apps that can fulfill their needs. Most mHealth app users heavily rely on the "wisdom of the crowd" and choose an app based on the number of downloads, the user rating, and the user reviews. There is a fundamental problem with this approach. An app which is appropriate for one user may not be effective for another. For instance, an expert mHealth user may find a particular app exceptionally good while a novice may find it extremely difficult to use. An app that can meet a teenager's health need may not be applicable for a senior citizen. In summary, utilizing the "wisdom of the crowd" as an app-filtering tool may not be appropriate for every user. This dissertation suggests that personalized app selection will have a huge positive impact. More specifically, an mHealth app will be successful and effective if it is chosen based on the user's skills. The results of this dissertation may contribute by pointing out the need to connect user skillset with the app filtering criteria. This dissertation will help to identify the skill level of a user and in turn suggest apps for the user. In this way, the number of downloads of other apps may increase.

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[19] http://www.ihealthbeat.org/articles/2015/9/17/just-36-mobile-health-apps-account-for-nearly-half-of-all-downloads

This dissertation may have a significant impact on current healthcare policy by informing the policymakers about the current situation of mHealth Literacy level of the general population. How the mHealth Literacy level of a user can be determined will be discussed later as a future project. Based on this information, healthcare policymakers should push the app industry and app developers to design mHealth apps to appeal to more users. This will help more users, thereby contributing to improvement in public health.

This dissertation can be useful for the doctors as well. As discussed earlier, personalization of mHealth apps is very important. Doctors typically know the health conditions of their patients. By knowing the mHealth Literacy level of their patients, doctors may suggest customized and personalized mHealth apps for their patients.

6.3.3 **Relationships among different skills within mHealth Literacy**

The coding and analysis of the final study transcripts and field notes revealed that some mHealth literacy skills are related to other skills. This section will discuss these relations.

Smartphone Literacy and App Literacy

All 24 participants saw both Smartphone Literacy and App Literacy as must-have skills with regard to mHealth apps. Participant 10 and participant 12 found a connection between these two skills, as in their view a user who owns a smartphone is likely to have App Literacy:

> I think once you have that knowledge [how to use a smartphone], it might be a little easier to use these apps because you are already familiar with that kind of technology. – P12

> I would think that as long as he [the user] has a smartphone, for any length of time, he could use any of these apps more or less effectively depending on what's asked to track; honestly, anybody picks up the smartphone, can probably use that app. – P10

Participant 9, an imam at a local mosque who used to work for Apple (the Company), did not agree. He had found that some smartphone owners are not proficient when it came to Smartphone or App Literacy. He shared his first-hand experience:

> When I was working for Apple, I used to deal with people who had no idea what they are doing with their smartphones. A lady told me that she had one app, a sort of game she plays, that's the only app she ever downloaded; she said that I don't want to download anything else; I just answer my phone call and play my game. Obviously, you will have that type of people. – P9

English Literacy and Numeracy

The final study analysis found that some participants who considered English Literacy a required skill also considered Numeracy a required skill. No participant considered English Literacy a required skill but did not consider Numeracy one. Six participants considered Numeracy a required skill and considered English Literacy mandatory if an app is not available in the local language of the user.

Computer Literacy and Web Literacy

As mentioned earlier, 10 final study participants expressed their opinions regarding Computer Literacy in relation to mHealth apps and can be divided into three groups: (a)

Computer literacy is a required skill (N=3), (b) Computer literacy is an optional skill (N=3), and (c) Computer literacy is not required (N=4).

In the case of Web Literacy, 14 participants gave their opinions and were divided into two groups: (a) Web Literacy is a required skill (N=12), and (b) Web Literacy is not a required skill (N=2).

An interesting observation was found between these two skills. Whether participants considered Computer Literacy a required skill or an optional skill, they considered Web Literacy a required skill as well. On the contrary, if participants did not consider Computer Literacy a required skill, they did not consider Web Literacy a required skill either. However, there were two exceptions. Participants 22 and 24 did not consider Computer Literacy a required skill. However, both of them considered Web literacy a required skill.

