

AN EXPLORATORY STUDY OF mHEALTH TECHNOLOGY ACCEPTANCE FOR
TYPE 2 DIABETES SELF-MANAGEMENT AMONG ADULTS IN LATER LIFE

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ABSTRACT

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An Exploratory Study of mHealth Technology Acceptance for Type 2 Diabetes
Self-Management among Adults in Later Life
(Under the direction of Sandra Greene)

In 2011, the Center for Disease Control and Prevention (CDC) reported that diabetes affects 8.3 percent of the entire U.S. population. These numbers continue to rise, and they increase as people grow older; about a million people between 45 and 65 were newly diagnosed cases in 2010. Further, as of March 6, 2013, a study commissioned by the American Diabetes Association cited that diabetes costs have risen from \$174 billion to \$245 billion in 2012; which is a 41% increase in the numbers from five years before. Astronomical costs provide evidence that the link between self-management and healthier outcomes has not been effective. Without systems that make it easy for people to manage their disease, along with some support in doing so, these numbers will continue to rise.

mHealth systems have shown efficacy in improving health outcomes. mHealth is the application of wireless technology to deliver or enhance healthcare services and functions, while allowing patient-centered mobility. More specifically, the mHealth product used in this research is a diabetes self-management system that can provide real-time, contextually relevant content and patient coaching, and a means of provider support from sophisticated data trends and pattern analysis based on patient input of blood glucose (BG) values – all via the patient's cell phone.

A modified version of a previously used Patient Technology Acceptance Model guided my research to look at factors that could influence acceptance of mHealth technology for use in this population made of up limited mobile phone users, within three domains: beliefs, attitudes, and practices; external facilitating conditions; and patient-centered antecedent factors.

Using qualitative research and analysis methods, I conducted in-depth interviews with adults in later life and gained insight into my research questions. The results of this research can inform recommendations for product design and development, marketing outreach, and product implementation and training. Finally, the plan for change would allow leadership in both industry and the public health community to use the research recommendations in a systematic, standardized way that could affect this populations' acceptance and ultimate use of mHealth technology for type 2 diabetes management.

With love and gratitude to my grandmother, Dorothy B. McNeil, and my mother, Dottie M. Simmons. You have always encouraged me to have strong faith in God, and instilled in me strength of character to know that if I start something, then I already have everything I need to finish it – no matter what rough patches or obstacles may come my way. To my close family and best friend (Aunt Carol, Aunt Judy, Ashley, Kailey, and April), thank you for always providing me with unchanging, unwavering stability, and support in so many ways, and the constant motivation to reach my goals.

“What lies behind us and what lies before us are tiny matters compared to what lies within us.”

- Ralph Waldo Emerson

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LIST OF ABBREVIATIONS

mHealth	Mobile Health
ICT	Information and Communication Technology
BG	Blood Glucose
HbA1c	Hemoglobin A1c
MPT	Mobile Prescription Therapy
TAM	Technology Acceptance Model
PTAM	Patient Technology Acceptance Model
UTUAT	Unified Theory of User Acceptance of Technology
PI	Principal Investigator
PWP	Patient Web Portal
mHealth D ²	mHealth Diversity and Diffusion
CCF	Community Care Facilitator

CHAPTER 1: INTRODUCTION

*“Public policy should continue to provide incentives to developers of technology while guaranteeing that resulting innovations are **available, affordable, and acceptable** to patients in later life and boomer families who are low income, poorly educated, and less tech savvy.”*

-Coughlin, J.F. et al. 2006

I have always had a passion for health program development that provides training, resources, and overall empowerment for people to live healthier lives. While working at a healthcare technology company, I questioned the acceptance of a particular self-management product by some people and not others. This acceptance was spurred by speaking with members of the community who seemed less enthusiastic with using it, during routine product testing. Statements like “Oh no honey, I don’t want to push the buttons,” indicated that something needed to be done if the technology was going to help everyone, not just those already technologically inclined. It was this experience that brought me back to focusing on my passion for health disparities. This experience has also driven my curiosity for technology acceptance and how I could make an impact to ensure broad acceptance by all.

A. The Issue: Diabetes

In 2011, the Center for Disease Control and Prevention (CDC) reported that diabetes affects 25.8 million people in the United States (“CDC - 2011 National Diabetes Fact Sheet - Publications - Diabetes DDT,” n.d.), or 8.3 percent of the entire U.S. population, and of that number, 7 million still do not know they have the disease. These numbers continue to rise, and increase as people grow older. In 2010, it was estimated that about a million people between the ages of 45 and 64 were newly diagnosed diabetes cases (“CDC - 2011 National Diabetes Fact Sheet - Publications - Diabetes DDT,” n.d.). Diabetes is the seventh leading cause of death in the U.S., and it is a major contributing factor for heart disease and stroke. But it is not just the U.S.; the problem is global and pandemic. The World Health Organization (WHO) reports that 347 million people worldwide have diabetes, and projects

that in another 20 years, deaths in the world attributable to diabetes complications will increase by two-thirds (“WHO | Diabetes,” n.d.).

Diabetes is a chronic condition in which the pancreas does not produce enough insulin, or the body does not use the insulin that it does produce efficiently. Insulin is the hormone that regulates blood sugar in the body. A person’s blood glucose (or blood sugar) can increase for a variety of reasons, from eating too many carbohydrates to not taking their diabetes medication as prescribed; or, they might not know it is high because they are not monitoring as they should. When blood sugars are not controlled in a person living with diabetes, it can lead to a hyperglycemia (consistent high blood glucose) and result in life-altering complications such as amputations, blindness, and kidney failure (“WHO | Diabetes,” n.d.).

The statistics presented for diabetes are indeed bleak, but there is hope in lifestyle changes that can prevent or delay onset of this condition. A healthy diet that monitors carbohydrate intake (as carbohydrates convert to sugar in the blood), regular physical activity, and maintenance of a healthy weight can aid people who are currently living with diabetes in preventing further complications, and help those without the condition to avoid it (“WHO | Diabetes,” n.d.). The American Association of Diabetes Educators (AADE) supports these self-management activities, as well as others such as healthy coping (to decrease stress and depression) and problem solving, in order to help patients better manage their diabetes (Funnell et al., 2010). This condition is definitely not a quick fix that can alleviate symptoms or complications through use of medication alone – the 8000+ hours outside of the clinical setting when many of these self-management activities occur

are vital for the person living with diabetes. Diabetes requires appropriate clinical decision-making in conjunction with effective self-management to prevent complications. In 2007, the U.S. spent \$174 billion dollars in indirect and direct diabetes medical costs (this includes time lost from work, etc.) (“CDC - 2011 National Diabetes Fact Sheet - Publications - Diabetes DDT,” n.d.). In 2011, The International Diabetes Federation (IDF) estimated that global healthcare expenditures were an upwards of \$465 billion U.S. dollars, and more than three-quarters of this amount is spent on diabetes care for people in later life between the ages of 50 and 79 (International Diabetes Federation, 2010). As of March 6, 2013, a research study commissioned by the American Diabetes Association cited that diabetes costs have risen from \$174 billion to \$245 billion in 2012; which is a 41% increase in the numbers from five years previous; the increased costs are attributed to higher financial burdens, more health resources used, and an increase in lost productivity (American Diabetes Association, n.d.). Such astronomical costs, especially for preventable complications, provide evidence that the link between self-management and healthier outcomes has not been effective for many diabetes patients. Without systems in place that make it easy for people to manage their disease, along with some support in doing so, these numbers will continue to rise. Due to the ubiquitous nature of mHealth, it can be part of a solution that helps people better manage their diabetes, if we establish how to best reach the people who need it most to encourage acceptance and use.

B. Background: Exploring the Evolution of mHealth

Information and Communication Technology (ICT) refers to the full scope of health care services delivery that is generally characterized by substituting and/or complementing

traditional face-to-face personal methods that support patient care with electronic communication and system networking capabilities to provide, exchange and/or facilitate exchange of health-related information (Bashshur, Grigsby, Krupinski, & Shannon, 2011). With ICT, networked computers and information systems allow for in-person contact, communications among providers and between providers and patients, and patient and provider access to sources of health information, decision-making and support systems. There are four domains of ICT: 1) telemedicine, 2) telehealth, 3) e-health, and 4) mHealth (Bashshur et al., 2011). Emerging technologies, as well as increasing sophistication of their functionality and innovative application in health care, drive these domains. Though there are some representations of the interconnected nature and overlap of these domains, it is important to distinguish and define these domains in the scope of ICT, because ICT is such a multidimensional concept, and meanings can vary depending on the context, technological configuration, application and interface uses. To this end, clear definitions will be useful in classification of the domains and constructing a more organized taxonomy for understanding and application (Pawar, Jones, van Beijnum, & Hermens, 2012)(Bashshur et al., 2011). They are described here from an evolutionary perspective.

Telemedicine

As the first health domain of ICT, telemedicine evolved in 1905, with the earliest known telephonic transmission of electrocardiographic information between providers (comparable to what later became fax transmission). The World Health Organization's Department of Essential Health Technologies defines telemedicine as:

The delivery of health care services, where distance is a critical factor, by health care professionals using ICT for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interest of advancing the

health of individuals and their communities. (World Health Organization, Department of Essential Health Technologies., 2003)

It is especially noteworthy to distinguish the domain of telemedicine, as many people use the term to refer inclusively to all systems, modalities, and applications that are described under ICT (Bashshur et al., 2011).

Telehealth

Decades later, in 1978, experts coined the term “telehealth” in order to expand the original scope of telemedicine by considering dimensions of health care that could be affected without the usual physical patient-provider contextual setting and physical interaction, then adding elements of patient and provider education and other patient care. Even more definitively, Field and colleagues wrote:

Sometimes the term telehealth is used to encompass educational, research, and administrative uses as well as clinical applications that involve nurses, psychologists, administrators, and other non-physicians. (Field MJ, 2002)

e-Health

By the late 1990s, electronic health (e-Health) comprised a domain of ICT characterized by increased functionality of the Internet and electronic data systems used to capture, analyze and exchange health care information (Bashshur et al., 2011). Eysenbach offers the following definition of e-Health:

E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology. (Eysenbach, 2001)

With the definition above, Eysenbach intends to be broad enough to depict that e-health is more than just “Internet and Medicine,” as was the general understanding of this domain as a “buzzword” in its early years. He wants the term to convey the dynamic environment and capabilities that the Internet can offer to health care (Eysenbach, 2001).

mHealth

By 2003, mHealth emerged and set itself apart as a separate domain through the personalization of networks with mobile phones. This emergence gave way to patient-centered care available anywhere due to the ubiquitous nature of the mobile phone and Internet connectivity. Istepanian and his colleagues, who are thought leaders in the field of mHealth, offer the most popularly cited definition of mHealth: “mHealth can be defined as the emerging mobile communications and network technologies for healthcare systems.” (Istepanian, Pattichis, & Laxminarayan, 2006)

Table 1: The Four Domain of Information and Communication Technology

Domain	Year of Inception	Summary of Distinction
Telemedicine	1905	Describes distance-based health care service delivery
Telehealth	1978	Extends beyond telemedicine’s care delivery to patient and provider education and other clinical/non-clinical service delivery
e-Health	1990s	Includes Internet-driven capabilities but does not necessarily denote remoteness
mHealth	2003	Focuses on use of wireless technology and on resulting patient mobility

Their definition includes emerging mobile communications, such as mobile computing, medical sensors, and network technologies for health care (Istepanian et al., 2006). They further describe mHealth as the evolution of e-Health systems that have progressed from traditional “wired” desktop systems (commonly referred to in the domain of telemedicine

as platforms), to more savvy wireless and mobile configurations. Pawar and his colleagues thought the Istepanian definition did not fully speak to the mobility of the person involved in the healthcare system; it focused too much on the mobile computing aspect. To this end, Pawar and colleagues offered the following definition to ensure a patient-centered approach:

mHealth is the application of mobile computing, wireless communications and network technologies to deliver or enhance diverse healthcare services and functions in which the patient has a freedom to be mobile, perhaps within a limited area.(Pawar et al., 2012)

More about mHealth

In its early days, mHealth was deemed to provide benefits such as: remote critical care; access to information at the point of care for better, more accurate, and swifter patient management; increased access to care, information and expertise in rural and underserved areas; personal health monitoring to generate warnings and actionable information (as well as to promote healthy lifestyles); better care coordination and management in emergencies and natural disasters; and information synergy from sensor technology that could provide better insight for the provider and patient regarding the patient's physical health state and management needs (Istepanian, Jovanov, & Zhang, 2004). In a few short years, we have experienced innovative mHealth technology leading to decentralization of health care, empowerment of both patients and providers, and more meaningful patient-provider interactions due to the timely and accurate exchange of healthcare information and data between members of a health care team. mHealth has set the stage for improving patient health outcomes and decreasing costs through quick and meaningful capture and analysis of larger amounts of data, in order to better understand the health of a patient and their health patterns over a span of time.

In late September of 2012, the mHealth Task Force released a pre-publication public draft, listing specific examples of mHealth (Goldman, Jarrin, & Trauner, 2012). These examples included medical devices that are used in multiple environments for remote monitoring, health- related software applications that allow patients ubiquitous interaction with their data, body area network sensors, such as for heart and pulse monitoring, that wirelessly monitor and send physiological data for further analysis and reporting. This list also named medical implant devices that restore function or sensing to non-functional limbs and organs, systems that allow for various data manipulations such as transfer, storage, and display through wireless (or wired) products, mobile diagnostic imaging that can be accessed virtually, and lastly, patient care portals that can be used for patient management by designated health care providers, such as nurses and case managers (Goldman et al., 2012).

So what are the key aspects of mHealth that make it advantageous above the other three domains of ICT? In short, the wireless connectivity that allows for expanded and continuous communication, the compact size and chargeability (and long life battery power) that allow for greater portability, and the computing power that supports a variety of multimedia software applications (Free et al., 2010); with the evolution of Smartphones, the ability to have all of these characteristics in one device is now possible.

As we see from the wide spectrum of mHealth examples listed above, mHealth can move beyond the function of a software application that a patient can download onto his or her cell phone to help track medications and symptoms, or a blood glucose monitor that collects values and perhaps even provides simple log reports of these values over time.

Even more valuable, a robust mHealth system can provide real-time, contextually relevant

educational content and patient coaching, and a means of clinical decision support for providers from sophisticated trend and pattern analysis (Bingol, 2012). mHealth experts asserted in 2006 that “the increased availability, miniaturization, performance, enhanced data rates and expected convergence of future wireless communication and network technologies around mobile health systems will accelerate the deployment of mHealth systems and services within the next decade.” (Istepanian et al., 2006)

The Concept Stimulus

Mobile Prescription Therapy (MPT), an mHealth technology solution, was utilized as a concept stimulus for the purposes of this study. WellDoc’s MPT system represents mHealth technology, clinical and behavioral science, and validated clinical outcomes combining to create a health care solution that was initially defined as “Mobile Integrated Therapy” (MIT) and is now recognized as this new category of treatment for type 2 diabetes (Bingol & Anthony Kouyate, 2012)(Peebles, Malinda & Iyer, Anand K., 2014). MPT holistically engages a patient in the self-management of their disease on a continuous basis. Further, it provides individualized, contextualized patient coaching and reminders for clinical visits, labs and exams. The longitudinal data that an MIT system can collect and analyze from acquired information (such as blood glucose, or BG values, or tracking of condition-related episodic events) can provide clinicians with more meaningful data to inform the decisions that they make for their patients.

MPT The technology that has been previously described served as the concept stimulus in this study. In the way of describing how the stimulus was used, the researcher gave an overview of some of the most distinguishing features of this system. A notable feature was the virtual patient coach that provides real-time coaching to patients on various aspects of

self-management. This coaching is typically the result of the patient interacting with the system using a data-enabled device (such as a Smart Phone, tablet, laptop, etc.), and inputting a clinical value relevant to their condition. For instance, if a diabetes patient enters their BG value at a specified reading time, such as before breakfast, the system provides the patient a message related to the actual value inputted, with feedback that is clinically, behaviorally, and contextually relevant based on the actual value. If the BG value is high, the system might render a message that gives suggestions on what the patient should do in order to bring the high BG down. If the BG value is within a normal range, the patient might receive a message that provides reinforcement for BG checking or overall education or inspiration for continued healthy self-care practices. If the BG value is low enough to be considered a potential health risk to the patient, the system will deliver messaging that prompts the patient to take appropriate actions to help them correct their BG, and reminds them to check it again to ensure that it is within a healthy range. Further, if the BG is low enough, the system will also suggest patient actions relative to seeking clinical advice and treatment. Another critical feature that underpins WellDoc's MPT system is the ability to analyze longitudinal data derived from patients, providers, or other members of the health care team, and provide trended feedback and reports to patients. The system is able to detect possible trends that might require further data points for analysis, such as more paired BG readings from bedtime and fasting over time to determine if the clinician needs to adjust medication. Similar types of data can be manipulated in order to provide clinical decision support to a provider between or before their patient's visit via displays of insightful data trends that could influence that patient's treatment plan.

C. Significance: Diabetes and mHealth

Given the diabetes landscape, there is a compelling need to explore mHealth interventions that will support self-management for patients of diverse demographic backgrounds, addressing and WellDoc is one of many health care technology companies that is establishing themselves as a provider of products and services that support patients' clinical and behavioral needs. In order to address the needs of intended users, companies that develop mHealth solutions for consumer use, conduct human factors testing (or design validation) on their products. The purpose of this testing is to ensure appropriate user interface and user experience outcomes. In short, the testing is done to ensure that the technology works as intended and is safe for specific groups of intended users.

For the reader's clarity, it is important to define the term "later life" prior to setting the stage for the impetus of this research. It is quite clear from perusal of literature in the gerontology and geriatric evidence bases, that this term has grown increasingly acceptable, and is used interchangeably with "elderly," "older," and "aging." Further, there is discourse in other social science fields such as sociology, social psychology and public health around the life course approach, that also use this term when describing latter stages in life (Lynch & Smith, 2005). Throughout this dissertation, the term "later life" will be used to describe the general age group of the people in which the researcher observed the phenomenon of interest, which was mid-fifty to mid-seventy, as well as the targeted age of the study sample in the proposed research, which is 60 to 74 (more justification for this age group is provided in Chapter 3). Moreover, and related to this proposal, peer-reviewed literature for diabetes also employs this terminology (Pompei, 2006).

As the facilitator of human factors testing process, I noted some interesting characteristics among a subset of participants. Though interviews with these participants did not uncover safety issues, there were some distinct barriers in using the technology among these individuals, who were all African Americans in later life. They experienced hesitation, difficulty and discomfort using the smartphone technology for the tasks presented, which would ultimately be the same tasks they would perform for diabetes self-management using the product. This phenomenon and the potential implications it could have for product uptake and use intrigued me. First, I wanted to explore whether this phenomenon was more widely applicable, or whether it was a coincidence among my small group of human factors participants. As many of these human factors participants expressed that they were not comfortable, or that they were limited or low-tech users, I was especially interested in exploring adults in later life and their barriers to mHealth use. For the purposes of this current study, the concept of being a “limited mobile phone user” was first self-assessed by the potential study participant when determining initial study interest. Upon recruitment, a participant’s self-designation regarding use was confirmed through the results of a validated survey instrument, and used as a pre-screening criterion for recruitment (as further described in Chapter 3). Given what I experienced with the participants as their preliminary reactions to use during human factors testing, I wanted to know what it would take for adults in later life with type 2 diabetes to accept and use mHealth technology. Further, the experience led me to ask other questions about the specific factors that might hinder or influence an older African American’s use of mHealth for diabetes management, and whether there were any differences in these factors than what would be found among a general population of adults in later life. After researching

the evidence around the phenomenon of interest, I understood that what I experienced might be associated with a concept called the “digital divide.”

In terms of the overall significance of the proposed study, Piette and Liang published reviews that portray how mobile phones have been used to improve diabetes-related outcomes; they depict some of the general challenges and potential for these technology-based interventions (Liang et al., 2011; Piette, 2007) (Joseph, 2006). Other reviews, such as one completed by Mulvaney et al in 2011, focused on evaluating the component features of various mHealth system designs, in order to see which ones were most efficacious for improving diabetes outcomes (Mulvaney, Ritterband, & Bosslet, 2011). Further, Holtz and Lauckner also evaluated studies that showed promise in using cell phones to help people manage their diabetes effectively (Holtz & Lauckner, 2012). It is clear that the mHealth world realizes the capabilities that mobile technology holds for improving diabetes outcomes with regard to assessing the patient, prompting patient behaviors and actions, educating and engaging the patient (Mulvaney et al., 2011).