6.4 Limitations of the Dissertation

One of the limitations of this dissertation was that all study participants had at minimum some form of college degree. Hence, the study was not successful in recording the view of a person who is not highly educated. There was variation among users in terms of ethnicity and country of origin. Also, for several users, English was not their first language. Despite this, all participants had good English proficiency. Hence, this study did not record the view of a person who did not know English at all. Another limitation of this dissertation is the challenge of looking for definitive patterns, given the relatively small number of respondents in the various demographic categories. To make the findings generalizable, a larger number of participants needs to be recruited who will come from different demographic backgrounds.

Another limitation of this dissertation is that the findings mainly reflect the perspective of the participants. It does not reflect the user-observation data. However, one thing needs to be noted that it is very difficult to study some taken-for-granted knowledge, such as language literacy.

As discussed earlier, existing mHealth apps are addressing a wide range of health issues However, all study participants mainly focused on health issues where the solutions are generally more familiar to laymen (e.g., diet, exercise, and sleep).

In 24 interviews and with nine skills, the study participants were asked unplanned probing questions (3.54 probing questions per participant) that explicitly asked them if a given skill was needed. Given that 69.1% of these questions were answered in the affirmative (the skill is required to use mHealth apps), it may have been that the researcher's authority led the study participants to be inappropriately guided to the answer they felt was expected of them.

6.5 Future Work

Findings of this dissertation open up several future research directions which can be summarized below.

6.5.1 **Meta-Analysis**

It has been pointed out above that health and technology researchers paid considerable attention to understanding how users have been using mHealth apps for health and disease management. However, no one has tried to identify the skills needed for mHealth Literacy.

Norman and Skinner conducted a comprehensive literature review to identify the skills that constituted eHealth Literacy (Norman & Skinner 2006b).

The first step of the meta-analysis process, i.e., the collection and selection of all relevant research articles, has already been completed. After exploring relevant papers from the healthcare domain (Fanning, Mullen, & McAuley 2012; Lustria et al. 2013; Mosa, Yoo, & Sheets 2012), the following eight major databases were searched for articles: Medline, ACM Digital Library, Ebsco, IEEE Xplore, Science Direct, Web of Science, PsycINFO, and Scopus. The following search string was used with all of these databases to collect the relevant articles:

((mobile phone OR cell phone OR smartphone) AND (health OR healthcare) AND (apps OR app OR applications OR application))

After selecting 172 articles for meta-analysis, the next step will be to code all these articles using the same coding scheme mentioned in Table 9 in section 3.1.2.

6.5.2 **mHEALS (mHealth Literacy Scale)**

As discussed in section 2.3.2, Norman and Skinner (2006a) designed eHEALS, an 8-item measure of eHealth Literacy scale, to answer the question of how to assess a user's capacity for engaging in eHealth. They evaluated the properties of eHEALS through a six-month-long user study with 664 participants. Building on the concept of eHEALS, one of my research goals is to design mHEALS, an assessment scale to measure a user's capacity to engage in mHealth. The results and analysis found from this dissertation will help to design such a

measurement scale. A longitudinal study with hundreds of users will be performed to evaluate the efficacy of mHEALS.

6.5.3 **Automated Mapping Between mHealth Literacy and App**

As discussed earlier, it is a cumbersome task for a user to choose the right app. Another of my future research goals is to design an automated process that will map users' mHEALS level and preferences onto the features of thousands of mHealth apps and identify the most appropriate app for the user. Text-mining techniques will be used to achieve this goal.

Besides these, in future, I also want to explore the potential role of the doctors, other health professionals, and health insurance companies in selecting and encouraging the use of mHealth apps. Also, where the responsibility lies for quality control (accuracy of the information as well as usability) can be another potential future research direction.

6.6 Summary

This chapter first provided a brief summary of this dissertation followed by a recapitulation of the final study findings. Then it addressed the implications of the final study findings: how mHealth Literacy augmented the domain of Health Literacy, how mHealth Literacy differs from Health Literacy and eHealth Literacy, and how different skills of mHealth Literacy relate to each other. This chapter also discussed how mHealth Literacy may help to revolutionize the existing mHealth app industry, may help app developers design better mHealth apps, and may help policy makers and healthcare professionals to improve healthcare performance. This chapter also discussed some limitations of this

dissertation. Finally, this chapter discussed some potential future directions for the work begun in this dissertation.

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Appendix A: Recruitment Flyer for the Pilot Study

Hello, I am a researcher from the University of Illinois at Urbana-Champaign in the US. I am investigating mobile phone-based healthcare applications (or app for short): **What literacy does a user need to receive health benefits from using a health-related app on a smartphone?**

Do you use any mobile health apps such as calorie count or food intake, step count, blood pressure monitor, diabetes control, running tracker, and weight management, etc.? If yes, please reply so that I can interview you briefly.

Thank you.

Shameem Ahmed

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217-979-9901

Appendix B: Consent Form for the Pilot Study

In accord with rules about informed consent, this document explains what research we are doing, informs you of your rights, and asks for your voluntary consent to participate. The research is led by Dr. Kate Williams and Shameem Ahmed of Graduate School of Library and Information Science department at the University of Illinois at Urbana-Champaign in the US.

In this study, we investigate the characteristics of the users of mobile phone-based healthcare applications (or app in short) to answer the following research question: what is mHealth Literacy? In other words, what does a person need to know in order to get health benefits from using a health-related app on a mobile phone? By participating in this research, you are helping to create a better understanding of how people are currently using mobile phone based health apps.

Participation will involve a face-to-face or phone/skype interview of approximately one hour in length. During this interview, you will be asked some questions and your answers will be audio recorded with your permission. There are no risks involved in participating in this research other than those involved in ordinary everyday life. Participation is entirely voluntary and you may skip any questions you do not wish to answer with no negative consequences. You can also stop participating in the research.

The materials from this research may be used for research presentations and publications. Your identity, participation, and answers will all be kept confidential by the research team, safeguarding your privacy.

If you have any questions regarding the research, please ask. You can also email or call the lead researchers collect at any time (Shameem Ahmed and Kate Williams, katewill@illinois.edu or 217-244-9128). If you have any questions about your rights as a participant in this study or any concerns or complaints, please contact the University of Illinois Institutional Review Board at 217-333-2670 (collect calls will be accepted if you identify yourself as a research participant) or via email at irb@illinois.edu. A copy of this document will be given to you.

☐ I understand the above and voluntarily agree to participate in this research.

☐ I consent to the audio recording of this interview.

Yes ☐ No ☐

Signature: _____

Printed name: _____

Email or phone number: _____

Date: _____

Appendix C: Interview Questions for the Pilot Study

Thank you for taking the time to participate in this research. I want to begin by, once again, verifying your permission to audio-record this interview. You are free to (a) discontinue participation in this study at any time (b) request that the audio recorder is turned off at any time and (c) pass on any question that you do not want to answer. Do you consent to this interview?

If yes, continue:

1. Tell me about the model and OS of your current smartphone.
2. For how long have you been using your current smartphone?
3. Did you use any other smartphone before?

   If yes, the follow-up questions:

   a. What was the model and OS of that phone?

   b. For how long have you used that smartphone?
4. What healthcare app are you currently using on your smartphone? What is the goal of this app?
5. For how long have you been using this app? How frequently are you using this app?
6. How did you get the information of this app at the very first time?
7. Did you install this app by yourself?

   If yes, the follow-up questions:

   a. Please share your experience of finding and installing this app.

   b. How hard was that?

c. Are you more comfortable now to install a new healthcare app?

8. Did you pay for this app?

   If yes, the follow-up questions:

   a. How much did you pay?

   b. How did you pay?

   If no, the follow-up question:

   a. Do you know how to buy a health app from the app store?

9. Please share your experience of using this app.

   Follow-up questions:

   a. Are you satisfied with this app?

   b. What features do you typically use and like?

   c. What features don't you like?

10. Using your own words, how easy or difficult was it to understand all the features and/or to interpret all the data provided by the app?

11. Do you think that the app helped you to get any health benefit? If yes, how?

12. Using your own words, what does a person need to know to get health benefits from a health app?

13. What do you consider a high-quality app versus a low-quality app?

    Follow-up questions:

    a. Have you ever seen an app you thought was inadequate?

    b. If yes, give the name of the app and why was it inadequate?