Two Kinds of Disparities: The “Digital Divide” and Health

The “digital divide” is a phrase that is commonly used to characterize the access that some individuals have to new technologies in order to gain benefit from them, versus those who do not (Pinkett, 2003). The American Library Association offers a definition even more applicable to my phenomenon of interest, particularly because, according to Boyd, it stresses the inclusion of both “access to information through the Internet, and other information technologies and services” and in “the skills, knowledge, and abilities to use information, the Internet and other technologies.” (Boyd, 2002). A 1995 report by the National Telecommunications and Information Administration (part of the U.S. Department

of Commerce) first made the concept of “digital divide” popular. Since then, there have been three additional reports written about the concept, and the latter from 2000 uses national survey data to posit noticeable demographic divides that exists between people with different levels of education, income, race, age, and geography (Pinkett, 2003). Most of the data from more than ten years ago were based largely on availability and access to Internet and computer-based technologies, and in most cases internet use was equated to computer use (Hayes & Aspray, 2010). Pew Internet and American Life Project cites that in current times, the ICT considered in the still existing digital divide does not preclude developing technologies that are electronic and provide Internet access as well (such as cell phones, laptops, e-readers, and tablets) (Zickuhr & Smith, 2012). The ICT that Pew refers to is more aligned with mHealth technology tools of focus in this study. Further, despite the common characterization of adults in later life being “computer-phobic,” there is evidence that a growing segment of baby boomer retirees are exposed to computers at work and also continue to use them at home in retirement (Hayes & Aspray, 2010). These baby boomers are a part of the population included in this study.

According to Hayes and Aspray, “although there is a proliferation of new technologies that convey information, many health care providers serve vulnerable populations or vulnerable individuals who do not regularly use those technologies, do not feel comfortable with them, and may never use them” (Hayes & Aspray, 2010). The goal of my study was to find out which factors might actually influence acceptance of mHealth technology for type 2 diabetes management among adults in later life who are limited mobile phone users. I explored barriers that might keep those individuals in later life from using mHealth

technologies (as described in the Hayes and Aspray statement above), and factors that might influence acceptance of type 2 diabetes mHealth technology, within the context of a model called the Patient Technology Acceptance Model (PTAM).

As a subpopulation, the grave health disparity in African Americans with diabetes is apparent. African Americans are twice as likely to be diagnosed with diabetes and die from related complications as their White counterparts. African Americans are at a 77% increased risk of diagnosis than White Americans (“CDC - 2011 National Diabetes Fact Sheet - Publications - Diabetes DDT,” n.d.). Further, with regard to later life, diabetes plagues one quarter of African Americans between the ages of 65-74, and one in four African American women over the age of 55 has the condition (American Diabetes Association, n.d.; Office of Minority Health, n.d.). These statistics define a group with looming disparities and potential opportunities to employ mHealth technology strategies for patient self-management. The window of opportunity to impact this population also seems to be open, as challenges to ICT use among minorities are already being identified in the health care arena (Goel & Sarkar, 2012), and the use of mobile phones among African Americans is high. Eighty-seven percent of African Americans own cell phones, compared to 80% of White Americans; they also use more of the features that their phones offer (Horrigan, 2009). Despite some continued claims about the “digital divide” or lack of technology access for African Americans, nearly 2/3 also use wireless Internet (Goel & Sarkar, 2012). There was not enough evidence-based literature regarding both African Americans in later life and ICT or mHealth barriers for acceptance among African Americans to clearly identify a problem specific to the group observed during the humans

factors testing; further, only three studies found in the literature alluded to such barriers to ICT use within African American populations with differing age ranges (Artinian et al., 2003) (Glasgow et al., 1997) (Joseph, 2006). However, given the barriers identified for ICT acceptance and use by adults in later life broadly, and the current landscape of mobile use and opportunity to impact the general populations' interactions with mHealth, this study moved to concentrate on elucidating factors that influence mHealth acceptance for type 2 diabetes self-management among adults in later life who are limited mobile phone users. Further, the researcher included a mix of racial demographics in the study, reflective of those described in the "digital divide," that might indicate or lead to further exploration of differences that could support the general notion of a "digital divide" within this exploratory study.

In their 2011 text that describes use of ubiquitous computing and information technology for diabetes management, Hayes and Aspray recognize and promote the need for health information designers to be aware of the many challenges in attitudes, demographic differences, and disparities described above (Hayes & Aspray, 2010). It is for this reason that this research study contributes to the current body of ICT knowledge on equalizing access in spite of the "digital divide."

D. Purpose, Specific Aims, and Research Questions

The purpose of this research study was to explore factors of acceptance for mHealth technology use for diabetes self-management among adults in later life who are limited mobile phone users. The factors explored via qualitative methods in this research included those that were theorized to predict intention to use, and lead to actual use of web-based technology in an elderly population, in a previous study.

My aims in this research were threefold. First, I intended to examine literature relevant to information and communication technology use in diabetes management (of which mHealth technology is a part) and its use in populations of adults in later life. Second, I wanted to explore factors in three distinct domains that might influence acceptance of mHealth technology. Third, I aimed to use the qualitative findings for acceptance from the previous aim in application of how health leaders might promote use of mHealth technology for diabetes management among adults in later life who are limited mobile phone users.

To address the specific aims outlined above, research questions were developed. The main research question that guides this study is "What influences acceptance of mHealth technology for type 2 diabetes management among adults in later life who are limited mobile phone users?"

Aim 1 was addressed through literature review, and the related research sub-questions are as follows:

Research sub-question 1a: How has Information and Communication Technology (ICT), which mHealth is a part, been used for diabetes management?

Research sub-question 1b: What ICT strategies have been used in aging populations? Which have succeeded? Which have failed? Why?

Aim 2 was addressed through qualitative inquiry using the following research sub-question:

Research sub-question 2: From among three domains of factors, which factors might influence acceptance of mHealth technology for type 2 diabetes management among adults in later life who are limited mobile phone users?

Aim 3 was addressed through application of the study's findings in a Plan for Change by answering the following research sub-question:

Research sub-question 3: How can health leaders use this information to promote appropriate use of mHealth technology for diabetes management among adults in later life who are limited mobile phone users?

CHAPTER 2: LITERATURE REVIEW

This literature review will be presented in three parts, because each part has specific relevance to the purpose of the proposed study. This review and analysis of the peer-reviewed literature was approached from three different perspectives that give insight and frame the study with respect to 1) use of mHealth for diabetes management, 2) mHealth use barriers and unmet needs to consider for adults in later life, and 3) mHealth development and implementation and their effect on health disparities. As cited earlier, the scope of ICT is wide and variable, so Appendix A gives an overview of specific features of the mHealth technology included in each study.

A. Part I: mHealth and Diabetes Management

Just as the number of diabetes diagnoses continues to rise, so does the availability of mHealth applications that help a patient manage their diabetes; the number of apps available in iTunes increased by 400%, up from 60 in 2009 to 260 as of 2011 (Chomutare, Fernandez-Luque, Årsand, & Hartvigsen, 2011). Growth and interest in mobile technologies is due to their great potential to aid in the self-management of chronic conditions, as they are able to facilitate and support behaviors and related goals in ways that are not obtrusive to the patient. Also, they are favorable because information can be automatically pushed to the patient and easily accessed. These functions support a technology that is more likely to be integrated into an individual patient's lifestyle, and

have appeal, utility, and feasibility for patient use (Katz & Nordwall, 2008). Early studies of specific health care interventions with cell phones focused on text messaging, or short message service (SMS) messaging, to improve health care processes and outcomes. These studies realized improvements in asthma symptoms, HbA1c, medication adherence, stress levels, self-efficacy, and smoking cessation rates; healthcare processes improved in the way of quicker medical diagnosis and treatment, improved teaching and training, and fewer missed appointments (Krishna, Boren, & Balas, 2009). Even as recently as 2010, researchers were still focused on exploring mHealth through mobile phone text messaging as aids to body weight loss, reducing alcohol consumption, and sexually transmitted infection prevention and testing (Free et al., 2010). Though the use of text messaging showed potential, there are even greater benefits for both outcomes and health care processes when going beyond the use of SMS as a key function. Of specific interest, some studies that have looked at the use of mobile phones for diabetes management with this broader view, citing design features and qualities of “messaging” that may contribute to effectiveness and usability, such as the level of tailoring, time relevance (feedback that is immediately driven by patient interaction with the system), and behavior change techniques, as well as methods of data transmission and analysis for informed patient and provider decision-making (Mulvaney et al., 2011). In contrast, a review by Chomutare et al focuses on the design of mHealth for diabetes, and concludes that there is not an evidence base that supports good design practices for how various modular applications for diabetes management integrate to provide a seamless user experience (Chomutare et al., 2011). These applications, or features, include BG tracking tools, back-end analytics systems, and real-time feedback based on varying categories of BG values inputted by the patient. This

feedback is critical for patients to better recognize and understand patterns, solve problems, and change behaviors with regard to self-monitoring of their BG, carbohydrate intake, and insulin titration over time; and recommendations for self-care can be tailored according to patient input and data (Chomutare et al., 2011). This review also uncovered the need for mobile diabetes applications as a whole to include clinically based, personalized and structured education or feedback as a feature, as this feedback is what builds the self-efficacy and skills a patient needs to benefit from monitoring their blood glucose. Also missing consistently from current technologies are social media applications that would support a patient's social engagement with peers. In addition to education and social media, the Chomutare et al review recommends the following features as important in diabetes self-management per evidence-based clinical guidelines: diet management, weight management, physical activity, provider communication and patient monitoring, medication management, other self-care (eye, foot), physical activity, psychosocial care, labs and immunizations, and complication management (Chomutare et al., 2011).

The studies aforementioned have sophisticated features and design potential; they do not rely solely on SMS messaging as a means for providing content, and the content generated is individualized, tailored, and/or customized. They focus on incorporating an overall system design, and are representative of the types of mHealth studies that will be the focus of diabetes management interventions described in the remainder of this section, as well as what will be used as the concept stimulus in this study.

The five studies that follow note higher amounts of feedback, tailoring, and real time messaging, and thus, might be considered more robust interventions. In 2008, a randomized control trial (RCT) was conducted using a diabetes management system,

DiabetesManager® (Quinn et al., 2008). This mHealth system provided real-time feedback on BG values, displays medication administration schedules and reminders on the phone, and includes treatment recommendations based on high and low reports of BG that are generated from proprietary algorithms. The type 2 diabetes patients in the intervention group who used the system experienced 2.03% decrease in HbA1c, which was clinically and statistically significant, as were patient and provider satisfaction with the system. The providers, who received electronic logs of BG values with suggested treatment plans, reported that using the system helped facilitate clinical decision-making, yield organized patient data, and reduced patient data review time (Quinn et al., 2008). Similarly, Yoo et al conducted an RCT study that used both cellular phone technology and the Internet to look at the effects of a multifactorial intervention that targeted blood glucose and related factors such as blood pressure and weight control in overweight, hypertensive, type 2 diabetes patients (Yoo et al., 2009). The system, called Ubiquitous Chronic Disease Care (UCDC), sent alarms to the patients reminding them to measure their BG using the monitoring device that was attached to the phone, as well as their blood pressures and body weight. As soon as data was entered, patients received algorithm-driven messaging, as well as encouragement and other self-care reminders. The UCDC system automatically confirmed and recorded exercise times that were predefined according to patient schedules; both the algorithm-driven and exercise-related messages were via SMS. The system also sent healthy diet and exercise messaging and other disease-related education. Providers could view all of the patient reported data on BG, blood pressure, and weight on the Internet website, and they could send individualized recommendations back to patients. Among the type 2 diabetes patients in the intervention group, there were significant improvements in

HbA1c (about 0.5%) as compared to the control. There were also significant improvements in blood pressure and cholesterol levels, all major markers for increased risks of cardiovascular complications (Yoo et al., 2009).

Another RCT conducted by Farmer et al showed a potential need for type 1 diabetes patients to receive real-time decision support for medication dosing and changes in lifestyle behaviors, such as diet and exercise, in addition to nurse support and real time feedback via an mHealth system (Farmer et al., 2005). This study population was comprised of young adults 18-30 years old, and the intervention used real-time transfer of patient data with feedback of the results. There was also a phone-based diary for insulin, physical activity, and food. The last and most integral component was nurse-initiated support through clinical advice and structured counseling, including goal setting and development of patient action plans. Though the decrease in HbA1c between the intervention and control groups in this study was not significant, over the course of the study, the median BG value reported by intervention participants was lower, and a higher proportion in the intervention group experienced an HbA1c reduction of 0.7% or greater by the end of the trial. Further, intervention participants transmitted more BG values than did those in the control group, indicating potential value and acceptability of the system for this group of participants (Farmer et al., 2005).

Carbohydrate counting is an important part of comprehensive diabetes self-management that can be hindered by its complexity and educational support needs that patients might require around the topic. Rossi et al created a system called the Diabetes Interactive Diary (DID) in an attempt to simplify the training that type 1 diabetes patients needed to count carbohydrates correctly (Rossi et al., 2009). The resulting two observational studies

investigated the feasibility and acceptance of the DID, and the effectiveness of the system on metabolic control. The system consisted of a carbohydrate and bolus insulin calculator, and a feature enabling communication between the patient and his or her provider via SMS. The system guided and supported behavior change around diet, physical activity, and bolus insulin titration with feedback driven by an algorithm. Patients reported information around BGs, insulin doses, food choices, and levels of physical activity, and they received real-time feedback including suggestions on daily carbohydrate intake and insulin dose changes based on back-end automatic calculations, in addition to other therapeutic and behavioral advice. For the first feasibility study, the patients overwhelmingly considered the system easy to use and helpful, citing the carbohydrate counter and insulin calculator as the most useful functions; over 63% of patients said that it had changed their eating habits (Rossi et al., 2009). The second study on clinical effectiveness for metabolic control showed non-significant HbA1c decrease; however, fasting BGs (after a night's sleep) and postprandial (after meal) BGs decreased significantly (Rossi et al., 2009). Not only can carbohydrate counting be difficult for patients, but those who are new to insulin and/or those going through insulin adjustments usually require frequent visits back to their provider as well as contact via telephone. Based on this information, Turner et al conducted an exploratory study to look at provision of additional type 2 diabetes patient support through an mHealth system for insulin initiation that can be integrated into patients' day-to-day lives (Turner, Larsen, Tarassenko, Neil, & Farmer, 2009). The intervention consisted of a system called "t+ Diabetes," with a feature that supported real-time data transmission and feedback to patients on their cell phone based on BG testing results and trends. Other features allowed patients to input blood pressure and weight

values, and an electronic diary enabled patients to log insulin doses. The BG values were captured using a BG monitoring device connected to the cell phone and transmitted via Bluetooth. Given all of this information reported by patients, immediate feedback was given to them in the form of summaries and charts that helped them monitor as needed and make self-management decisions (accompanied by nurse review and follow-up). The initial experience and level of engagement of providers regarding the system indicated that it was a valuable support tool for helping to manage patients new to insulin and those who continued to have uncontrollable BGs. Patients reported both feeling more “in control” of their diabetes, and increased levels of self-efficacy in self-management, particularly for insulin titration (Turner et al., 2009). Patients also experienced a non-significant 0.52% decrease from the start of the intervention, but the change in HbA1c was not a specific clinical outcome of interest for this study (Turner et al., 2009). Furthermore, this type of integration of glucose monitoring devices into the mobile phone was studied elsewhere and also considered a useful tool for diabetes management with regard to automatic data upload (Carroll, Marrero, & Downs, 2007).

The five studies above show that, overall, mobile phone interventions that aim to effect glycemic control through diabetes self-management tend to reduce HbA1c values, and greater reductions are seen in those interventions that occur in a type 2 diabetes population. Having the ability to input, view and even send BG values might make a patient more attentive to them. However, a system that generates clinical feedback with information that a patient can use in self-management actions, such as the appropriate actions to fix a low or high BG, the amount of insulin or carbs to take, or clinically prescribed diet or physical activity changes, can prove even more beneficial for the patient.

The ability for a provider, whether a doctor or nurse, to review patient-reported data and send clinical feedback is also beneficial; using a BG monitor that is integrated with the mobile device decreases the chance for user error or other problems with self-report even more by making the transfer and collection of data seamless over the network. But, the fact that a user can simply track their BGs via a mobile device that is with them at all times should not be dismissed, as this circumstance leads to increased attention to the actual BG values for some patients. These studies show several instances where an algorithm is used in the back end of the system in order to generate user-specific clinical advice, based on patterns of values and other patient-reported data points. These algorithms are indicators of a system that can support a patient with exactly what they need, and be able to deliver that support in real time through a means that is always “on” and available. This support can be in the form of clinical or behavioral guidance, and is important for a patient’s overall ability to self-manage their disease.

Knowing that CDC statistics underscored how difficult it is for the majority of type 2 diabetes patients to adhere to self-care plans (CDC, n.d.), Katz and Nordwall wanted to test whether the Confidant mHealth system would support chronic disease self-management in a group of type 2 diabetes patients (Katz & Nordwall, 2008). This system collected data from a range of home monitoring devices, and then transmitted the data using Bluetooth technology from the patient’s cell phone to a main server. The server, in turn, sent the patient feedback in the form of a text message. In phase I deployment of the system, the messages that patients received only commented on their compliance with the system and meaningful data points were not collected for appropriate feedback customization to the patients. Nevertheless, a lowered HbA1c supported the feasibility and utility of the system,

and positive changes in patient self-efficacy and activities related to self-management. These results demonstrated that technology that provides tailored advice by gathering patient-specific information (name and confirmation of BG checking, in this case) will benefit the patient, and can enhance their ability to self-manage (Katz & Nordwall, 2008). Similarly, Faridi et al conducted another feasibility study to examine how the Novel Interactive Cell-phone technology for Health Enhancement (NICHE) would impact both self-management and clinical outcomes (Faridi et al., 2008). This mHealth system also used biometric devices to collect patient data on weight, physical activity and BGs, and transmitted them to an online server. In return, the patient was sent tailored feedback that prompted them to enhance their self-care behavior. The system indicated improvements of self-efficacy in the study population. Even though HbA1c decreased among the study population, there were no significant results indicated for any of the clinical outcomes of interest (Faridi et al., 2008).

The previous two studies were not robust in their original system feedback to patients, nor in the level of their disease education or behavioral motivation components, but they do further make the case for wireless transmission of biometric data, so that the patient spends less time and feels less burdened by record keeping and input (Faridi et al., 2008; Katz & Nordwall, 2008). Further, they support the use of tailored feedback that is specifically targeted to the patient, with easy to follow actions and behaviors, increasing the likelihood of patient attention and follow-through (Kreuter & Skinner, 2000). Both were proactive in realizing the potential of their system to improve self-management in patients, and stated the need for continued testing in larger population samples.

A few of the other studies reviewed do not possess as diverse a set of mHealth technology features as the ones cited above, but there are implications from these studies that are applicable to mHealth development efforts. For instance, usability testing of food registration technologies in a population of type 1 and 2 diabetes patients piloted approaches with a mobile phone, web-based application, and a photo blog using both the mobile phone and the PC (Årsand, Tufano, Ralston, & Hjortdahl, 2008). User comments indicated that this type of application that supports healthy eating habits should be integrated with those that support other critical self-management actions, such as BG self-monitoring and exercise. Specifically, the study participants commented that no matter what form of technology they used, simply recording and reviewing their daily dietary habits was motivating for healthier eating habits. They also cited that mobility and configuration of such technology was important to address their own unique needs. Lastly, they wanted rewards and educational content as a result of input in order to keep them motivated (Årsand et al., 2008). Another study based largely on texting of BG values by patients and subsequent review and comment by a provider after a span of time using the WellMate system, indicated two important points (Vähätalo, Virtamo, Viikari, & Rönnemaa, 2004). First, if the intent of the technology was to replace some of the patient's clinic visits, then this technology still proved very time-consuming from a provider involvement perspective. Perhaps cost savings would come in the form of less expensive providers who monitor patients using the device for communication and support. Second, this technology seemed to work best for those who were motivated to use it (Vähätalo et al., 2004). Though this latter point might be due to lack of randomization in this study's design, it brings up needs that could be addressed during technology training and implementation.

Training and educational materials could aid patients in understanding how the product works to help them, and convey a sense of novelty and excitement about the product and how it can fit into their daily life to benefit them most. Further, work has been done with type 1 diabetes that tests methods of insulin dose calculation based on an individual patient's lifestyle. The results show that using the Intelligent Neural Network for Suggesting Unambiguous Levels of Insulin via Need (I.N.N.S.U.L.I.N.) application to select food options, servings, and exercise, holds value in calculating insulin dosages (Curran, Nichols, Xie, & Harper, 2010). The benefit of their system is the central server that collects and analyzes data, and presents it to both patients and providers in ways that are actionable and user-friendly.

In conclusion, of the 11 studies reviewed, eight showed some positive decrease in A1c, a marker for improvement in blood glucose control in diabetes self-management. Of the remaining three studies, two were usability studies of mHealth technology, and one was a feasibility trial; none of these studies were looking at specific health indicators as outcomes of interest. The studies explored have given a greater understanding and broader overview of all of the features that can be included in mHealth in order to improve diabetes health. Of these specific studies, the following features seem to commonly align with A1c reduction: multiple modalities for user interaction, a defined role for the clinician and increased communication with the patient, multiple interventions for the patient that are tailored and/or adaptive in design, higher levels of real time interactivity, and greater amounts of feedback to the patient. For more information on the features included in these studies, see Appendix A.

B. Part II: mHealth and Adults in Later Life: Barriers and Unmet Needs

There was one study among those related to mHealth and diabetes management that had implications for use barriers in a population of adults in later life (Ferrer-Roca, Cárdenas, Diaz-Cardama, & Pulido, 2004). This study found that mainly young and elderly patients recorded their BGs and body weight, and they received text messages to acknowledge receipt of the information. The researchers asserted that the SMS diabetes system was really beneficial to the elderly population because they are known to have trouble controlling their diabetes. The study also revealed that since some of the elderly patients needed younger relatives to help them with data entry on the mobile phone, there was good reason to use biometric devices to automatically transmit this information, like the systems used by Katz and Norwald, and Faridi (Faridi et al., 2008; Ferrer-Roca et al., 2004; Katz & Nordwall, 2008).

Since many of the current ICT also link with a web portal for user access on a more traditional computer (or laptop), it's relevant to examine both 1) barriers related to age differences in general computer use, as well as 2) barriers that might be related to use of patient web portals by an older population (Osborn, Mayberry, Mulvaney, & Hess, 2010). First, designers of technology often do not consider the elderly as a potential user group, which puts this population at a disadvantage (Parsons, Turner, & Kearsley, 1994); but it is evident that this population needs to be considered in design. From Czaja and Sharit's research findings, people in later life typically have less experience with computers, and it is important that they be introduced to such technologies in ways that build their comfort, confidence, and self-efficacy (Czaja & Sharit, 1998). They also point out that seniors need

to experience success in task performance, understand both the benefits and usefulness of the technology, and be provided with adequate support during technology interaction.

Second, many forms of ICT also include a patient web portal, it is relevant to point out barrier-related highlights from a review of patient web portals (PWP) as they relate to an elderly population (Osborn et al., 2010). Evaluation of various patient web portals have shown success with the following: enhancing patient provider communications, improving a patient's ability to manage their disease, expanding a patient's access to health information, improving a patient's overall satisfaction with their care and improving patient outcomes. Many of the mHealth systems reviewed in the literature section above do include a web-based interface or portal through which the patient and/or their provider can access, input and review information. Studies show that a variety of ages are willing to use technology like PWP to manage their diabetes (Osborn et al., 2010). However, one study asserts that more extensive assistance and training might be needed to increase the use of PWP in a less computer literate population, like older populations (Kaufman et al., 2006). This particular study cites a cognitive usability framework for effective use of telehealth technologies by seniors with diabetes, called the Informatics for Diabetes Education And Telemedicine project (IDEATel). The researchers observed cognitive barriers in a group of computer illiterate, underserved seniors in three categories. For example, seniors had problems with perceptual-motor skills, including their abilities to grip the mouse, mouse/cursor coordination, ability to locate cursor on screen, and ability to click on links. With regard to their mental model of how the system works, seniors had difficulty with using widgets such as menus and navigation buttons, perceiving system feedback, and knowing how they would initiate an action on the system. Additionally, the

health literacy and numeracy skills of the seniors contributed to their lack of understanding when reading charts (row and cells/columns), seeing patterns of change, and being able to draw correct inferences from data displayed and understand other diabetes relevant materials and common terminology (Kaufman et al., 2006). Outside of the cognitive framework, it is important to note that these seniors also exhibited problems with their self-efficacy; when tasks were difficult or a participant was unable to complete it, their decreased self-efficacy affected their willingness to keep going. The usability and training studies led to system redesign, as well as focused training collateral and methods that aimed to reduce many of these system barriers described above that might keep older adults from using the system (Kaufman et al., 2006). Though the system described above did not incorporate use of a mobile phone, it considered many of the same modalities that are used in mHealth, such as a web portal interface, patient data uploads (i.e. for glucose values) and clinical data storage and analysis. The use of a mobile phone in the IDEATel intervention would be what Coughlin et al considers “...putting the panoply of devices and gadgets into practical use” (Coughlin, Pope, & Leedle, 2006). His team posits “the aging population, its health care needs, and the availability of a wide range of novel technologies are creating a wide range of possibilities to drive innovation and collaboration in disease management...” (Coughlin et al., 2006)

Another study looks at the use of a personal health record based system called “Personal Health Information Management System” (PHIMS), in an elderly and disabled population (Lober et al., 2006). This telemedicine project involved patient data entry (with optional provider assistance) for patient demographic and medical information, questions and comments from the patients to their providers, and medication listings. Almost 80% of the

patients needed help with both entering and updating information in the PHIMS; further, the majority of patients could not do either activity independently, largely due to computer anxiety and a lack of computer literacy (levels of computer illiteracy and anxiety affected their ability to do so even more than cognitive and physical impairment, and health literacy) (Lober et al., 2006). Of note, type 2 diabetes tends to have a debilitating effect on patients over time, due to issues like neuropathy and macular degeneration; both of these might be particularly relevant in the use of mHealth technology by an aging population. Due to functional limitations and computer inexperience cited as barriers in many of the studies above, Demiris et al published guidelines for the design of web-based, clinical systems for elderly patients related to system interface (i.e. hardware and software), user training and support, and system content (Demiris, Finkelstein, & Speedie, 2001). These experts say that the system interface needs to include web pages that are simple and clear, there should be alternatives for completing the same system action, navigation within the site should be clear, and proper visual displays, such as simple, large and representative icons, should be used, with much consideration given to the use of colors. Further, error messages should be understandable and assistance within the system should be easy to find; distracting sound effects and features should be limited, and all of these components should be tested with target users throughout the design phase. With regard to training and support, these researchers also believe that training is an important factor for people in later life and their ability to use technology for their health care. Training should be personalized in order to address individual barriers for system use, and it should include education around web navigation and assessment of web-based information (Demiris et al., 2001). In the way of content, links should be provided within the system that are useful

and understandable to the user, and the user should not have to go many levels “deep” to find information. Guidelines regarding the electronic communication between providers and patients, and security measures, should be followed. All of these guidelines that Demirisi described could help increase access and use of a clinical system in an elderly population that has functional limitations and/or inexperience with computer technologies (Demirisi et al., 2001).

Given all of the information available regarding levels of experience and capabilities with the use of ICT within an aging population, researchers have also explored technologies that use a diversified approach for design. Lorenz and Oppermann designed for diversity in a group of users aged 50 and up by developing and evaluating mHealth technologies that came in the form of various monitoring devices with user interfaces that ranged in level of difficulty (Lorenz & Oppermann, 2009). This study reminds us that as technology evolves, the range of devices and interfaces available for use is also growing; one person’s prior abilities and experiences, or wants and needs regarding system use, will not mimic those of another. This evidence especially supports the need for systems, as well as training and implementation support that can be customized and adapted to a specific user’s needs. Other countries, especially those that seem to have a particular reverence for the care of their aging population, have developed systems that encourage family connections and safety measures for people in later life in an effort to keep them living healthy. A system was used in Korea that was designed to achieve better glycemic control (HbA1C of less than 7%) and less hypoglycemia among seniors aged 60 and older with type 2 diabetes (Lim et al., 2011). This system was built upon a clinical decision support system (CDSS). This rules engine enabled patients to be more effective in their own self-management and control of

their BGs, and generated patient-specific messages in the form of instant feedback regarding medication or lifestyle (diet and exercise) changes. Also, if a patient's BG was low, then their designated family member received notification to ensure that the episode was treated. Overall, this system proved successful in achieving greater glycemic control and fewer hypoglycemic episodes than the control groups among elderly diabetes patients (Lim et al., 2011). This study is particularly useful in showing the utility of mHealth (referred by Lim et al as ubiquitous, or u-healthcare) in an older diabetes population when it gives automated real-time data and generates real-time, individualized feedback. Further, a system used in China, called iCare, was created to provide real-time mHealth monitoring of elderly patients, a personal health information system, medical guidance, and auxiliary functions that keep the patient safe throughout the day and night (Lv, Xia, Wu, Yao, & Chen, 2010). It makes use of biosensors to monitor physiological signs of the patients. A constant analysis system alerts family and emergency entities if any of the signals are ever off or abnormal. A GPS device enables interested parties to locate the person as necessary, and all physiological data is sent to a server to make up the patient's personal health information system. The system analyzes data, which enables providers to set thresholds of urgent conditions for the elderly, and provide tailored guidance on health-related actions. iCare is intended for overall distance-based health management, and the system has the ability to analyze data and send tailored, real-time feedback (Lv et al., 2010). Further, another system used in Algeria that monitors mobility, location, and vital signs of the elderly, utilizes a web portal that can be accessed by other members of the health care team (Bourouis, Feham, & Bouchachia, 2011). Lastly, a study that has reviewed issues around development and implementation of mobile monitoring technologies such as

u-Healthcare and iCare, purports two important points that are relevant to current and future mHealth development (Kang et al., 2010). First, there needs to be an infrastructure that can direct relevant data to specific members of a patient's health care team. If all the information goes to the provider all the time, especially without any analysis or clinical decision support tools that render useful, actionable information, it could result in information overload. Second, the study cites a critical need for the technology to be designed in ways that make it easy for adults in later life to use (Kang et al., 2010).

In conclusion, much literature exists that is related to use of ICT and mHealth among elderly populations. However, the fact still remains that there are multiple barriers facing this population that must be explored in order to reach this age group, especially to better serve their health needs. As Kaufman put it, "understanding the dimensions of this (digital) divide is essential for meaningfully engaging seniors in computer-mediated healthcare activities." (Kaufman et al., 2006) Now that these barriers have been established, this knowledge can inform the theoretical framework and methods for research in this population in Chapter 3, with the intent of ultimately engaging this population in using mHealth technology.

C. Part III: mHealth and Health Disparities

There is increasing evidence supporting the need for new Information and Communication Technologies (ICT) in health education and delivery. Not only does this include the growing number of minority populations using cell phones, but information about the role that such ubiquitous technologies can play in increasing healthcare access and self-management. Barriers and opportunities have been studied in minority populations to increase and

ensure uptake and usability in ways that can meaningfully impact clinical outcomes. Kaiser Permanente found significant differences between use of personal health records between White Americans and African American members; 30.1% of African American members registered for using a personal health record online, while 41.7% of White members registered (Roblin, Houston, Allison, Joski, & Becker, 2009). Further, minority populations are less likely to go online than White Americans. However, notable in this world wide web-based digital divide is opportunity in that minority Americans use mobile phones, and their related Internet functions and applications, more than White Americans (Horrigan, 2009). Pew Research Center studies show that “nearly two-thirds of African Americans are wireless Internet users, and minority Americans are significantly more likely to own a cell phone than their White counterparts,” and minority Americans use more of their phone’s data functionality and capabilities (Gibbons, 2011; Horrigan, 2009). Further, trends and usage in social media via the web support increasing options to use health-related ICT to address health disparities among minority populations, promulgating the growth of health related applications, interactive systems and tools that can support people engaging with and managing their health care (Gibbons, 2011). According to Dr. Michael Christopher Gibbons of John Hopkins, specific barriers to adopting such health ICT could increase or exacerbate the existing health disparities in minority populations (Gibbons, 2011). One of these barriers, from a human factors design and development perspective, is minority patient interaction with the technology in the care process; it may not serve those who need it most to develop the technology with assumed similarities in interaction across a population of users (Gibbons, 2011). A lack of addressing user needs could result in barriers that affect the safety and usability of the technology, and ultimately impact desired

clinical outcomes. Another category of patient utilization barriers specific to minorities are a lack of perceived benefit from the technology, and inconvenience or inability for patients to fit the technology into their everyday lives; other patient-related barriers include lack of trust, technical problems, lack of computer skills, ill-suited training, technology fears, and cognitive and/or physical disabilities (Gibbons, 2011). There are numerous opportunities for health ICT to address healthcare disparities by connecting minority patients and providers for more clinical monitoring that could improve clinical decision support and treatment changes. Health ICT could also increase access to the provider, and promote shared decision-making, patient engagement and patient empowerment, all integral in improving patient-provider relationships. Additionally, it could support provision of patient health education in ways that are relevant, accessible and appropriate to the patient (Gibbons, 2011), as well as support behavior modification through messaging, interaction, and social support (Roblin et al., 2009). Many major players in the field of health ICT recognize the potential that it has to eliminate health disparities, while emphasizing the importance of supporting patient engagement in ways that provide patients with meaningful, relevant, and actionable information that can be used to improve their own care; they also are proponents of monitoring whether members of disparate patient populations use such technologies, and establishing approaches that ensure that they do (Tirado, 2011). The latter aligns with how this study will contribute to this field of knowledge, specifically related to how people in later life accept and use mHealth technology for diabetes management.

Through the Affordable Care Act of 2010, the Federal government is placing increasing importance on health ICT being an integral component of Quality Improvement (QI)

initiatives, but little attention is paid to how the use of technologies could actually worsen the disparities that exist (Weinick & Hasnain-Wynia, 2011). Two noteworthy studies included in a systematic review of the effectiveness of such technologies in minority populations provides evidence that health ICT could be a useful, yet challenging approach in decreasing diabetes disparities. The first study demonstrated that patient access to a personalized, computer-generated report of diabetes values and goals improved HbA1c among an African American patient population (Levetan, Dawn, Robbins, & Ratner, 2002). On the other hand, even though the second study found that exposure to multimedia education about diabetes resulted in increased disease susceptibility, the authors underscored the practical challenges regarding technical support, testing, and user skills that need to be considered when developing health technologies for minority populations, as the lower-literacy study participants in this population did not spend as much time on the computer (Gerber et al., 2005).

Doctors Goel and Sarkar's ideas sum up this part of the literature review well when they posit that patient barriers for uptake and use of health ICT could contribute to health disparities if development and implementation of these technologies are not attentive to the needs of a diverse population (Goel & Sarkar, 2012). They substantiate what others have asserted as to the importance of patient perceived value and motivation to use the technology, which can be affected through targeted marketing and interventions.

Collaborative and coordinated efforts on the part of web designers, health systems, vendors, providers, and patients will be necessary in order to achieve improved health outcomes for all (Goel & Sarkar, 2012). This research can inform the three areas that Drs.

Goel and Sarkar assert as having an effect on the acceptance, uptake and use of health ICT like mHealth: the high level of complexity in the design of these technologies, lack of awareness of the technologies, and availability of training and technical support; the end goal of this research, much like theirs, is to ensure that there is “no patient left behind” (Goel & Sarkar, 2012).

D. Methods, Limitations and Conclusions

As each part of this literature review has its own section for discussion and implications, this chapter will conclude by tying all three of those sections together. Overall, if one considers mHealth with respect to 1) diabetes management, 2) use in an aging population, and 3) how it could affect health disparities in minority populations, then one would see that these realms have yet to be integrated to produce a school of thought around how the technology is used by a specific disparate population, African Americans in later life, for their diabetes management. There is definitely a paucity of literature for any empirical evidence linking directly to African Americans in later life and how they use cell phones for diabetes management. Opinions and evidence exists regarding the negative impacts on disparities if minority population access, uptake and use are not supported, but information was not found regarding specific studies that have assessed barriers and facilitators for mHealth technology acceptance so that the chances for such disparities are reduced among African Americans in later life. This lack of information is likely because mHealth is a newer technology in the world of ICT, and widespread adoption and use has only been growing in the past five to ten years. On a related note, with regard to this timeframe, the publication years for the majority of the literature that aligns with true mHealth system intervention components and functions of greatest interest in this study

are no more than five years old (unless inclusion of the article was necessary for other reasons).

Much of the "highlighted" literature for the diabetes management section was based on randomized controlled trials. I chose studies that were either targeting a type 1 or type 2 adult diabetes population, mostly due to the similarity in the nature of self-management actions between the two conditions, which largely resulted in similar intervention components. I excluded children/adolescents because of the amount of parental involvement to be considered, making much of the disease management activities and necessary intervention components focused on caregiver needs for patient support, rather than patient self-management (and the younger the child, the more parental guidance that would be necessary).

For the literature featured in Appendix A for mHealth and adults in later life (focused on barriers), only two of the five were directly related to studies in diabetes patients. Other studies were exemplary of using mHealth technology with an elderly population, which is still insightful to the research. Moreover, a few other articles of interest that informed this part of the literature review were from studies of mobile technology in the eastern part of the world, showing how progressive other countries are with using mHealth to support the health of their elders.

Literature that was connected to this third area around mHealth and health disparities was quite different from the rest; only three articles were highlighted that were found to support the barriers and needs of minority populations with regard to ICT, which were informative but not specific to mHealth. The remainder of the content discussed in this last section was based on reviews and chapters in texts that brought out the links between

health disparities and ICT, and the current challenges we face; sometimes, they even offered broad suggestions on what can be done to ensure that we do not perpetuate such disparities with technology, as it continues to evolve as a tool in chronic disease management.

For this literature review, more than 50 articles relevant to the three areas were considered, but there were 33 that met standards of inclusion and exclusion as described above. From that group, 19 provided the most support to the proposed study with regard to the intervention design, and barriers (see Appendix A).

E. Literature Review Summary

There are two research sub-questions previously cited that are addressed by this literature review:

Research sub-question 1a: How has Information and Communication Technology (ICT) been used for diabetes management?

ICT has been used in a variety of ways for diabetes management that have been covered in the scope of this literature review. Most noteworthy is that the majority of technology in related literature shows clinical improvements in diabetes outcomes. It is also clear that there is a wide variety of features and functions included in ICT technologies, including mobile phones, web-based portals, and other electronic monitoring devices. Finally, the pieces of such systems that relate most closely with clinical improvements are multiple modalities of interaction, communication with provider, tailored/adaptive design, and real-time feedback and interaction.

Research sub-question 1b: What ICT strategies have been used in aging populations?

Which have succeeded? Which have failed? Why?

The ICT strategies that have been used in aging populations align with many of the same technologies that were cited for use in the general population for diabetes management. Success of ICT in these populations seem to be tied to training and introduction to the technology, support, and understanding of use of the technology, especially with regard to ease of use. Failure can be linked with not including adults in later life in the design phase in order to address potential barriers up front; there are issues about visual interaction and interface that should be considered in design, especially in aging populations. Lastly, it seems that in countries that have an expressed reverence for supporting aging loved ones in place, there is intentional development and planning around the capabilities and communications with the social support system.

In this literature review, no evidence was found in the search that connected African American patients' "mental models" (i.e. their attitudes and beliefs about uptake and use, facilitating conditions, and antecedent factors), regardless of age, with their use of mHealth technology, especially regarding barriers and facilitators for acceptance, uptake and use. However, there was the Patient Technology Acceptance Model (PTAM) literature that focused on an older homecare population, and even though the technology used to develop that model was only a web portal with no mobile interface, it provided a foundational framework to begin the exploration of mHealth use in the specific population of interest (Or et al., 2008). Conclusively, these two studies further support my work's focus on wider population of adults in later life through a mixed composition in the study sample (not just

those of a specific race), and use of a previously defined model of technology acceptance as a starting point.

CHAPTER 3: METHODOLOGY

A. Theoretical Framework Development and Background

The theoretical framework for this study was built on an existing model, called the Patient Technology Acceptance Model (PTAM) (Or et al., 2008). The constructs in this model were specifically used to test predictors of technology use for homecare patients in later life with chronic disease. This model was developed from earlier work with the original Technology Acceptance Model (TAM), which included constructs of perceived ease of use and perceived usefulness of technology among employees in the corporate sector (Davis, 1989). The Unified Theory of User Acceptance of Technology (UTUAT) was also built from the TAM, and expanded to predictors of behavioral intention to use technology, which theoretically leads to the behavioral outcome of technology use (Venkatesh, Morris, Davis, & Davis, 2003).

As aforementioned, the previous research upon which this study is built identified predicting factors for acceptance of web technology for chronic disease management from PTAM (K.I & Karsh, 2006). However, prediction assumes that one would be able to compare the factors and conditions related to intended use with the end result of actual use or not. Since the mHealth technology used as a concept stimulus for this research is not widely available on the market for general consumers, it is not in the scope of this research to determine whether the factors and conditions studied would actually predict use; further, measuring prediction

would also lend to a quantitative research design. For these reasons, in the scope of this study, these factors were applied to mHealth technology for diabetes management to explore their application for influencing acceptance among adults in later life who are limited mobile phone users; other factors deemed important to the population of interest from the literature review were also included.