14. Do you usually share your data with others (e.g. doctor, family member, friend, social media, etc.)?

If yes, the follow-up questions:

a. To whom you usually share the data?

b. Why and how (e.g. via email, Bluetooth, simple copy-paste, etc.) do you share this data?

15. May I know your age and educational background?

Appendix D: IRB Approval for the Pilot Study

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Office of Vice Chancellor for Research

Institutional Review Board
528 East Green Street
Suite 203
Champaign, IL 61820

August 1, 2014

Kathleen Williams
GSLIS
LIS 131
501 E. Daniel St.
Champaign, IL 61820
M/C 493

RE: *mHealth Literacy: A Dissertation Pilot Study to Characterize the People's Ability to Use Mobile Phone-based Healthcare Applications*
IRB Protocol Number: 15055

EXPIRATION DATE: 07/31/2017

Dear Dr. Williams:

Thank you for submitting the completed IRB application form for your project entitled *mHealth Literacy: A Dissertation Pilot Study to Characterize the People's Ability to Use Mobile Phone-based Healthcare Applications*. Your project was assigned Institutional Review Board (IRB) Protocol Number 15055 and reviewed. It has been determined that the research activities described in this application meet the criteria for exemption at 45CFR46.101(b)(2).

This determination of exemption only applies to the research study as submitted. Please note that additional modifications to your project need to be submitted to the IRB for review and exemption determination or approval before the modifications are initiated.

We appreciate your conscientious adherence to the requirements of human subjects research. If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact me or the IRB Office, or visit our website at http://www.irb.illinois.edu.

Sincerely,

Rebecca Van Tine

Rebecca Van Tine, MS
Assistant Human Subjects Research Specialist, Institutional Review Board

c: Shameem Ahmed

telephone (217) 333-2670 • *fax* (217) 333-0405 • *email* IRB@illinois.edu

Appendix E: Recruitment Flyer for the Final Study

I am a researcher from the University of Illinois at Urbana-Champaign. Currently, I am living in Memphis, TN. I am investigating mobile phone-based healthcare applications (or app for short): what literacy does a user need to receive health benefits from using a health-related app on a smartphone?

Are you 18 years of age and older? Do you use any mobile health apps such as calorie count or food intake, step count, blood pressure monitor, diabetes control, running tracker, and weight management, etc.? If yes, please call me at 217-979-9901 or send me an email at ahmed9@illinois.edu so that we can set up a time and place to interview you briefly.

In the interview, I will ask some questions regarding your use and experience of mobile phone based healthcare app you are currently using. You will also show me different features of your app on your smartphone or tablet. I will not collect any personal data from your app. Finally, I will walk you through another app that does the same or related thing, only differently. The interview will take approximately 60-75 minutes.

You will receive 20 dollar cash for your participation.

Shameem Ahmed

ahmed9@illinois.edu

217-979-9901

Appendix F: Consent Form for the Final Study

In accord with rules about informed consent, this document explains what research we are doing, informs you of your rights, and asks for your voluntary consent to participate. The research is led by Dr. Kate Williams and Shameem Ahmed of Graduate School of Library and Information Science department at the University of Illinois at Urbana-Champaign in the US.

In this study, we investigate the characteristics of the users of mobile phone-based healthcare applications (or app in short) to answer the following research question: what literacy does a user need to receive health benefits from using a health-related app on a smartphone? By participating in this research, you are helping to create a better understanding of what literacy a person should have to use mobile phone based health apps to receive health benefits.

The interview will have three separate sessions. At first, we will ask some questions regarding your use and experience of mobile phone based healthcare app you are currently using. Then, you will show us different features of your app on your smartphone or tablet. We will not collect any personal information from your app. Finally, we will walk you through another app that does the same or related thing, only differently. The interview will take approximately 60-75 minutes.

The entire interview session will be audio recorded. Also, some field notes might be taken in the paper during the interview. There are no risks involved in participating in this research other than those involved in ordinary everyday life. Participation is entirely

voluntary and you may skip any questions you do not wish to answer with no negative consequences. You can also stop participating in the research. You will receive 20 dollar cash for your participation.

The materials from this research may be used for research presentations and publications. Your identity, participation, and answers will all be kept confidential by the research team, safeguarding your privacy. In published results, your information will be anonymized or reported only in summary fashion.

If you have any questions regarding the research, please ask. You can also email or call the lead researchers collect at any time (Shameem Ahmed and Kate Williams, katewill@illinois.edu or 217-244-9128). If you have any questions about your rights as a participant in this study or any concerns or complaints, please contact the University of Illinois Institutional Review Board at 217-333-2670 or via email at irb@illinois.edu. A copy of this document will be given to you.

I understand the above and voluntarily agree to participate in this research.

Yes ☐ No ☐

Signature: _____

Printed name: _____

Date: _____

Appendix G: Interview Questions for the Final Study

1. Would you please tell me your full name?
2. For how long have you been using a smartphone?
3. What healthcare app(s) are you currently using? For how long have you been using this app(s)? How frequently are you using this app(s)?
4. Please share your experience of installing this app. Did you install this app by yourself?
5. How did you learn to use this app?
6. What were the major challenges in using and learning how to use this app?
7. What were the major breakthroughs in using this app?
8. Tell me about your struggles and victories with this app.
9. Do you feel your health has improved after you started using this app?
10. What, if any, is the evidence for that improvement? Could you please explain or share an example?
11. Do you talk to anyone about your app use? If yes, who are they (family, friends, colleagues, etc.)?
12. Do you seek and/or get help from anyone about using this app? If yes, who are they (family, friends, colleagues, etc.)?
13. Tell me about an instance of help you sought or received? Who helped you, what happened?
14. Do you involve your doctor or healthcare professional in your app use? If yes, how? Did you share your data with them?

15. Tell me about a time when you talked with your doctor or other health professional about this or any other healthcare app.

[Interviewee will show the interviewer how he or she uses the app in question]

16. Can you please walk me through the healthcare app you are currently using?

[After finishing the walkthrough]

17. What are the features of this app that you typically use?
18. What is your favorite aspect of this app?
19. What is the most challenging aspect of using this app?
20. Do you have any additional comments on healthcare apps, what you have said earlier, or anything else related to healthcare apps that you want to share with me?

[The interviewer will walk the interviewee through another app that does the same or related thing, only differently]

21. What are the major differences you have found between these two apps?
22. What would be the biggest challenge in using or learning how to use this new app?

[Questions on mHealth Literacy]

23. Considering all your experiences with the app you are using and the new app I showed you, according to you, what basic skills or knowledge should a person have to get health benefits from a health app?
24. Why do you think a person should have these basic skills or knowledge?

25. According to you, what are the challenges a person may experience if he or she does not have these skills?
26. Is there any additional skill that you consider to be useful for getting a better experience with the healthcare apps?

[Few more final questions before finishing the interview]

27. What is your current occupation?
28. Would you mind telling me your age?
29. Would you mind telling me your highest educational degree?
30. What city/country are you from?
31. Can you suggest anyone else who uses a healthcare app that I could contact about participating?

Appendix H: IRB Approval for the Final Study

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Office of the Vice Chancellor for Research

Office for the Protection of Research Subjects
528 East Green Street
Suite 203
Champaign, IL 61820

May 26, 2015

Kathleen Williams
GSLIS
131 LIS
501 E. Daniel St
Champaign, IL 61820
M/C 493

RE: *mHealth Literacy: Characterizing People's Ability to Use Smartphone-based Health-related Applications*
IRB Protocol Number: 15876

EXPIRATION DATE: 05/25/2018

Dear Dr. Williams:

Thank you for submitting the completed IRB application form for your project entitled *mHealth Literacy: Characterizing People's Ability to Use Smartphone-based Health-related Applications*. Your project was assigned Institutional Review Board (IRB) Protocol Number 15876 and reviewed. It has been determined that the research activities described in this application meet the criteria for exemption at 45CFR46.101(b)(2).

This determination of exemption only applies to the research study as submitted. Please note that additional modifications to your project need to be submitted to the IRB for review and exemption determination or approval before the modifications are initiated.

We appreciate your conscientious adherence to the requirements of human subjects research. If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact me at the OPRS office, or visit our website at http://www.irb.illinois.edu.

Sincerely,

Rebecca Van Tine

Rebecca Van Tine, MS
Human Subjects Research Specialist, Office for the Protection of Research Subjects

c: Shameem Ahmed