A modified version of the PTAM combines relevant constructs from the TAM and UTUAT to focus on three domains of factors that could influence acceptance of mHealth technology in the study population. The first domain includes beliefs, attitudes and current practices for mHealth technology use that could influence mHealth technology acceptance. The second domain includes external facilitating conditions and factors that could influence mHealth technology acceptance. The third domain includes patient-centered antecedent factors existing prior to the participants' exposure to the concept stimulus that could influence mHealth technology acceptance. It is theorized that the three domains described above are directly linked to behavioral intention to use mHealth, which will affect actual mHealth technology use behavior (K.I & Karsh, 2006). This research is focused on investigating the factors that might influence patient acceptance of mHealth technology for diabetes management among adults in later life who are limited mobile phone users.

Specific Constructs of the Theoretical Framework – Beliefs, Attitudes and Practices

Perceived usefulness and *perceived ease of use* are two key core constructs of the Technology Acceptance Model (Davis, 1989). Perceived ease of use refers to “the degree to which a person believes that using a particular system would be free of effort” or “the degree of simplicity associated with use of a particular system.” Perceived usefulness is defined as

“the degree to which a person believes that using a particular system would enhance his or her job performance.” Venkatesh refers to the constructs as effort expectancy and performance expectancy, respectively (Venkatesh et al., 2003). Davis, who developed the TAM model, asserted that if users found a technology easy, then they would consider it beneficial (Davis, 1989). These constructs are also predictors that have been shown to influence technology acceptance and use.

Subjective norm is a construct in the Theory of Reasoned Action, and is a predictor of acceptance according to the PTAM (K.l & Karsh, 2006). Within this construct, an individual has perceived social influence to perform or not perform a particular behavior. Further, patients are more likely to accept a technology if they believe that others who are important to them think they should use it.

Intrinsic motivation and *computer affect* are two psychological factors that appear to have an influence on technology acceptance and related use (Venkatesh, 2000). They refer to the attitudes of individuals towards a specific health information technology (K.l & Karsh, 2006). For the purpose of this study, computer affect will be called mHealth technology affect.

If people don't feel confident in their ability to use computers (low self-efficacy for computer use), then they might experience anxiety around using them.

Computer anxiety has also been associated with low levels of computer use (Compeau & Higgins, 1995). For the purpose of this study, computer anxiety will be called mHealth anxiety, and lower levels of mHealth anxiety might influence acceptance of the mHealth technology.

With regard to *self-efficacy*, which is part of Bandura's Social Cognitive Theory, the concept of computer self-efficacy can refer to how a person perceives his or her ability to use computers to accomplish a task (Bandura, 1978). Other studies have shown that self-efficacy influences an individual's adoption of information technology (Compeau & Higgins, 1995). In the PTAM model, a patient's computer self-efficacy is assumed to be a predictor of acceptance and use (K.I & Karsh, 2006). Therefore, in this study, mHealth self-efficacy was explored as a factor that could influence mHealth technology acceptance.

Perceived behavioral control is a construct in the Theory of Planned Behavior. In this theory, Ajzen refers to perceived behavioral control as an individual's perception of the ease or difficulty of performing a particular behavior, which, in turn, influences their intention to do the behavior (Ajzen, 1991). Studies have shown, and Or et al believe in the case of health technology for older adults, that a patient's perceived behavioral control will, in fact, influence acceptance and actual use behavior (K.I & Karsh, 2006).

Trust in mHealth technology is a new construct in this domain that is explored through this study based on concepts and empirical testing for trust factors that influenced patient use of an obstetric system (Montague, Winchester, & Kleiner, 2010). Montague's research in trust of medical technology yielded that patients' trust in care providers was the largest component of trust in technology (Montague et al., 2010). Trust is defined as "an emotional characteristic where patients have a comforting feeling of faith or dependence in a care providers' intentions with common dimensions such as competence, compassion, privacy and confidentiality, reliability and dependability, and communication" (Pearson & Raeke, 2000). These five dimensions of physician behavior are those on which patients are believed to base their trust. Lastly, the concept of trust was later found to be a newly

considered factor in the Technology Acceptance Model via a study that explored and modeled consumer perceptions that affect the use of mobile payment systems (Dahlberg, Mallat, & Öörni, 2003).

Specific Constructs of the Theoretical Framework – External Facilitating Conditions

This domain includes external facilitating conditions and factors that can be affected through patient involvement with entities external to themselves. *Training, implementation/on-going support*, and *social support* will be the foci of this domain, and are all new constructs in the way in which they are used in the modified PTAM model that guides this study. *Patient-provider trust relationship* is another external facilitating factor that this domain will explore based on aforementioned work in the area of patient medical technology acceptance (Or et al., 2008).

Specific Constructs of the Theoretical Framework – Patient-Centered Antecedent Factors

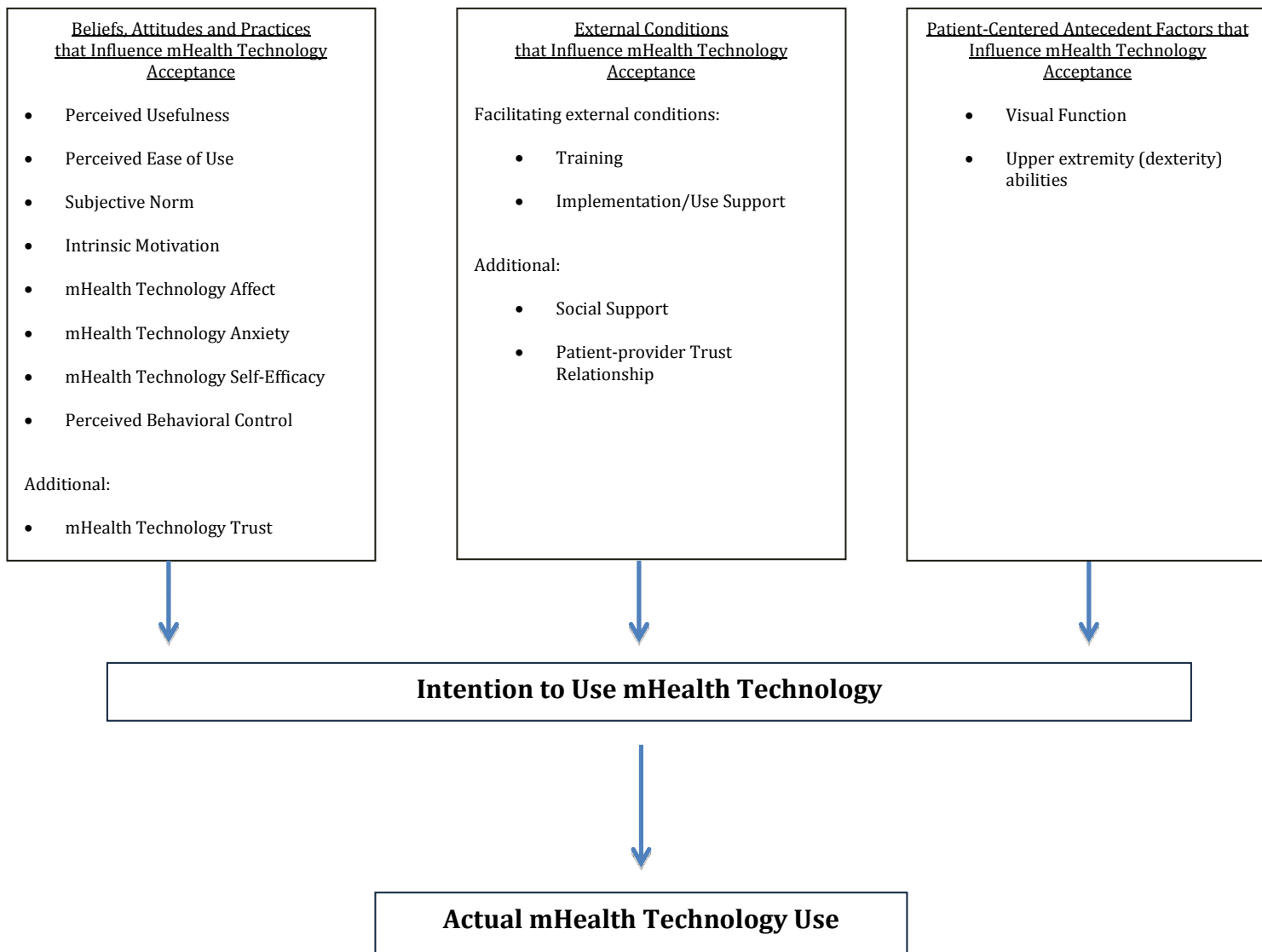
The last domain includes patient-centered antecedent factors as primary foci; these factors are related to the patient's physical abilities, and include the patients' *visual function* and *upper extremity (dexterity) abilities*. Further, these factors were also part of the original PTAM, consistent with the researcher's emphasis on consideration of factors related to being both an adult in later life and chronically ill, especially with regard to the progressive effects of type 2 diabetes (K.I & Karsh, 2006).

In conclusion, for the patient as the user, beliefs and attitudes for mHealth technology acceptance and the external facilitating conditions for mHealth acceptance could be

impacted through segmented marketing tactics. Both domains could also be affected through training content and delivery. Further, on-going use support and guidance for patients to implement the technology into their daily lives could be integral in both domains. The patient-centered antecedent factors of visual function and upper extremity abilities could be insightful for product design and development strategies with regard to accommodating needs that would best support members of this population with diabetes management.

Figure 1.

**A Theoretical Framework for Acceptance of mHealth Technology
for Type 2 Diabetes Self-Management among Adults in Later Life who are Limited
Mobile Phone Users**



*(based on modified version of Patient Technology Acceptance Model(PTAM)(Or et al., 2008)
used as basis for this study)*

B. Qualitative Research Design

The Principal Investigator (PI) of this study used a qualitative research study design for inquiry. Qualitative research allowed the researcher to learn about individuals as they experienced or conceptualized the topic of particular interest (Creswell, 2002). It also allowed for an in-depth and iterative data collection process of asking questions, and probing on an individual's responses, to get an array of emergent themes and new ideas as the process ensued. A qualitative study design was most appropriate in the case of studying mHealth acceptance among adults in later life who are limited mobile phone users, due to the technology's early stage in both development and its use for disease self-management (Creswell, 2002). This design allowed room to explore aspects of the topic with members of a population that might be less familiar with mHealth technology, and for introducing a concept stimulus into the discussion that could anchor perceptions to glean greater insight from the interview questions (Trochim, 2005). Further, the strategies associated with this qualitative approach allowed the researcher to study a small number of subjects within an intense and prolonged period of time in order to analyze the resulting data for "patterns and relationships of meaning" (Moustakas, 1994). The data gleaned allowed the researcher to gain even greater understanding of the real phenomena as experienced by the population of interest; she engaged with their perspectives through immersion and direct interaction with them and the mHealth technology that was being explored. This can pave the way for subsequent research that is more defined, specific and even quantitatively assessed, based on the descriptions gleaned from this more formative stage of exploration.

Setting the Stage for Data Analysis: The 'Framework' Method

The “framework” method was the selected approach for qualitative data analysis in this research study. This matrix-based approach provided guidance and structure for data ordering and synthesis. The ‘framework’ method was developed at the National Center for Social Research, and is used widely today by qualitative researchers. It is particularly useful for applied or policy relevant qualitative research for which the aims and objectives are set in advance. Since the aims of this research are specified, and the findings are intended to lead to the development of recommendations and a plan for change, this analysis approach was useful. Further, because data collection was structured and the study results would inform the research sub-questions within a defined population of interest, the ‘framework’ approach was most appropriate (Pope, Ziebland, & Mays, 2000). This method is similar to the more common approach of thematic analysis that uses codes to find recurring and significant themes. However, the thematic analysis approach can result in sections of the original data being separated from the complete body of original data, which can lead to misinterpretation of data, increasing subjectivity, and fewer links between the stages of analysis from how themes are developed to final findings and results (Firth & Smith, 2011). The key difference in applying the ‘framework’ method lies in: 1) how transparent it allows the data analysis phases to be, 2) how the stages of analysis are distinct yet interconnected, and 3) how true the two former points allow the researcher to remain to participants’ original descriptions. The transparency it brings to the analysis process is particularly important because it allows the researcher to explicitly and systematically apply the stages that guide the process, and document them, in case another researcher wants to build from the study or undertake a similar process (Firth & Smith,

2011). With respect to this study, following a method with such well-defined stages made it even more possible for the researcher to reconsider ideas and “rework” pieces during analysis. Further, due to the process being so well documented, the study’s rigor and credibility was enhanced (Huberman, A. M. and Miles, M., n.d.). (Ritchie & Spencer, 1994). Table 2 below shows the five key stages in the ‘framework’ method, and how they were applied in data analysis for this study(Pope et al., 2000). The application of this method will be further discussed later in this chapter under “Procedures for Analysis.”

Table 2: The Framework Method

Stage	Description of Stage Analysis	Output of Analysis for this Study
Familiarization	Immersion in the raw data by listening to tapes, reading transcripts, and studying field notes to begin to list themes and ideas, especially recurring.	Researcher listed key ideas, themes, and concepts as extracted from interview output.
Identifying a thematic framework	Identification of all of the key issues, themes, and concepts by which all the data can be examined and referenced develops into thematic framework that draws upon: 1) original aims and objectives, as pulled through in interview guide, as a priori themes 2) emergent issues brought up by participants 3) analytical themes that are noted early on from patterns in participant views, opinions, experiences	Researcher constructed an index of the data that was searchable and manageable for subsequent labeling and exploration; this index was used to assign categories to data in next stage.
Indexing	Application of the index systematically to the raw data.	Researcher labeled and tagged raw data in analysis software. Researcher refined index.
Charting	Abstraction and synthesis of data to “lift” them from their original context and rearrange it according to their respective thematic references. Individual charts for each key subject area, and entries made for several respondents on each chart.	Researcher developed charts with headings and subheadings drawn from the thematic framework. A chart for each key subject area, with entries was made for several respondents, will be included in analysis section of dissertation.
Mapping and Interpretation	Use charts from above to define concepts, map ranges and nature of phenomena, create typologies and find associations between themes. Identification of underlying motivations, patterns, and explanations to inform strategies that address the phenomenon of interest.	Researcher gleaned strategies to inform the recommendations and plan for change.

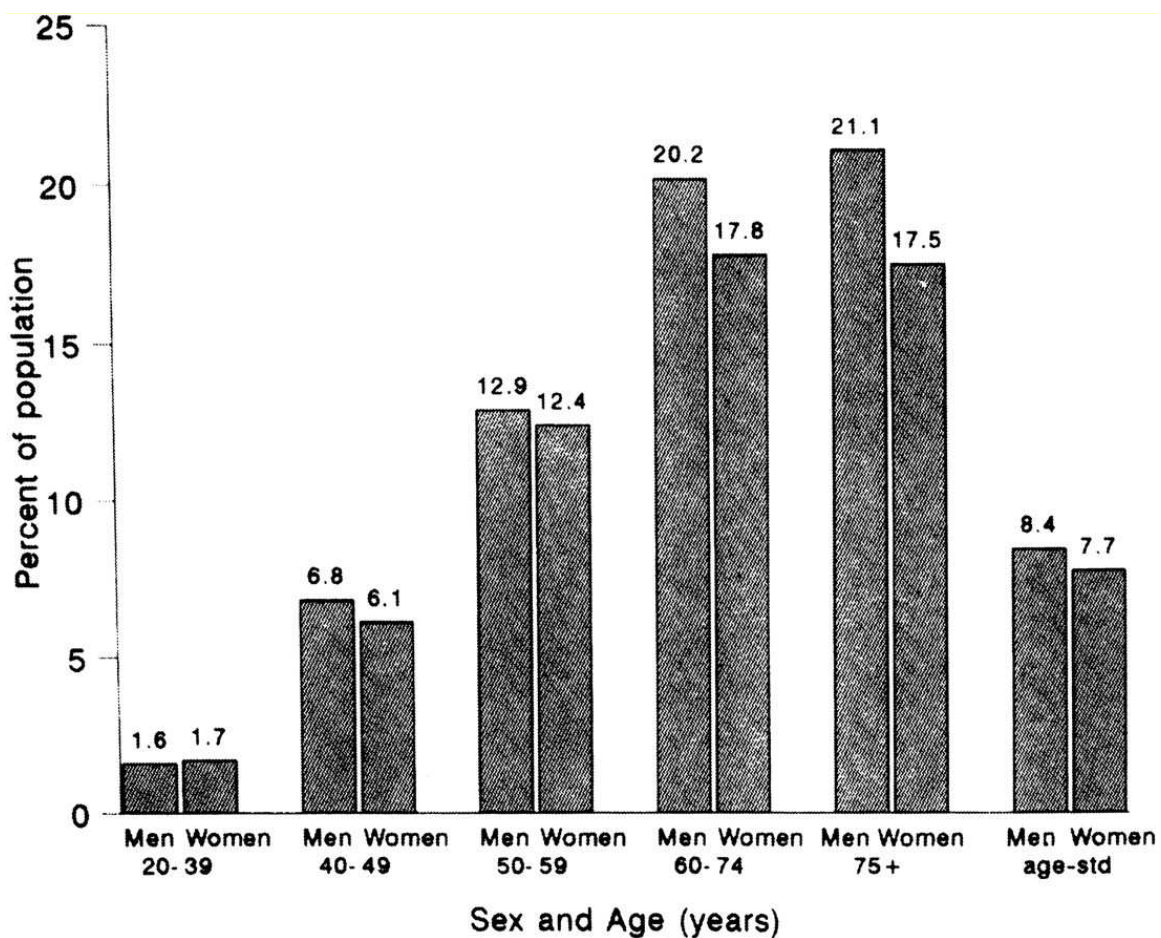
Data Collection: Sampling Justification and Inclusion/Exclusion Criteria

According to Creswell, when the researcher is the primary data collection instrument, their bias, personal values, and assumptions should be identified up front (Creswell, 2002). In this case, the PI of this study was directly influenced by 1) her former position as a behavioral scientist at an mHealth technology company; 2) her keen interest in health disparities; and 3) her desire to ensure wide-scale uptake of health technologies that can produce meaningful patient health improvements.

According to NHANES III Health and Nutrition Survey results (see Figure 3 below), over 50% of the population of American men and women with diabetes are between the ages of 50 and 74 (Meneilly & Tessier, 2001). Further, the population of men with diabetes nearly doubles from ages 50-59 to ages 60-74, and for women in those age groups it increases from about 12% to almost 18%, respectively. By the age of 75, distinctly increased risks of complications from diabetes, as well as related co-morbid cognitive decline, neuropathic, and visual symptoms, could be present (Meneilly & Tessier, 2001). For this reason, the PI chose to focus this study on a segment within an age demographic that is not yet 75, but is still included in the highest age prevalence category. This focus on adults in later life (defined in this study as ages 60 to 74) with type 2 diabetes allowed the PI to explore perceptions within the population at a point before potentially confounding health-related limitations (as mentioned above) that might affect their interest or functional ability to even consider mHealth acceptance or participate in the interview became a limiting issue. Further, research shows that a quarter of African Americans in the 65-74 year old age demographic are already living with diabetes (American

Diabetes Association, n.d.). Since the PI was interested in race as a potential determinant in the digital divide for mHealth, the sample intentionally included African Americans, in addition to White Americans. The PI targeted the 60-74 years of age of the life span for all participants to ensure inclusion of this most relevant age group of the U.S. population with type 2 diabetes.

Figure 2. Prevalence of diabetes in men and women in the U.S. population, based on the Health and Nutrition Survey, HANES III (Meneilly & Tessier, 2001)



The sampling frame for this study was developed with specific attention paid to the individuals with characteristics required to answer the research questions. Further, the PI wanted to recruit a sufficient sample size that would yield a thematic

saturation for analysis. The purposive sampling approach for this study was conducted for selecting pre-defined participants who would fit the inclusion and exclusion criteria of the study (see Table 4). The ultimate sample for this research included a mixed gender group of 9 African Americans and 7 White Americans (16 adults total), between the ages of 60 and 74, who had type 2 diabetes, and who identified via the pre-screening process as limited mobile phone users (and were functionally capable of completing the interview).

For my study, race was a particular determinant of interest for the digital divide, and I wanted to ensure enough racial variation for heterogeneity. The purposive sampling strategy allowed me to be informationally representative by making sure certain cases that varied on the pre-selected variable of race were included in the sample. Furthermore, Miles and Huberman posit that this method of sampling can assist with identification of subgroups, and comparisons that emerge from a small sample, such as this one, could be suggested as areas for future research (Miles & Huberman, 1994). Though race was not a primary focus of distinctive confluence in my study, if the findings suggested that it was indeed a variable that influenced potential mHealth technology acceptance for diabetes self-management, that might warrant further exploration of the phenomenon in future studies (Sandelowski, 2000).

Based on a study of average African American consent rates for in-person interviews, I chose to use the 80% consent rate as justification of the number of participants I targeted overall for recruitment (Wendler et al., 2006). It is important to keep in mind that this target for recruitment did not consider the thematic

saturation that might later dictate whether more or less participants were actually needed in the end. In order to achieve my sample size, I recruited 20 participants, with the intent of consenting 80% of that number, for a total of 16 participants in my final sample, following positive screening for the study criteria and consent. As half of that sample was African American, I also used the strategies suggested in the research for optimal recruitment, such as selecting one African American religious institution for recruitment, one medical facility that served a majority of African American patients, and one community center that was in an African American neighborhood and had majority African American patrons; flyers were posted at those locations so that patrons were aware of the opportunity to participate in the research. Table 3 shows the ideal sampling frame that was originally intended for recruitment.

Table 3. Ideal Sampling Frame for Recruitment

Recruitment site/source	Race of adult in later life with type 2 diabetes between the age of 60- 74	Total # targeted for recruitment	Desired number retained for final interview sample (after initial contact/screening)	
Church (African Methodist Episcopal)	White	0	0	
	African American	3	2	
Medical Facility	White	3	3	
	African American	3	2	
Community Center	White	2	2	
	African American	3	2	
Word-of-Mouth	White	3	3	
	African American	3	2	
		20	16	8 White, 8 AA

A tool from the Pew Internet and American Life Project was used for pre-screening to allow discernment of technology user types (Appendix C). Further, this same organization has found that limited users of technology are more likely to be of limited education, over the age of 65, lower income, disabled, ethnic minority, and non-native English speakers (Madden & Fox, 2006). The PI used specific determinants from this concept of the “digital divide” to ensure a heterogeneous mix of demographics in the study population (such as income and education), but these will not be used in analysis, as they were not systematically collected as data. As Patton suggests, commonalities such as income and education might emerge in my study results, but those will not be direct variables of interest in this research (Patton, 2001). For this limited sample, exploratory study, the PI will not be

including other ethnic minorities, as language or cultural barriers might exist and need to be accounted for that are outside of the scope of this study. However, with Miles and Huberman's point mentioned heretofore in mind, if variances are uncovered in study results from this purposeful sample, it could justify further research around mHealth acceptance relative to those specific races.

Data Collection: Recruitment

The purposeful sample in this study allowed the PI to recruit a small group of people nested in the context of the study's phenomena of interest, and to study them in-depth, producing information-rich cases from which more can be learned about what is of central importance to the research focus (Miles & Huberman, 1994),(Patton, 2001). In order to retrieve the sample, the PI recruited from organizations with which she is currently affiliated, such as community recreation sites, private medical practices, and faith-based institutions, in the District of Columbia metropolitan area (includes Maryland, D.C., and Virginia). The PI also used established connections with people who are living with type 2 diabetes in various states and who might be interested in participating in the study. The PI gained buy-in from key leaders and authority figures at the recruiting organizations and institutions. She secured permission at these sites to use flyers, word-of-mouth, church bulletins and service announcements, and postings on affinity group websites, to recruit study participants. Individuals who were interested and self-selected as being a limited mobile phone user and meeting the initial inclusion criteria of having type 2 diabetes, being 60-74 years old, and being African American

and/or White, contacted the researcher directly (via phone). At that time, the PI described the study aims and participant benefits. Afterwards, if the individual was still interested, the fourteen question Pew Internet and American Life Project Technology User Typology Questionnaire (Appendix C) was used as a screening tool to assess the potential participant's level of technology use. For ease in administering the assessment, the online version of this tool was used to automatically generate a user's technology typology. This tool was important in selecting participants because this research was more interested in perceptions of people who are limited mobile phone users. Thus, a person's level of technology use was another criterion for inclusion in the study population. Specifically, this research involved those who were segmented as "Stationary Media Will Do" which, using the evidenced-based, categorical definitions of Pew's technology typology tool, indicated a limited mobile phone user, per the definition that is applicable to this research. These are people who, as a result of a technology assessment, segment into one of the following four typologies, as described in the Pew Internet and American Life Project(Horrigan, 2009):

Desktop Veteran - These people are no more likely than average to have a cell phone (lower adoption rates than other groups. They are not "adventurous" with their cells; those with cell phones use them intermittently for phone calling and rarely for non-voice use. They aren't too enthused about how technology makes them available to others. They say it would be hard to give up their landline phones.

Drifting Surfer – Nearly half of these people use their cells for most of their calls, but only use the main function of calling (i.e. only occasional text messaging, if any). Few would find it hard if their cell phone was taken away; they say they would cope just fine. The mobile phone is not central to their lives.

Information Encumbered – These people prefer "old media," like their landline phone; they are unattached to the cell. Only 2% use cell for most of calls, and only 7% text daily (very few use non-voice data applications, one in nine do so on a

typical day). This group might feel overloaded by all the information that these newfangled devices bring to them, and most need help setting them up. They are also not thrilled how it makes them available to others.

Technology Indifferent – Only 7% of these people say that it would be hard to give up their cell phones. They use their landlines more than their cell phones; not many have even sent texts or taken pictures with their cell phone. Ten percent use it for most of their calls, few use it for any other functions (non-voice data applications) beyond that. Giving up their cell phone would not bother many people in this group. This group also prefers “old media,” such as landline phones and televisions.

For the remainder of this research, the user groups of interest will be called “limited mobile phone users,” and can be defined as people who have one or more of the following characteristics for the purposes of recruitment and screening (from the list below). Further, in recruitment materials, the PI used messaging that encouraged participation from people with these specific characteristics.

- Uses cell phone mainly to make and receive phone calls.
- Does not regularly send or receive text messages
- Does not regularly access other non-voice applications on their cell phone (i.e. goes online, etc.)
- Can be bothered by how “available” their cell phone makes them to others
- It would not be hard for them to give up their cell phone (would be harder for them to give up their landline phone)
- Might need help with setting up cell phone and/or cell phone functions from time to time
- Feel like they would cope just fine without their cell phone, as it’s not “central” to their lives

This screening process included questions that helped the PI determine the individual’s functional eligibility for continuation with the study, which was another criterion for inclusion. Since the PI recruited people living with at least one chronic condition, there could have been other potentially debilitating complications that could affect their participation in this study (i.e. any that could affect their ability to communicate, or the abilities to use eyes and fingers to explore and manipulate the

mobile phone). It was also important that any potential participant be able to take part in the in-depth interview session as intended. For this piece of the screening, three questions were asked that, when answered affirmatively, confirmed the potential participant's ability to complete the interview as intended. This included answering interview questions and using the concept stimuli. These three assessment questions were the following: 1) Will you be comfortable speaking with me in person for a question and answer based interview, for about an hour? 2) Are you able to see text (words) and images (pictures) on a cell phone screen? 3) Are you able to use your fingers/fingertips to press buttons on the cell phone touchscreen and/or your keypad? Following positive determination of eligibility for the study using the web-based tool and the three questions outlined above, the individual re-confirmed interest in participating in a one-hour in-depth interview about managing their diabetes using mHealth technology. Table 4 outlines the inclusion and exclusion criteria for this proposed study.

Table 4: Inclusion and Exclusion Criteria for Study

Selection Criteria for Study Participants	Inclusion	Exclusion
Type 2 Diabetes as Health Condition	Type 2 Diabetes ONLY OR Type 2 Diabetes AND Other Condition	Type 1 Diabetes OR Other condition WITHOUT Type 2 Diabetes
Age	Ages 60-74	Age <60 OR Age>74
Race	African American/Black AND/OR White (European American)	NOT African American/Black AND/OR White (European American)

Technology Typology	“Stationary Media Will Do”=Limited Mobile Phone User	“Motivated by Mobility”= NOT a “Limited Mobile Phone User”
Physical Functioning	Acceptable for study purposes	Unacceptable for study purposes

Consent forms were completed with individuals who were eligible and agreed to participate prior to starting the interview session (see Appendix B). The interviews took place in a public location of reasonable access for the participants, and one of their choosing; live interviews allowed for participant engagement with the concept stimulus, and were necessary for this data collection method. As a token of appreciation for each the participant’s time, the PI provided a free diabetes education toolkit to all participants and made herself available as a professional health professional resource for health-related self-management concerns after the research interview.

Special Recruitment Considerations

There is inconsistent evidence about the willingness of minorities to participate in health research. A literature review by Wendler, et al refutes the widely held belief that minorities are more reluctant to participate in research efforts than non-Hispanic White Americans⁸⁵. This study also suggested that it might not be unwillingness of the African Americans to participate that contributes to lower rates of minority participation; instead, it contends that other factors that are more inherent to the study’s design should be thoughtfully considered⁸⁵. These factors include ensuring minority access for relevant study and recruitment information, and intentional selection of study sites that will

include minorities. According to this study, when such factors are in place, consent rates of African Americans are comparable to those of White Americans. With regard to recruiting adults in later life and minority populations, there were special considerations explored and accounted for in this study. For recruitment in a general population of adults in later life, evidence suggests that it is just as feasible to recruit from my age group of interest (up to age 74) as it is from any other age group, and this population of adults seem to be good study participants who are compliant with study protocols (Carter, Elward, Malmgren, Martin, & Larson, 1991). However, research also suggests that as people age, it is important to offer alternatives other than phone interviews to mitigate any reticence that might be present due to hearing issues; the study accounted for such considerations by opting for in-person interviews. Feasibility of including adults in later life into studies could even increase with longer recruitment periods, so the time factor was accounted for in the recruitment phase of this study, with allowances built into the timeline for unexpected recruitment challenges (Carter et al., 1991). There are also evidence-based techniques that have been used for recruiting ethnic minorities in later life that were employed in this study, especially in regard to African American recruitment (Areán & Gallagher-Thompson, 1996). One technique was to ensure family and community buy-in during recruitment by allowing people the time to ponder their participation in the study and to ask any questions that they might have, and continuing to provide this access to the PI and study-related materials during and after the interview. This technique could help to overcome any distrust or fear that might result from outstanding questions or concerns about potential

involvement with the study (Areán & Gallagher-Thompson, 1996). In this study, participants were able to further discuss the details of involvement with family members, friends, and other social supports; they could also make further inquiries of the PI as necessary. As mentioned previously, potential mistrust and fear that could decrease participation were addressed by using techniques that gain buy-in from individuals in leadership positions at community sites or institutions (such as a pastor at a church of interest). The more that interested adults in later life are aware that their leadership supports the endeavors of this research, the more likely they are to agree to participate (Curry & Jackson, 2003). Another consideration that has been indicated to affect the participation of adults in later life is the location of the research; interviews were conducted in places conveniently located for the participants, and of their own choosing; these locations included local senior centers, quaint cafes, or their homes. Research shows that the more conveniently located and the less travel time and expense that are tied to the research on behalf of the participant, the more likely they are to trust the efforts and follow-through (Curry & Jackson, 2003). The last, and potentially the most crucial element of recruitment in my population of interest, was ensuring that participants receive education about their condition, and that they clearly understand what benefits they would gain from participating in this study (Areán & Gallagher-Thompson, 1996). Providing participants with education (in the form of a toolkit) about their diabetes self-management was specified in IRB documentation as both an educational aspect of participant involvement as well as a direct benefit of participation. Further, there was enough time allotted after the interview session for the PI to serve as a certified

health education specialist resource person if the participant wanted to go through the education toolkit, or if there were further questions that the participant had about his or her condition or specific aspects of self-management. Using the strategies described above likely increased final enrollment and consent of African American adults in later life as participants into this study.

Data Collection: The Interview Process

This study relied on semi-structured, in-depth interviews for gathering information, and the results of the interviews were analyzed and the findings were used to inform recommendations and a “plan for change.” Specifically, the approach for this study used a modified version of the Patient Technology Acceptance Model (PTAM) (Or et al., 2008), adapted to categorize relevant factors that might influence patient acceptance of mHealth technology into three domains. The factors in each domain of this model served as the basis for questions in the interview guide, and addressed the research question and sub-questions. The semi-structured, in-depth interview sessions included open-ended questions with the intent of eliciting views and opinions from the participants (Creswell, 2002). The interview questions came from three main areas; the first area included questions around beliefs and attitudes as mHealth technology acceptance factors, and elucidated what the adults in later life currently do and think about cell phone and technology use, how they might use it for their health management, and why they would or would not use an mHealth technology such as the one they were shown. The second area of questions included external facilitating conditions for mHealth technology acceptance, and explained

what adults in later life expect and need for support in using mHealth, and what and/or who will influence this use. The third area of questions was about patient-centered antecedent factors for mHealth technology acceptance, and they provided insight into health-related barriers for use, and how these could be mitigated. Table 5 outlines descriptions of what the PI intended to learn from interview questions, and it maps that content to the specific research sub-questions and aims of this study (interview guide in Appendix B). At the beginning of the in-depth interviews, the participants were exposed to a concept stimulus that would provide them with a clearer understanding of mHealth technology function and features, since the technology itself is fairly new. The concept stimulus was described at length in Chapter 1, and was used to anchor the thoughts and ideas of the participants around the questions of interest; the tool was explained in an informal way to each of the participants through live use and demonstration.

In summary, the 16 final interviews for this study lasted anywhere from 1 ½ and 3 hours. The average time that an in-depth interview lasted in this study was about 2 hours. Two interviews were not considered in final analysis, as the participant did not meet the inclusion criteria for technology segment. To the researcher's knowledge, only one person declined to interview for this study, and his reason for decline included a lack of health care and resources that are provided to him, and his feeling that participation in this study would not impact his current care or diabetes management.

Table 5. Interview Question Development

*Research Sub-Questions (RSQ)	Study Aims Addressed	Interview Question Category	General description of what I want to learn in order to address RSQs (see Appendix for full interview guide)
RSQ 2: From among three domains of factors, which factors might influence acceptance of mHealth technology for type 2 diabetes management among adults in later life who are limited mobile phone users?	Explore factors in three distinct domains that might influence acceptance of mHealth technology	Beliefs, attitudes, and practices as mHealth technology acceptance predictors	<ul style="list-style-type: none"> - Cell phone description, usage, comfort, motivation to use - Use of technology for health and/or diabetes management - Perceived benefits of mHealth system usage - Perceived ease of use of mHealth system - Influencers of use of mHealth system - Mediators of confidence, comfort, nervousness, and trust
		External facilitating conditions for mHealth technology acceptance	<ul style="list-style-type: none"> - General needs for mHealth use - Support for mHealth system use (start up, beginning of use) - Influence of doctor/healthcare team (positive and/or negative) - Influence of social support (positive and/or negative)
		Patient-centered antecedent (physical) factors	<ul style="list-style-type: none"> - Description of health status - Health related factors as barriers for use - Help/support for use in presence of physical barriers
RSQ 3: How can health leaders use this information to promote appropriate use of mHealth technology for diabetes management among adults in later life who are limited mobile phone users?	Use the qualitative findings for acceptance from the previous aim in application of how health leaders might promote use of mHealth technology for diabetes management among adults in later life who are limited mobile phone users in a Plan for Change	(All three interview question categories cited above)	<ul style="list-style-type: none"> - What themes emerge from qualitative analysis that might suggest further study to ultimately influence acceptance strategies during implementation in similar populations?

*Research Sub-Questions 1a and 1b are addressed in the literature review.

C. Qualitative Data Analysis

There are five common techniques that are shared by most qualitative analysis plans, and the plan for this research followed the same cadence: 1) Documentation of the data collected and how it was collected; 2) Organization and categorization of the data into concepts (coding); 3) Demonstration of how one concept might influence another by connecting the data; 4) Corroboration and comparisons through evaluation of alternative explanations, disconfirming evidence, and negative cases; and 5) representing the data through a report of the findings (Schutt, 2009). The qualitative data used for this research was primary data gleaned during the interviews through note-taking and audio recording. The PI also ensured that the analysis process was well documented by using the interview guide for note-taking with each interview participant. This form allowed for easy extraction of participant characteristics, key issues and themes, summary information per interview question, items from the interview that were especially illuminating, and items for follow-up/clarification to be addressed prior to the end of the interview (the latter included items that might have been out of scope as they were brought up). The individual participant interviews were recorded and transcribed into text documents. The PI's hand-written notes on the guide were used to compare against the transcribed documents for accuracy (and to highlight meaningful and poignant statements or quotes from participants). This comparison was also a way to cross check that interpreted notes were not mistaken for the transcribed data.

Qualitative Analysis Software

The PI used a qualitative data analysis computer software package, NVivo 10, for all coding and analysis of participant interviews and field note output. Using the qualitative analysis software, interview transcripts were imported and coded, and themes that emerged were retrieved, sorted, and categorized for complete analysis (Lieber & Weisner, 2010). NVivo supported the PI in managing data, ideas and themes, and in querying, developing models, and reporting on data generated from the interviews and related field notes (Bazeley, 2007). More about use of NVivo will be discussed in the procedure for analysis.

Procedures for Analysis

The researcher first immersed herself into the data by listening to recordings of the interviews, reading transcripts, and studying field notes that were taken during the interview. As this process ensued, the researcher listened specifically for recurrent themes and ideas. Next, the researcher developed an exhaustive thematic framework by identifying all of the key issues, concepts, and themes by which the data could be referenced and analyzed; this activity was aligned with what Saldaña described as the “First Cycle” coding process (Saldaña, 2013). Most important in the “Framework” analysis approach, the original research questions and aims of the study were used as the basis of the thematic framework. Development of the thematic framework was an iterative process that also included emergent issues that came out of the interviews, and themes that surfaced through further data analysis. A detailed index view of the preliminary thematic framework of this study,

also called the “Codebook/List of Codes for NVivo Analysis” in Appendix E, displays the 40 different codes that were used to classify the interview. The codes were used to index the data systematically in NVivo, resulting in another round of synthesis and reduction in which several codes were collapsed and the index was refined; Saldaña refers to this as “Second Cycle” coding (Saldaña, 2013). The next stages in “Framework” analysis involved both deductive and inductive identification of final themes from the codes that ultimately translated to the findings that will be discussed in Chapter 4, and laid the foundation for further discussion and recommendations in Chapters 5 and 6, respectively.

It is important to explicitly point out where the qualitative analysis software was used in the ‘Framework’ method of analysis. During the thematic framework identification stage, the aim was to use NVivo to create indices that allowed for labeling transcript data in manageable “bites” for later retrieval and exploration (Ritchie & Spencer, 1994). The preliminary aims and objectives of the research pulled through into the interview questions, to inform thematic framework identification. During the next stages, NVivo supported the researcher’s analysis efforts for labeling and tagging the transcript data (indexing) and creating models as patterns were thematically identified and concept labeling occurred (charting). Of note, the former stage called indexing was not the traditional notion of “coding” because it more accurately portrays the status of categories and the way in which they “fit” the data (Ritchie & Lewis, 2003). The use of the software continued throughout the mapping and interpretation stage of analysis, until key themes and associations were distilled into final strategies; these were ultimately the foundation

of recommendations in the plan for change that this study offered for the use of mHealth for diabetes management among adults in later life who are limited mobile phone users.

Coding Reliability

Though there is some debate regarding the use of reliability assessment in qualitative research, the researcher employed a process for consistency and reliability in the analysis process for the coding activities that were described above (Cook, 2011). The rationale for using this more positivist lens for reliability was to ensure that there was another aspect of this study, not previously considered during the methodology planning, that could potentially add to the rigor, as well as the credibility, dependability, confirmability, and consistency of this exploratory study. Such information around reliability could be of import from the perspectives of key stakeholders in medicine and technology who might be more aligned with positivist approaches to data and research. After investigating methods employed in other qualitative studies to assess reliability, the researcher modeled her approach after that of a study in a similar health-related discipline which was intended to elicit participant perceptions, beliefs, and attitudes – similar to this mHealth study. As defined by Cook, this reliability assessment type involved “multiple coders confirming the coding of the data into a coding framework or the ‘accuracy’ of themes” (Cook, 2011). To conduct the assessment, the researcher chose random sections of five of the semi-structured, in-depth interviews that best represented a variation in race, age, gender, from the five technology user typologies among the participants (approximately a 30% sample of the interviews conducted). The

codebook was given to another doctoral-level qualitative researcher, along with the relevant interview transcript sections. The task as described to the other researcher was to review the transcript data using the codebook as a guide, and assign codes to the data. The outcome of this review was confirmation of the codes as originally assigned by the researcher, and implicit confirmation of the resulting categories and themes (all codes assigned to data matched between the two researchers and no new codes, categories, or themes emerged). Further, once this inter-coder reliability process was complete, the researcher did not do another round of coding since the level of inter-coder reliability was deemed acceptable, and due to the fact that the semi-structured interview format lent to a more straight-forward compilation and dis-aggregation of responses as data (Hruschka et al., 2004).

Appendix F includes tables of emergent themes that were the results of these procedures for analysis, categorized by each domain of the theoretical framework. These tables include factors that might affect acceptance and use of mHealth technology, and they lay the foundation for training, marketing, and design.

Potential Limitations in the Study Design

There is a main limitation of this research (inherent in the use of exploratory, qualitative research) that needs to be identified in order to understand how the results of this study will be analyzed, discussed, and applied in later chapters. Though the small sample size is what allowed for the in-depth exploration of study participants' perspectives to make this study rich, it is also what limits the ability to generalize, transfer, or suggest relationships among any of the study's findings

around factors for acceptance that were explored. The findings from among the participants in this study are non-representative and cannot be used to describe the broader population of interest. They also cannot be used to alter the original model upon which the study is built, as that would require further quantitative validation.

According to Trochim, validity is “the best available approximation of the truth of a given proposition, inference, or conclusion.” He defines reliability as the degree to which findings from a study can be replicated, given similar conditions (Trochim, 2005). These two definitions grounded the PI’s understanding of the strategies that were needed to ensure that the study design for this research was both valid and reliable for a better quality of research. There are even clearer criteria than those traditional ones aforementioned that can be used to judge qualitative research.

They were applied in this study to enhance the overall soundness of the research plan and subsequent findings, and are as follows: credibility, transferability, dependability, and confirmability (analogous with internal validity, external validity, reliability, and objectivity, respectively, in traditional quantitative research)

(Trochim, 2005). Since the credibility can only come from the perspectives of the participants that are interviewed, the researcher ensured that clear, straightforward questions and clarifying probes were asked during the interviews – this led to increased credibility of overall data results. Using the repeat-back method for further clarification on participant statements and insight aided in credibility a well.

The PI enhanced transferability by ensuring that she sufficiently described the context of the research, the specific characteristics of the population, and underlying assumptions for the research (Trochim, 2005). Further, the PI’s recognition of the

small sample size and the exploratory scope of this research effort allowed those who seek to transfer the results to a different context, to make a more informed judgment about wider application and next steps of related inquiry. This effort is also loosely connected to the researcher's perspective and impetus for conducting the research (as described in the "Significance" in Chapter 1); though anecdotal instances of African Americans in later life facing barriers in using this technology during human factors testing occurred, perhaps this case would not be true for a larger sample of the population. However, the literature review showed that barriers do exist in the population of adults in later life, and they are worth further exploration to address and overcome them, from a health disparities perspective. Since one can be assured that data collection in qualitative research will not to be performed in exactly the same way every time (Trochim, 2005), dependability was tied to how the PI accounts for the changes that occur throughout the study (the settings, external influences, etc.), and how it affected that way the PI approached the study. Per Trochim, confirmability is the extent to which results can be confirmed or corroborated by others (Trochim, 2005). In order to enhance confirmability for this study, the PI provided full disclosure to all data, and called upon other researchers to carefully examine data collection procedures, analysis methods, and actual data, for any researcher bias or distortion that might have been present. Creswell presents two specific strategies that the PI implemented to ensure accuracy in findings. First, she clarified any bias related to her former employment at a health care technology company early on to "create an open and honest narrative" (Creswell, 2002). Second, she used a second coder to ensure

reliability in the coding process; the purpose of this was to corroborate accounts of the PI's findings and analyses, so that they would prove resonant by other people (Creswell, 2002).

IRB and Confidentiality

So that all ethical issues were considered during the conduct of this research, it was necessary for the Institutional Review Board (IRB) at the University of North Carolina to review and approve the proposed research plan prior to any contact with human subjects (Trochim, 2005). This formal process ensured that measures were put in place that protected the rights and safety of participants. In accordance with ensuring respect for participants and full disclosure of research activities, the researcher sought approval from the IRB prior to any recruitment activities; upon this approval, the researcher was officially named as the PI of the study. The information submitted for approval included the overall research plan and details for information that would be asked of or shown to the participants. This information included any recruitment materials and consent forms that explained the study and benefits to the participants.

Once IRB approval was secured, recruitment and data collection through semi-structured, in-depth interviews began. Even though the members of the target population were in a higher risk group with the chronic disease diabetes, the nature of this study did not require that they have special protection or accommodations. The sections of the IRB application included any potential risks, protection for participants from identified risks, elements of informed consent for the participants,

potential benefits from participation in the study, and importance of the knowledge to be gained.

A last consideration that was important with regard to the IRB process is the researcher's affiliation with the technology being used as a concept stimulus. As a former employee at an mHealth technology company, it was important that the researcher fully disclose any conflict of interest in the IRB application; it should be noted that the PI's relationship with the company as employee was resolved by the time data collection began, and there was no conflict of interest at that point to consider. Further, it was the researcher's goal to ensure that the IRB understood the full scope of how the plan for change from this study could impact the broader world of public health, and would not be used solely for inter-organizational product improvement efforts. To do this, the researcher clearly defined the knowledge and the extent to which it could be gained through the results of this study.

Chapter 4: FINDINGS

This chapter reports the results of in-depth, semi-structured interviews that were conducted to explore factors for acceptance of mHealth technology. The purpose of this research was to understand whether those same factors that were theorized to predict intention to use, and therefore led to use of a web-based technology in a home care setting with older adults, were also applicable with regard to their influence on adults' in later life acceptance of mHealth technology. The main research question for this study is: "what influences acceptance of mHealth technology for type 2 diabetes self-management among adults in later life who are limited mobile phone users?" The findings presented in this chapter will serve as the basis to address this study's research questions and aims.

A. Profile of Research Participants

A total of sixteen individuals were interviewed. All of the participants in this study were living with type 2 diabetes, and taking some form of medication. The age of the sixteen research participants ranged from sixty to seventy-four, as indicated in the original study criteria, and the average age of participant was sixty-nine. More females than males participated in the study; there were ten females and six males. In terms of racial distribution, there were nine African Americans and seven White Americans who participated in this exploratory study; all of the interviews were with residents of Maryland, the District of Columbia, Virginia, or North Carolina. All of the participants were

physically able to participate, indicating that they were comfortable with verbal questions and answers during the one-hour interview session, there were able to see text and images on a cell phone screen, and they were able to use their fingers/fingertips to press buttons on a cell phone touchscreen or keypad.

In terms of the user typology for each research participant, all of the participants were segmented into at least one of the four technology types of interest, according to the online automated Pew Internet and American Life Project Technology Typology Questionnaire. The original segments of interest were: desktop veteran, drifting surfer, information encumbered, and technology indifferent. However, upon reaching the seventh interview, two of the participants who identified with and had characteristics of one of the four original segments, actually segmented as “mobile newbie.” For this reason, the researcher re-evaluated the description of this segment as described by Pew, and determined that it would be included as another group into which research participants could be segmented, for the purpose of screening. The following description includes the two main characteristics of the “mobile newbie” as described by Pew that relate to this study; these users employ mainly the plain old fashion voice capability of the cell phone, and most of them need help from others with their technology(Horrigan, 2009).

“Mobile Newbies happily use their cell phones for keeping in touch with others. They do this mostly using the plain old fashion voice capability of the mobile device, although occasionally they will fire off a text message to someone. They like being more available because of their cell phone and would not like to give it up. Troubleshooting technology may be part of the story here, as most need help from others in getting new devices and services to work.”

Overall, there was one technology indifferent participant, three desktop veterans, four drifting surfers, four information encumbered, and four mobile newbies. Among the ten females, most were drifting surfers or information encumbered. Between the two races

involved in the study, more White Americans were mobile newbies, and more African Americans were drifting surfers. There was a mix among the research participants with regard to the types of mobile phones they owned. Three of the participants owned smartphones (all android), and the other 13 participants owned an older model flip phone or candy-bar shaped phone.

Figure 3: Gender and Race Demographics

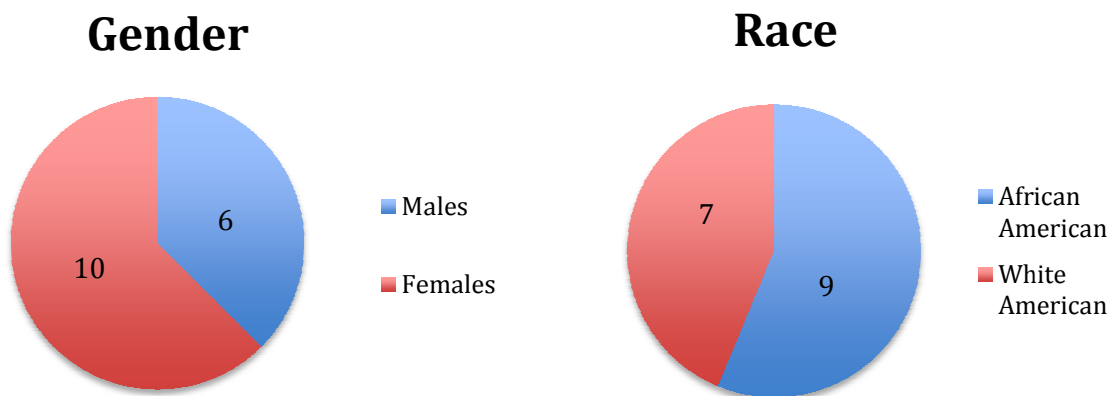


Figure 4: Technology Types by Gender and Race

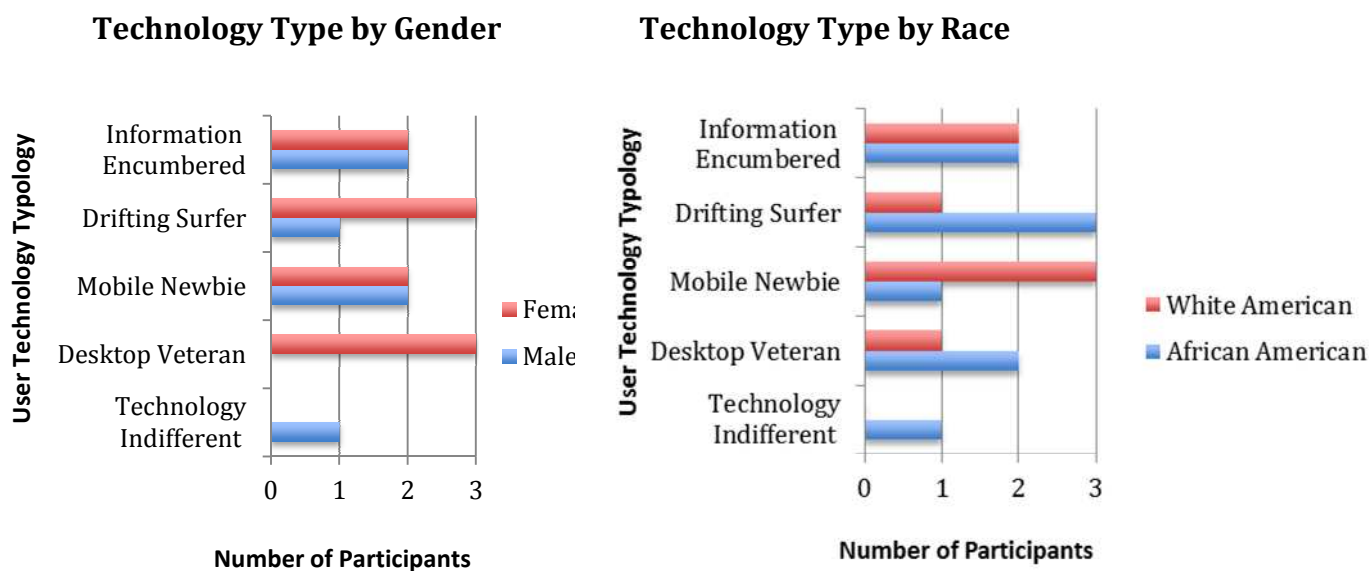


Table 6. Sample Characteristics of Study Participants

Characteristic	Total Number of Sample (N=16)	Total Percentage of Sample (%)
Age *		
< 69	6	37.5
≥ 69	10	62.5
Gender		
Male	6	37.5
Female	10	62.5
Race		
African American	9	56
White American	7	44
Education		
≤ High School	8	50
> High School	8	50
Work Status		
Retired	14	87.5
Employed Full-time	1	6.25
Employed Part-time	1	6.25
Income		
<\$25,000/year	6	37.5
\$35,000 - \$75,000/year	3	18.5
>\$75,000/year	7	44
Technology Segment		
Mobile Newbie	4	25
Drifting Surfer	4	25
Desktop Veteran	3	18.75
Technology Indifferent	1	6.25
Information Encumbered	4	25
State of Residence		
District of Columbia	1	6.25
Maryland	10	62.5
North Carolina	2	12.5
Virginia	3	18.75

B. Findings

The theoretical framework presented in Chapter 2 suggests three domains of factors that influence mHealth technology acceptance. The findings below highlight the attitudes, beliefs, practices, and insights around external and physical conditions that were offered by adults in later life in this study, in order to richly depict what would influence their acceptance of mHealth technology; Table 8 that concludes this chapter outlines each of the findings presented at the end of this chapter in summary form. To present a more concrete picture of the factors found among this study population that influence mHealth technology acceptance, the data collected to compile these findings have been divided into the three domains of the theoretical framework, and are presented in the order in which they were originally demonstrated to participants in the interview setting, within those domains. Because some of the factors investigated crossed domains with regard to the findings, this point is noted as applicable.

Beliefs, Attitudes and Practices as Factors that Influence mHealth Technology Acceptance

Finding 1. Adults in later life in this study find the mHealth technology easy to use, useful and highly beneficial for monitoring and recording for diabetes management, though perhaps not directly for themselves due to their own current BG regulation or self-care practices.

All of the participants referred to this mHealth technology as being easy to use, and some supported that view with caveats around their existing knowledge of or familiarity with

technology use. Some of the participants referred to the demonstration of mHealth technology's benefits as an effective way of getting themselves and others to use it. One participant summarized the connection of benefit and use by saying, "...if it's for my benefit, I'm going to do it" (Black male, 74, mobile newbie).

As a result of the concept stimulus portion of the interview, participants were informed and had a clear of understanding of the benefits of use, and the majority of the participants viewed the mhealth technology as beneficial. Among the benefits cited by participants, most frequently mentioned was the ability to monitor, track, record, and regulate BGs. Further, when participants were asked what the mHealth technology would have to do to be most useful for them, most of the responses mapped back to these benefits. The table below shows the full spectrum of participant responses for the benefits of mHealth technology, from most to least mentioned.

Table 7. Benefits of the mHealth Technology

1. Monitor, track, record, and regulate BGs
2. Maintain and provide records for doctor
3. Provide health information/guidance
4. Give reminders for 1) action, 2) accountability, or 3) awareness/reinforcement
5. Organize information
6. Give helpful hints
7. Connect with doctor

8. Maintain records for user
9. Track information for caregiver
10. Track information on eating and other activity
11. Access anytime, anywhere
12. Use as decision-making tool

It is noteworthy that participants in this study distinguished the level of benefit gained from system use between themselves and other people living with diabetes. Many participants specifically noted that because they took oral medications, their blood glucose was stable, and their doctor did not require them to take and record readings throughout the day. Further, even if a participant recorded readings, either he or she had already developed comfort with using a paper-based system for monitoring, or had a BG monitor that would automatically store the results, eliminating their direct need for this type of mHealth technology. Thus, they concluded that a system like this might be more beneficial for someone who was recently diagnosed with diabetes, had a more severe/less controlled case, or was very forgetful. This sentiment is demonstrated by participant commentary like the following:

"I have a brother who is worse off than I am. He doesn't keep track [of his BGs], he doesn't do blood testing or anything. I think it would be beneficial for him." (White female, 69, Drifting Surfer)

Finding 2. Adults in later life in this study are self-reliant in the final decision to use mHealth technology, though they will consider the opinions of their family members

and doctors who think they should use it, and those who might help them use it.

The majority of the participants in this study said that their adult children, doctor, friends, significant other/spouse, and siblings would think that they should use the mHealth technology. Even so, the same majority exhibited independence in their thoughts/decision-making around use of the mHealth technology, in response to whether the opinions of others who were important to them would affect whether or not they would use it. This independence was exhibited by comments such as:

"...ultimately it's my decision." (Black male, 70, Technology Indifferent)

"...because all you have to worry about is yourself." (White female, 71, Mobile Newbie)

"I form my own opinion on everything I see, not what somebody tells me..." (White male, 66, Information Encumbered)

"Because if it's good for my health and if it's good for me, I'm not stopping." (Black Female, 67, Drifting Surfer, #2)

"No, because this is my life." (White female, 70, Desktop Veteran)

"I draw my own conclusions...I do me." (Black female, 62, Desktop Veteran)

"...they have some influence, but I would still have to make my own judgment." (White female, 70, Desktop Veteran)

The few who indicated that someone's opinion would influence use were largely referring to their doctor, and they still asserted that it was a consideration, not a final decision. This was exemplified by statements like "I think if my doctor said 'I think it's a good idea; you

need look at it,' then yeah, I would." (White female, 70, Mobile Newbie). A similar statement by a participant was "if [my doctor] doesn't like it, I mean, I would still use it, but his opinion would help." (Black female, Drifting Surfer, #1)

Participant responses to an interview question about the need for someone to help them use the mHealth technology also informed the external facilitating condition domain as factors related to social support. Similar to subjective norm, the adults in later life in this study noted people in their lives who would assist them with using the technology, but they did not think that they would need such assistance as a result of how easy the concept stimulus was for them to use. When participants were asked about other people who might help them use the system, there were a variety of individuals named, including those same people who would think that participants should use this mHealth technology. Further, the contact people via customer service or tech support, and people in their community, such as church members, neighbors, and librarians, were also mentioned by a few participants for use support.

Finding 3. Adults in later life in this study are comfortable with using their mobile phones. They also are comfortable and confident in their ability to use mHealth technology; they are generally positive and receptive to the tool.

Participants described multiple ways in which they already use their mobile phones. Almost all of the participants mainly use their cell phones to make and receive phone calls, and some carry their mobile phones so that they can contact someone in case of an emergency. Some participants said that they send/receive text messages, though infrequently. A few of the participants use their phones to keep up with family and friends,

and others use the mobile phone alarm and calendar for scheduling, and the camera, video, and internet-based games for entertainment purposes. Overall, the participants seemed comfortable with the ways they reported using their cell phones. The participants in this study admitted the utility of their cell phones, and one participant summed it up as follows:

Well, first of all, a telephone is useful...if you don't have it...you're like a duck out of water...you feel for it." (Black male, 74, Mobile Newbie)

All of the participants were motivated to use their mobile phones to check in and “keep in touch” with others. One participant said that he uses his phone “to be in touch with other warm bodies in the world.” (White male, 74, Information Encumbered) Other common factors for motivation to use the mobile phone were convenience, and the fact that it offers quick access and saves time.

The majority of study participants reported being comfortable with using their mobile phones; some even identified themselves as being very comfortable. Further, most of the participants’ comments indicated that it did not take them very long to become comfortable with use. Their rationale for their own swift learning curves was because they were not afraid to explore their mobile phone technology, or “play with it,” so that they could learn. However, one participant described her steep curve of learning and comfort with her mobile phone as follows:

“...I’m still not used to it. Sometimes I’ll ask somebody that I’m sitting next to ‘how do you do this,’ ‘how do you back up,’ or... ‘where’s the space button?’” (Black female, 61, Desktop Veteran)

When asked about using their current mobile phones for diabetes management, most of the participants did not report that they conducted any related activities using their phones. However, a few said that they used their mobile phones to call and schedule medical appointments or the calendar to record medical appointments, and that these activities were indeed part of their diabetes management. All of the participants at some point used blood glucose monitors as another diabetes management technology, and many said that they also used blood pressure cuffs. Participants stated that it did not take long to gain comfort with using those two health technologies, as they were simple to understand and learn.

The concept stimulus for self-management presented to the participants was on an iPhone, and none of the participants owned this specific phone model; the majority of them owned an older model cell phone (like a flip phone), rather than a smartphone (Table 6). With regard to advances in cell phone technology, a few of the participants freely shared their thoughts on moving from a flip phone or candy bar phone to a smartphone. This was not in response to a specific interview question, but was offered as commentary when they shared insights around how long it took them to get used to using their current cell phone, or in response to how they use their current cell phone (features, etc.). They described their hesitations associated with the expected learning curve, change, and lack of familiarity with the new smartphone features, and specifically referred to themselves or their cell phone as “old school.”

The majority of the participants offered positive feedback about the mHealth technology. Their comments included attributes such as, “good, great, interesting, cool, nice, perfect,

neat, and ‘it’s for me!’” Overall, the mHealth technology was well received by the participants. The following quote is from a participant who offered a forward-thinking comment about the use of this technology overall:

“I think this is the technology of the future - within the next ten years or maybe even five years. And I think it’s a really good idea. In general, I think all doctors will have a way to monitor, through computers or hand-held technologies, so obviously, the elderly won’t have to leave their house if they choose not to. And they won’t be going into the doctor’s office, they will just monitor through technology. It’s perfect actually, it’s really good.” (White female, 70, Desktop Veteran)

Contrary to the generally positive attitudes, a few participants offered criticism of the technology, clearly expressing their notion that such support should be provided by real people, or have a higher-level function that can mimic human activity. One respondent characterized the technology as being “slow, wasteful, and lacking flexibility;” he also asserted “it’s better for humans to support humans as opposed to humans depending on being supported by machines.” (White male, 74, Information Encumbered) Another participant with similar thoughts said “it ain’t going to work, I can see that right now. Still got a way to go.” He also contended, “this won’t actually call the medical doctor for you...it’s not really doing too much for you.” (Black male, 62, Drifting Surfer)

There was nothing about the mHealth technology that made the majority of the study participants nervous about using it. Even so, a few participants cited additional concerns about mHealth technology that might cause them or someone else to be nervous, including security, lack of prior knowledge or experience, small font size, and accidental deletion of

information. In conclusion, the majority of the participants seemed comfortable and confident upon first use of the mHealth technology as a concept stimulus.

Finding 4. Adults in later life in this study exhibit a patient-provider trust relationship that could serve as a positive influence on mHealth technology trust, thus influencing acceptance and use (barring few security and privacy-related issues).

Participants were asked whether the advice or suggestion of their doctor would influence their decision to use the mHealth technology, and the majority of the participants reported that the doctor would have some influence on their decision. Contrary to this, a participant who gave a negative response highlighted the perspective that a doctor might feel the technology takes the place of his or her job. Here was the underlying explanation for his thoughts:

“Because, don’t forget now, what you do in the inside is what’s cutting them out. They want to be everything...they getting a royalty from [diabetes] too...so the doctor’s really not going to support this.” (Black male, 74, Mobile Newbie)

Another participant with a negative response said:

“No, because some of these doctors are total jerks...if you know what I mean. You can’t get the truth out of them half the time. “ (White Male, 66, Information Encumbered)

It is important to note that in this study, the participants who indicated a patient-provider trust relationship (associated with the “external conditions” domain) were the same participants who said that they would trust mHealth technology. Further, the majority of

the study participants clearly stated that they would trust new mHealth technology like this one. Those that hesitated or were not as trusting pointed to reasons such as hackers, viruses, security and privacy. Participants with high levels of trust offered ideas around what might increase the level of trust of others (peers) who might not be as trusting. The participants' comments focused on how they would give insight from their own experience and offer demonstrable evidence about why the mHealth technology should be trusted. A few participants suggested confirmation of security measures to address trust issues (i.e. that there was a Personal Identification Number, and how information would be transferred, stored, and backed-up). Lastly, a couple of other participants pointed out the unlikelihood of someone who was not already trusting to change. Here is how one participant described a hypothetical attempt to increase someone else's trust in mHealth technology:

"I would have to let her know about my experience with it. What research I've done on it, and explain it to her in a very different...very, very gentle way: 'I realize that you're from a generation of distrust of things that take place, but we don't have much more time on the face of this earth...don't you want what you have left to be easier? Don't you want what you have left to be more beneficial to your health? None of us are going to live forever. The better you take care of you now the longer you will be here.'"
(Black female, 62, Desktop Veteran)

External Facilitating Conditions that Influence mHealth Technology Acceptance

Finding 5. Adults in later life in this study do not think they need formal training on mHealth technology; they mainly desire guidance and instruction for start-up, and a contact/support number for on-going technical assistance/support issues that might arise.

Most of the participants said that they would need some direction for using the mHealth technology to help them get started, either in the form of a manual or user guide for reference, or even demonstration of use that would include step-by-step instructions and explanations of functions and procedures. A few of the participants initially stated that they did not think they would need anything in the way of instructions or direction, or any other outside help, to get started with using the mHealth technology. They expressed their desire to “play” with the mHealth technology to get started, through comments such as:

“I play until I learn.” (Black female, 72, Information Encumbered)

“...but you know just playing with it, I can figure certain things out.” (Black male, 62, Drifting Surfer)

“I would have pressed a lot of things; I would have played with it.” (White female, 71, Mobile Newbie)

“I would just say you can play with it...” (White male, 73, Mobile Newbie)

"I am the type of person who pushes every button they have on the phone." (Black Male, 74, Mobile Newbie)

When probed further about their need for formal training on how to use this mHealth technology, most of the participants did not think that they would necessarily need what they would consider "formal" training. The participants in this study described their desires for a short walk-through or demonstration sessions that would allow them to play with the tool and receive specific guidance. Most cited the need for little to no time for start-up help and support. With regard to the type of help or support these participants thought they might need once they began to use the mHealth technology by themselves, most identified a customer service or technical support number, through which they could contact a real "live" person if they encountered a problem with using the system.

Finding 6. Adults in later life in this study cite the value of peer support for guidance and use of mHealth technology and as a way to increase comfort, confidence, and trust of others.

Many participants in this study presented a link between them being the model or teacher for a peer's use of the mHealth technology, and how that might help increase someone else's comfort, confidence, and trust. They reported the following types of peer support that could be helpful: explanation of using mHealth technology, establishment of benefits, and ways of increasing confidence and trust in the tool. Several comments ultimately demonstrated the value participants placed on peer support, as exhibited by the excerpts below:

"...my assisting her with the operations of it. My assistance with her background

knowledge. Showing her how it helps me.” (Black female, 62, Desktop Veteran)

“If I’m talking to someone who has used it, you know, that’s in the same category age-wise and...sometimes that’s more helpful than getting an expert...” (Black female, 67, Drifting Surfer, #1)

“I’ll tell the person and show it to them how good it is...” (Black male, 74, Mobile Newbie)

Finding 7. Adults in later life in this study cite specific strategies for advertising and marketing as they relate to what is influential for them and their peers for mHealth technology acceptance.

Emergent within the context of this study, and disconnected from any specific factor in the original theoretical framework, were participants’ opinions around advertising and marketing of the mHealth technology. Participants’ comments suggest several critical factors including: inquiries around whether it had been tested, suggestions for using endocrinologists/doctors as the focus audience of a marketing campaign, using a narrow group of users to get this technology off the ground and then expanding to a larger audience, securing good endorsements that will attract the target audience, and considering where people in this age group go and what they do as potential advertising opportunities. One participant pointed to a person’s social support network, including adult children, as a potential influential target audience for the mHealth technology, with the comment “...target the younger market because you want...the children saying ‘mom, you need that!’” Other participants stressed the importance of target market and timeliness of the launch of such a technology with statements such as:

“...the sooner that it comes out in the market, the better it is to help folks like me.”

(Black female, 67, Drifting Surfer, #1)

“It would seem to me that from a marketing point of view it would be better to sell it to an endocrinologist and say ‘we’d like you to push this to people and this is how it’s going to help them and make your life easier. (White male, 74, Information

Encumbered)

“The key...just getting it out there, because sometimes even if the doctor hasn’t said anything but you hear about it or saw something, then you can bring it to the doctor and say ‘what do you think?’” (Black female, 67, Drifting Surfer, #2)

Patient-Centered Antecedent Factors that Influence mHealth Technology

Acceptance

Finding 8. Though some adults in later life in this study identify health issues for themselves related to vision and upper extremity (dexterity) abilities, they do not consider these health issues as barriers to use of mHealth technology; overall, they consider themselves to be in good health.

Demiris and his colleagues assert that technology can help patients be more involved in their own medical care, but it can also be a barrier if patients cannot use it easily and effectively for their needs (Demiris et al., 2001). Participants were asked to describe their own health status during the interviews. Most of the participants rated their health as good or pretty good. The participants were then asked to identify if there were any barriers related to their physical health that might impede their use of the mHealth technology.

Most of the participants described vision issues such as blurriness, intermittent numbness in fingers, and arthritis problems in the hands, but none thought that those barriers would actually keep them from using the mHealth technology. This is exemplified in statements like:

“There is some blurriness sometimes and I’m sure that’s from the diabetes...if it was extreme, might make it difficult to use it.” (White Female, 69, Drifting Surfer)

“Well, sometimes I have found...I experience numbness, it’s not constant...but when they get really numb...I could always switch and use my other hand.” (Black Male, 70, Technology Indifferent)

“Well, I got arthritis in both my hands. But, when I can’t, when my finger won’t bend for the computer, I just use a pen.” (Black Female, 62, Desktop Veteran)

Participants were also asked about any other health issues that could present barriers to using the mHealth technology for themselves or others. Participants identified the following: hearing problems, dementia/mental health issues, and gout; they were all within the context of potential barriers that other people might face when using mHealth technology.

Finding 9. Adults in later life in this study think that vision and upper extremity (dexterity) issues that might affect mHealth technology use could be mitigated by display changes (such as font size and brightness) and sound/voice activation features.

Participants were asked to think of what might assist someone who has problems with

their vision to use the mHealth technology. The most common ideas for assistance that participants offered were for increased size and brightness of features on the mobile phone display screen, and sound and voice activation for command and information input.

Participants were also asked about what might assist someone who has problems with their fingers, such as neuropathy or arthritis, to use the mHealth technology. Again, sound and voice activation for command and information input were most common ideas for assistance, and participants had less insight and recommendations in this area than the former. For assistance with both vision and upper extremity issues, another less frequently mentioned commonality was having someone else provide the assistance with inputting information in the mHealth technology, which could suggest a level of caregiver involvement for mHealth technology use. Comments that indicate this idea of caregiver involvement include:

"They might actually need people...that can push the buttons" (White female, 69, Drifting Surfer)

"They would have to have someone else record the information for them." (Black female, 72, Information Encumbered)

C. Summary

The findings from the in-depth interviews present implications for further research, based on the factors associated with mHealth technology acceptance that were explored among participants in this study. These findings, and their potential links to both research and practice, are further explored in Chapters 5 and 6.

Table 8: Findings of the Study

Finding 1	Adults in later life in this study find the mHealth technology easy to use, useful and highly beneficial for monitoring and recording for diabetes management, though perhaps not directly for themselves due to their own current BG regulation or self-care practices.
Finding 2	Adults in later life in this study are self-reliant in the final decision to use mHealth technology, though they will consider the opinions of their family members and doctors who think they should use it, and those who might help them use it.
Finding 3	Adults in later life in this study are comfortable with using their mobile phones. They also are comfortable and confident in their ability to use mHealth technology; they are generally positive and receptive to the tool.
Finding 4	Adults in later life in this study exhibit a patient-provider trust relationship that could serve as a positive influence on mHealth technology trust, thus influencing acceptance and use (barring few security and privacy-related issues).
Finding 5	Adults in later life in this study do not think they need formal training on mHealth technology; they mainly desire guidance and instruction for start-up, and a contact/support number for on-going technical assistance/support issues that might arise.
Finding 6	Adults in later life in this study cite the value of peer support for guidance and use of mHealth technology as a way to increase the comfort, confidence, and trust of others.
Finding 7	Adults in later life in this study cite specific strategies for advertising and marketing as it relates to what is influential for them and their peers for mHealth technology acceptance.
Finding 8	Though some adults in later life in this study identify health issues for themselves related to vision and upper extremity (dexterity) abilities, they do not consider these health issues as barriers to use of mHealth technology; overall, they consider themselves to be in good health.
Finding 9	Adults in later life in this study think that vision and upper extremity (dexterity) issues that might affect mHealth technology use, could be mitigated by display changes (such as font size and brightness) and sound/voice activation features.

Chapter 5: DISCUSSION

This chapter will focus on synthesizing and analyzing the findings that address the aims and answer the research questions for this study. This chapter will also explore how the study's findings apply to the original theoretical framework for mHealth technology acceptance for diabetes management among adults in later life who are limited mobile phone users. Lastly, this chapter will offer limitations of the research, and serve as a platform for future research suggestions, based on the study's findings. The culmination of this discussion will be a "plan for change" (Chapter 6) that might be considered by entities when addressing potential factors for mHealth technology acceptance.

A. Synthesis of Findings related to Aims and Research Questions

As a part of the aims of this research, I wanted to explore factors in the three domains that might influence acceptance of mHealth technology. The primary research question that followed from all of the aims of this study was "What influences acceptance of mHealth technology for type 2 diabetes management among adults in later life who are limited mobile phone users?" This exploratory qualitative study suggested that a variety of factors and conditions within a patient technology acceptance model might influence acceptance of mHealth technology for type 2 diabetes management among adults in later life who are limited mobile phone users. Below, the research question is addressed, in summary, by each domain of the framework:

What are the attitudes, beliefs, and practices among adults in later life that influence whether or not they would use mHealth technology for diabetes management?

The attitudes, beliefs, and practices as factors that influence acceptance of mHealth technology for diabetes management among adults in later life who are limited mobile phone users in this exploratory study include: perceived usefulness, perceived ease of use, intrinsic motivation, mHealth technology affect, mHealth technology self-efficacy, perceived behavioral control, and the construct of mHealth technology trust. However, social influence was not as important for this group of participants as a whole with regard to ultimate decision making for use, as they consider input of others, but make their own final determinations about use.

What external conditions would adults in later life need to support (or what might inhibit) their use of mHealth technology for diabetes management?

The external facilitating conditions that influence acceptance of mHealth technology for diabetes management among adults in later life who are limited mobile phone users in this study include: a personalized introductory session, and a customer service/technical support contact number. The common sentiment across all participants was that they would not need much training or start-up help/support to use mHealth technology, because it was easy to use.

What patient-centered antecedent (physical) factors exist among adults in later life that could impact their use of mHealth for diabetes management?

The patient-centered antecedent factor that influences acceptance of mHealth technology for diabetes management among adults in later life who are limited mobile phone users in this study is perceived health and well-being. The majority of the participants in this study overwhelmingly felt that such barriers would not impede their use of mHealth technology.

B. Application of Findings to the Theoretical Framework

The initial theoretical framework (Figure 2) provided a guide for this study, and led the researcher in data collection. It was theorized, based on previous models of patient technology acceptance and related literature, that the factors specified in each domain would influence acceptance of mHealth technology for type 2 diabetes self-management among adults in later life who are limited mobile phone users. This next section will discuss how the study's findings might apply within each domain of the framework and how the literature supports such application.

Beliefs, Attitudes and Practices as Factors that Influence mHealth Technology Acceptance

Beliefs, attitudes, and practices as factors in the theoretical framework that influence mHealth technology acceptance were suggested to be the following: perceived usefulness, perceived ease of use, subjective norm, intrinsic motivation, mHealth technology affect, mHealth technology self-efficacy, perceived behavioral control, and trust in mHealth technology. Based on the findings from this research, all of these factors might influence acceptance among adults in later life who are limited mobile phone users, except subjective norm and mHealth technology anxiety. To this end, the study's findings prompt further questions about the applicability of both subjective norm and mHealth anxiety for adults in later life who are limited mobile phone users with varying levels of technology use and experience. Discussion of specific findings related to the beliefs, attitudes, and practices are found below:

Discussion of Finding 1: Adults in later life in this study find the mHealth technology easy to use, useful and highly beneficial for monitoring and recording for diabetes management, though perhaps not directly for themselves due to their own current BG regulation or self-care practices.

The theoretical framework suggests that ease of use is a factor that influences mHealth technology acceptance, and consistent with the literature and the framework, this study's findings exhibit the same. The prominence of this factor among study participants lends further support as to why human factors testing processes for a product's safety and usability are important in mobile health technology development. These processes should ensure that technologies developed for use among adults in later life who are limited mobile users are easy to use. Further, ease of use also relates to perceived usefulness (or how beneficial they perceive the technology to be) in that would support their use of the mHealth technology. Researchers have found that adults in later life are actually motivated to use mobile applications, such as mHealth technology, when they are sufficiently informed of the resulting benefits."(Mynatt, Melenhorst, Fisk, & Rogers, 2004)(Melenhorst, Rogers, & Bouwhuis, 2006) To support this claim, participants of this study indicated that showing them and their peers the benefits of using the technology to manage their diabetes would be an effective way to promote use. Further, the respondents related specific usefulness to the ability to convey health benefits and facilitate self-management, similar to a group of researchers who studied internet use by patients as a health resource(Mead, Varnam, Rogers, & Roland, 2003).

There was a privacy and technology framework for older adults proposed in 2011, to inform the development, adoption, and use of technologies(Lorenzen-Huber, Boutain,

Camp, Shankar, & Connelly, 2011). This framework incorporates a dimension of perceived usefulness, and within that dimension is awareness of perceived vulnerability. The framework suggests that adults in later life might have the idea that other “older” people could use technologies for their benefit, but the subjects themselves (who participated in the study for this framework) do not perceive a personal need. Within the context of this framework, and based on this mHealth technology study’s findings, we can deduce that a patient’s clinical profile and his or her daily self-management needs could be additional determining factors for accepting and using mHealth technology, that could contribute to their perceived vulnerability. These factors should be assessed among target populations for mHealth technology uptake and use, and further analyzed for appropriate target messaging and appeal before developing marketing and outreach campaigns for audiences.

Discussion of Finding 2: Adults in later life in this study are self-reliant in the final decision to use mHealth technology, though they will consider the opinions of their family members and doctors who think they should use it, and those who might help them use it.

The theoretical framework suggests that subjective norm is a factor that influences mHealth technology acceptance. Contrary to the literature, the findings from this study indicate that adults in later life who are limited mobile phone users are not more likely to accept a technology if they believe that others who are important to them think they should use it. Though the participants in this study specified that they thought an adult child would they think should use this mHealth technology, they denied that the opinion of people in their circle would affect their ultimate decisions about use. These findings could justify further exploration of the role of subjective norm among adults in later life, as

previously assumed social influences might not be as impactful as originally thought within this group.

Gerontology researchers have considered factors such as geographically dispersed families and limited access to knowledgeable and supportive family members as reasons why there seems to be a trend toward more adults in later life taking more proactive roles in their own health affairs; further, there is a shift away from the paternalistic model of the 1960s and 1970s, and some adults in later life are increasingly more independent and self-sufficient (Peters, Hess, Västfjäll, & Auman, 2007). Another consideration for such self-sufficiency could be explained by Sixsmith's work around older adults' perceptions of independence and autonomy within a proposed privacy framework for home-based technology (Lorenzen-Huber et al., 2011). Ultimately, as noted in this framework and supported by data related to this finding, adults in later life want "the ability to stay in control of decision-making" (Lorenzen-Huber et al., 2011).

Discussion of Finding 3: Adults in later life in this study are comfortable with using their mobile phones. They also are comfortable and confident in their ability to use mHealth technology; they are generally positive and receptive to the tool.

The theoretical framework suggests that mHealth technology anxiety is a factor that would influence mHealth technology acceptance. However, the majority of the participants in this study did not experience any nervousness or anxiety associated with use. With regard to aspects of this mHealth technology that have the potential for evoking nervousness or anxiety, it was clear that as long as participants' inquiries were answered or that there was information provided before engagement with the technology that could potentially

mitigate such concerns, then these factors would not influence acceptance negatively. This finding supports the importance of providing instruction or orientation in a user guide or other related support resource. Some of this study's findings related to comfort, confidence or self-efficacy, and anxiety for use of mHealth technology are supported in the literature by the work of Czaja and Sharit around aging and attitudes toward computers(Czaja & Sharit, 1998). They found that the more prior computer experience older participants had, the more positively they rated comfort, competence, and efficacy. Further, these researchers' findings also indicated that attitudes toward computer technology are modifiable for people of all ages. Lastly, these exploratory results challenge the common belief that adults in later life hold more negative attitudes toward computer technology(Czaja & Sharit, 1998).

Discussion of Finding 4: Adults in later life in this study exhibit a patient-provider trust relationship that could serve as a positive influence on mHealth technology trust, thus influencing acceptance and use (barring few security and privacy-related issues).

The theoretical framework suggests that mHealth technology trust is a factor that would influence mHealth technology acceptance. However, before that construct was explored as an mHealth technology acceptance factor in this research, the patient-provider trust relationship was investigated as an external facilitating condition in the theoretical framework. Most of the answers and comments provided in relation to a patient-provider trust relationship were framed in the context of the provider's influence, and how that would impact participants' use. The majority of participants said that the advice or

suggestion of their doctor would have a positive influence on mHealth technology use. Related commentary from participants indicated a concentration of ideas in the dimension of competence, which is one of the five dimensions of physician behavior on which patients base their trust; therefore, the participants' comments were reflective of a positive patient-provider trust relationship. Further, Montague's research on trust of medical technology yielded that patients' trust in care providers was the largest component of trust in technology (Montague et al., 2010). If we conclude that the patient-provider trust relationship then leads to a participant's trust in mHealth technology, this conclusion is further supported by the fact that the same participants in this study who indicated a patient-provider trust relationship were the ones who said they would trust mHealth technology.

Since security and privacy concerns were the main ones noted with regard to trust, the literature was further explored through this lens. The importance of offering a safe and secure experience to adults in later life is underscored in a white paper about how older populations have adopted technology for health (from Intel-GE, in 2013) (Care Innovations, Intel-GE Company, n.d.). To minimize privacy concerns of older adults, they emphasize the importance of making privacy and information security options clear through features like encryption, authentication and controlled access. To further mitigate trust concerns for mHealth technology, it is also important to provide clarity and transparent information to older users about the security and privacy of their data up front. For this study, a few participants asked what would happen if their phone on which the mHealth technology application was downloaded got lost or stolen, and when they learned about the password access and Personal Identification Number (PIN) for securing health information, they

seemed satisfied with those privacy and security features. The rationale of why there were few participants in this study for whom security was an issue could relate to findings from the privacy framework of home-based technologies(Lorenzen-Huber et al., 2011). As was

External Facilitating Conditions that Influence mHealth Technology Acceptance

the case in that study, most of the participants for this mHealth technology research were generally unconcerned about information privacy, and this was reflected in statements like “I could care less if someone had access to my BG values.” (Black female, 62, Desktop Veteran) The research on privacy framework pointed out that other concerns seem to trump those related to privacy and data security for adults in later life, such as independence and autonomy of making choices about their health, and being able to provide useful information (sharing data) to people who need it and can use it to take care of them (i.e. doctors and family members)(Lorenzen-Huber et al., 2011).

External facilitating conditions in the theoretical framework that influence mHealth technology acceptance were suggested to be the following: training, support for implementation (start-up) and on-going use, and social support. Yet, based on the findings from this research, these conditions might not influence acceptance among adults in later life who are limited mobile phone users. To this end, the study’s findings suggest the need for further exploration of these conditions for successful and practical introduction and application of mHealth technology within adults in later life.

Discussion of Finding 5: Adults in later life in this study do not think they need formal training on mHealth technology; they mainly desire guidance and instruction for start-up, and a contact/support number for on-going technical assistance/support issues that might arise.

The findings from this study suggest the use of a “personalized introductory session,” in which the user receives a customized, one-on-one demonstration and user guide/directions for using the mHealth technology. Also, having a “customer service/technical support contact number,” seemed to be the preference among participants in this study. Both of the previously suggested conditions are supported by related PTAM research, in that “patients who feel they receive end-user support in terms of technical assistance, instructions, manual, and sufficient and proper training in using the technology should be more likely to accept it”(K.l & Karsh, 2006). Further, it was originally thought that social support, as an external facilitating condition, would influence acceptance of mHealth technology. However, among the participants of this study, since subjective norm for use was low, and ease of use was high, it followed that the need for social support in order to actually use the system would also be low; an important distinction in this social support is that it describes help from others to actually use the technology. Again, the fact that participants generally did not perceive a need for such help connects back to the ideas around independence and self-reliance that were resonant with these participants and supported in the literature(Lorenzen-Huber et al., 2011)(Peters et al., 2007).

Discussion of Finding 6: Adults in later life in this study cite the value of peer support for guidance and use of mHealth technology and as a way to increase comfort, confidence, and trust of others.

A finding that was not originally suggested in the theoretical framework was the idea of peer support. Participants in this study spoke about their desires to be the person that would show a peer how to use it, explain how they should use it, and establish the benefits of use and ways of becoming more confident and trusting of the tools; these sentiments are supported by research that indicates the value of peer support models and peer collaboration in training for technology use (Woodward et al., 2013) (Xie, 2007). One study demonstrated that use of “peer tutors” in a program to teach adults in later life (age 60 and above) how to use information and communication technology (ICT), led to increases in confidence for both completing tasks via the technology and overall technology use over time; they attribute this increase to the potential role of the tutor-learner relationship. The researchers in this study also assert that integrating peers into programs that require use of technology by those who previously were not as savvy, will permit adults in later life to access new services and achieve desired outcomes over time – thereby increasing empowerment, and affecting the “digital divide” (Woodward et al., 2013). Another study on teaching informational technology to older adults also supports the views of the participants in this mHealth technology study (Xie, 2007). The researchers cite using peers as advantageous in the learning process due to “their own-age related changes in physiological and psychological conditions, and similar learning experiences that might have been previously encountered with a specific technology.” Peers are able to understand the learners’ situations and provide appropriate instruction and training

accordingly. The Plan for Change (Chapter 6) will further explore application of a peer support model led by Dr. Ed Fisher of Peers for Progress (Fisher, Earp, Maman, & Zolotor, 2010). Three key tenets of this existing peer model align with how mHealth technology can support a diabetes patient through 1) assistance with diabetes in daily life, 2) provision of social and emotional support, and 3) linkages to clinical care. Development of an approach that teaches an older diabetes patient about using those particular functions of mHealth technology within a collaborative learning model could further impact acceptance and sustained use of the technology. Furthermore, collaboration has been shown to positively support adoption and learning for new technology among adults in later life (Vrkljan, 2010). This collaboration is especially beneficial for improved outcomes when both a range of experiences and exposures are intentionally matched in a dyad, and training strategies compliment the older adult's skill set and accommodate his or her diverse needs. In Demiris' considerations for designing clinical technology interventions for an elderly population, he suggests that the increased difficulty in learning due to age can be addressed through the provision of appropriate and sufficient training (Demiris et al., 2001). The work conducted by him and his colleagues specify that the process of learning can be enhanced by three aspects: 1) a detailed manual that explains concepts and procedures with simple language and text; 2) graphs and images that supplement and explicate the text as well as illustrate points (using examples and screen shots); and 3) text that explains how the system works and how it can/should be used. When a technology is introduced in a very interactive and understandable manner, it is likely to increase the receptivity of adults in later life toward computers. (Roger Edwards, 1989) A similar statement was an outcome of research by Edwards and Engelhardt on computers and older individuals. The

characteristics of introduction to technology as being “interactive” and “understandable” also resonated from participant responses in this mHealth study, as participants who cited an actual need for training had a preference for a one-on-one interactive demonstration or “walk-through” style of training. A more hands-on method of introducing the technology to older people was further supported by the work of Eisma et al, where workshops were developed to provide new users with background and experience of technology use. Their research found that such hands-on experience was more helpful than a simple verbal explanation or demonstration, and could even affect a study participant’s attitude toward technology. In that study, it was also noted that this interactive method made participants more aware of the possibilities of using the technology (Eisma et al., 2004). We should also consider here the participants’ desires in terms of training, as many did not feel the need for it. Since this sentiment is the case for the present study, we can further relate Demir’s consideration for “personalized training” as a way to ensure that any introductory or demonstration session addresses the needs of individual users and allows them opportunity to work on use of mHealth technology system features that are most meaningful to their individual situations.

It is important to note that in the previous finding, participants did not perceive a need for help or actual support in using the technology for themselves. However, they brought up ideas around using peer support in the case that others might require such support (others in their social settings, i.e. community centers and churches, who might benefit from this diabetes management technology). Specifically, ideas related to peer support were in response to interview questions that probed on how others might feel more comfortable and confident with using the system, when the respondent had already expressed a level of

comfort.

Discussion of Finding 7: Adults in later life in this study cite specific strategies for advertising and marketing as they relate to what is influential for them and their peers for mHealth technology acceptance.

Adults in later life in this study might offer viable contributions with regard to advertisement and marketing of this mHealth technology. The importance of involving adults in later life in market research efforts is substantiated by findings from research that purports the importance of knowing how they perceive advertisements, their levels of interest, and their attitudes in order to inform the development of more effective campaigns that can contribute to both communication about and selling their product(Estrada, Moliner, & Sánchez, 2010). Researchers note that adults in later life form “an increasingly influential consumer group with regard to purchasing power and demographic weight”.(Estrada et al., 2010) With respect to products that involve a greater amount of involvement (which could be exemplified by mHealth technology), researchers say that older adults want to see more advertising that is a true reflection of themselves, which is an important consideration in mHealth technology campaign development. Advertising and marketing can affect their attitudes and behaviors of acceptance related to consumption, so even the comments from this small sample of adults in later who are limited mobile users underscore the importance of studying this group to determine what is most effective.

Patient-Centered Antecedent Factors that Influence mHealth Technology

Acceptance

Patient-centered antecedent factors in the theoretical framework that influence mHealth technology acceptance were suggested to be visual function and upper extremity (dexterity) abilities. Yet, based on the findings from this research, these conditions might not influence acceptance among adults in later life who are limited mobile phone users. To this end, the study's findings suggest the need for further exploration of these conditions for successful and practical introduction and application of mHealth technology for adults in later life.

Discussion of Finding 8: Though some adults in later life in this study identify health issues for themselves related to vision and upper extremity (dexterity) abilities, they do not consider these health issues as barriers to use of mHealth technology; overall, they consider themselves to be in good health.

The findings for physical health issues among the participants in this study relate to research by Hermanova. His work asserts that adults in later life might not be able to see well or use computers effectively due to the decline in functioning caused by chronic health conditions, and aging, that could leave disabling affects (Hermanova, 2009). This lack of ability can be extrapolated to use of mHealth technology, as it also requires the user to be capable of seeing text and graphics on the screen and operating the keypad/touchscreen on the mobile phone.

The types of physical health issues cited among participants in this study were expected in a group of adults in later life living with type 2 diabetes, but it was unexpected that the

participants would not relate these issues to user barriers. According to PTAM, a patient's acceptance, and use of mHealth technology, could be the result of such perceptual-motor functions(K.l & Karsh, 2006). Study participants did not view blurriness of text and images nor finger numbness as deterrents for using mHealth.

The construct of perceived health and well-being was included in the semi-structured interviews for participants only as a conversation-starter and lead-in to discuss more specific health issues in relation to use of mHealth technology. According to Calvin and Or, this construct has influence such that if patients view their health poorly, it could have a negative effect on acceptance and use of mHealth technology. Patients who perceive themselves as less healthy are typically frail and weaker, which could be viewed as impediments to their ability to use mHealth(K.l & Karsh, 2006). After reviewing the results, it is clear that the generally high perception of health and well-being among these participants is a pattern that warrants further exploration in relation to mHealth technology acceptance and use.

Discussion of Finding 9: Adults in later life in this study think that vision and upper extremity (dexterity) issues that might affect mHealth technology use could be mitigated by display changes (such as font size and brightness) and sound/voice activation features.

The findings from this study suggest that visual and upper extremity (dexterity) abilities are important antecedent factors that must be addressed in the design and development processes for mHealth technology, so that further physical health-related barriers will not be issues for use. When asked about assistance for vision and upper extremity (dexterity)

related barriers, participant comments were consistent with findings from Demiriz and his team around consideration for “elements of proper visual display,” which include simple icons, large buttons that increase that can be selected (on screen), and larger font sizes with clear labels and headings (Demiriz et al., 2001). Further, color should be used conservatively, and brightness contrast considered for screen viewing. There are a number of more specific design considerations around color that should be carefully followed and applied by designers to help compensate for visual deficits that might come with both age and diabetic retinopathy issues. For the participants that commented on availability of sound/voice activation as mitigating features to address both visual and dexterity-related issues, they were actually alluding to the evolving concept of “ambient intelligence” (AmI), which “provides a vision of the information society, where emphasis is on greater user-friendliness, more efficient services support, user empowerment, and support for human interactions” (Emiliani & Stephanidis, 2005). There is vast opportunity for this new intelligence to be applied for people with challenges and barriers to technology use, like the disabled and the elderly (Emiliani & Stephanidis, 2005). The concept of AmI goes beyond the “talk to text” mobile feature voice recognition that has just recently become increasingly popular. It includes product development with multimodal interaction and alternative methods of input/output such as voice recognition and synthesis, pen-based pointing devices (also brought up by the participants of this study), vibration alerting, sophisticated input prediction, and other modes that can accommodate users. AmI is described as a way to facilitate the design of “universally accessible” solutions, or solutions that are “designed for all” because they incorporate barrier-free design concepts (Emiliani & Stephanidis, 2005). The ability to use AmI for mHealth technology would allow

participants with visual decline or even intermittent blurriness an option for information input and output. Further, for people who have trouble with their fingers or hands, the same alternative methods of input and output could be used via mHealth technology features on the mobile phone.

C. Limitations of the Research Study

While the findings of this research study may provide a structure to guide future research in populations with similar attributes, there three limitations that must be taken into consideration that could affect both the interpretations and application of these findings. First, the purposive method of data collection for in-depth interviews in this research could have presented selection bias. The participants in this study included adults in later life who were interested in the research and volunteered for the study because they knew it could help with diabetes management for themselves and others. Their level of savvy, interest, and independence with new technologies might not reflect those of a broader audience of adults in later life, random rather than self-selected, who are also classified as “limited mobile phone users.”

Second, the process of introducing the concept stimulus (the mHealth technology tool) to the participants in this study could have presented bias as well. In this study, the researcher was able to clearly explain the benefits of the features of the tool to each participant as he or she was perusing it. This would not be true in the more naturalistic environment that participants might have experienced as a true consumer who bought the product and formed their own perceptions of benefits of their own. This also relates to the limitation that participants in this study were only exposed to the concept stimulus for a

limited time at the beginning of the interview; in a naturalistic experience, they would have been exposed for a longer period of time, and the data would likely reflect more accurate perceptions of independent use and barriers to use in real-life situations.

A last limitation of this research is that it only involved one type of mHealth technology for diabetes management. It was used a concept stimulus to introduce the technology to the participants, as the majority of them were unfamiliar with this new and innovative self-management tool. In order to address this limitation, the researcher emphasized with the participants that this was only one example among many of such an mHealth technology tool.

D. Implications for Future Research

The data collected for this study allowed for exploration of the factors and conditions that could influence acceptance of mHealth technology for type 2 diabetes management among adults in later life who are limited mobile phone users. The findings from this exploratory study present opportunities for more rigorous and generalizable research. The following recommendations for future research are presented.

First, the focus of this study is on a sample of adults in later life between the ages of 60 and 74. In this study, participants even in the upper age group did not feel that health-related barriers would impede use, nor did they perceive a need for training on the technology tool. Further research that is geared toward an even older population of adults is supported (for example, in those older than 74 years), as this group would presumably experience even greater barriers to use due to disease progression and age-related health barriers.

Second, since there was no way to assess whether the factors and conditions explored with the participants would manifest differently once they were off and own their own using it in more naturalistic environments, a future study could integrate a real-life usability of the mHealth technology tool for a period of time. Following this time period, the participants could return and answer the questions about acceptance of the tool. There would presumably be a difference between reported perceptions from participants upon initial introduction and use, and those held by participants after a period of more independent, on-going use.

Also, a later study could propose to look at a few examples of mHealth technology tools that might be representative of many of those main features and functions most effective for clinical outcome improvement, rather than just one. This would increase transferability of the findings of this research study as well, to a wider variety of mHealth technology tools for diabetes management.

Another consideration for future research would be to analyze the factors of mHealth acceptance in the context of participants' education and income. These factors were not analyzed in the three domains of mHealth technology acceptance in this study, but since the digital divide and prior studies point to these same demographics as moderators, they should be considered as potential influences on acceptance as well.

A last, but important effort for future research, would be development of a more rigorous and representative study for mHealth technology acceptance. Since this study provided rich, detailed descriptions of participants' perspectives related to mHealth technology acceptance, a next step could involve a quantitative study of the factors that emerged from

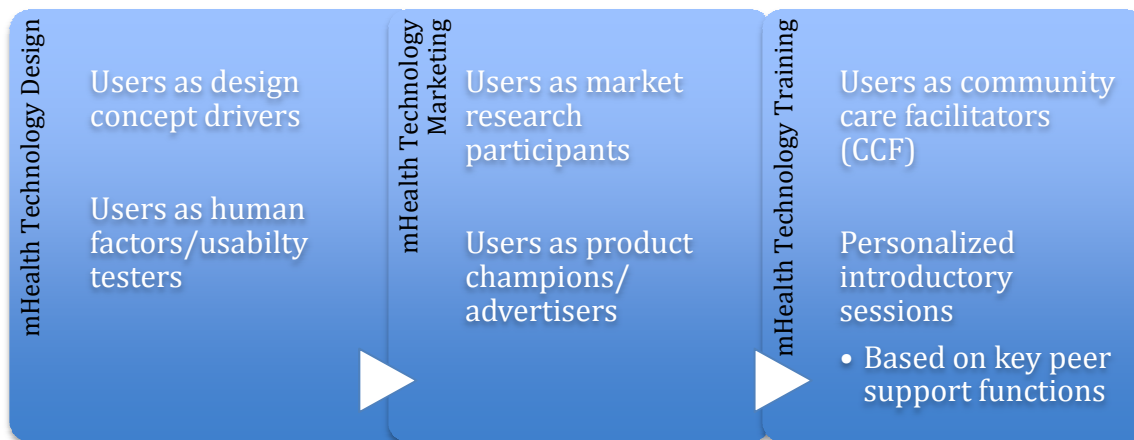
this study, with a larger target population. A validated survey could be constructed based upon the suggested findings from this exploratory qualitative research, and piloted with a target group of limited mobile users who are in the same target age group as this study. Using the qualitative research in this way could help further develop quantitative methods and instruments, in a way that is intentional and allows the researcher to target the factors for mHealth acceptance that are most relevant to study in this population. As asserted by Steckler et al, having this combination of methods for researching can allow for the weaknesses in the qualitative methodology (small sample, in this study) to be compensated for by the strengths of the quantitative methodology (which could be a more representative sample that makes inquiry with more varied demographic of participants in a future study)(Steckler, McLeroy, Goodman, Bird, & McCormick, 1992).

In summary, this research study is in no way conclusive regarding the factors of mHealth technology acceptance that should neither be changed in the theoretical framework that guided the study nor in how this could potentially be applied in a real-world setting in order to affect acceptance among adults in this target population. However, the research does raise questions about the applicability of the factors studied within this specific population, and how they should be carefully considered in any future research or project implementation. This will be further explored in the plan for change that is presented in Chapter 6.

Chapter 6: PLAN FOR CHANGE AND CONCLUSIONS

The purpose of this dissertation was to explore the factors and condition that could influence mHealth technology acceptance for type 2 diabetes management among adults in later life who are limited mobile phone users. The plan for change presented in this chapter further explores the possibility of applying the findings from this exploratory study from a programmatic perspective within the context of the study's theoretical framework; it will illustrate how the findings can inform programmatic design. This chapter will describe recommendations from the basis of the findings and discussion from chapters 5 and 6, segmented into the following categories that can impact acceptance: mHealth technology design, mHealth technology marketing, and mHealth technology training. Combined, these categories comprise a pilot project called mHealth Diversity and Diffusion, or "mHealth D²." Figure 7 below represents this pilot project.

Figure 5: mHealth D² – mHealth Diversity and Diffusion



A. mHealth D²: Design Process

Related findings:

Finding 1 Adults in later life in this study find the mHealth technology easy to use, useful and highly beneficial for monitoring and recording for diabetes management, though perhaps not directly for themselves due to their own current BG regulation or self-care practices.

Finding 3 Adults in later life in this study are comfortable with using their mobile phones. They also are comfortable and confident in their ability to use mHealth technology; they are generally positive and receptive to the tool.

Finding 8 Though some adults in later life in this study identify health issues for themselves related to vision and upper extremity (dexterity) abilities, they do not consider these health issues as barriers to use of mHealth technology; overall, they consider themselves to be in good health.

Finding 9 Adults in later life in this study think that vision and upper extremity (dexterity) issues that might affect mHealth technology use, could be mitigated by display changes (such as font size and brightness) and sound/voice activation features.

A project titled “Usable Technology for Older People – Inclusive and Appropriate,” or UTOPIA, has an example of a model for including adults in later life in the development process in order to glean insight about their relationship with technology that could inform system requirements early on in the design and development process (Eisma et al., 2004). Further, this project’s approach utilizes a strong partnership base of older people, from which they have learned other lessons around interacting with adults; they emphasize the importance of clarity in the role of the older people in ways that are understandable and

not “technology jargon;” they also encourage using hands-on elements as part of the data-gathering process, and providing a social atmosphere for the participants.

UTOPIA brings to light many of the same factors for consideration in the technology design process as do the participants in this research study. For this category, the mHealth D² pilot might pull from a diverse base of adults in later life from which they could solicit design concept drivers and later in development as a part of use case studies, usability and human factors testing to ensure that the mHealth technology is easy to use, useful, and beneficial for their unique diabetes self-management needs. The developers should also take into consideration the levels of comfort and confidence the participants in development and design processes might have with using other mHealth technologies, and use that as a foundation from which to build features that encourage and facilitate such feelings for use. Lastly, directly related to usability of the technology tool, some adults in later life might not consider their current health conditions as barriers for use, whether they actually might impede use. Assessment of individuals and accounting for such use barriers from among a wide range of adults with diabetes will be imperative for successful implementation, as will feedback from the participants on what would facilitate their use when faced with similar barriers.

B. mHealth D²: A Model for “Training”

Related findings:

Finding 5 Adults in later life in this study do not think they need formal training on mHealth technology; they mainly desire guidance and instruction for start-up, and a contact/support number for on-going technical assistance/support issues that might arise.

Finding 6 Adults in later life in this study cite the value of peer support for guidance and use of mHealth technology as a way to increase the comfort, confidence, and trust of others.

Technology companies and organizations that seek to include product implementation support for their customers and/or patients might consider that not all adults in later life necessarily desire a full training for some mHealth technology tools; specific instruction/guidance and resources for startup might suffice. One way that mHealth D² could leverage adults in later life who have already had involvement, buy in and proficiency with the mHealth technology, would be to utilize them as “community care facilitators” (CCF). The CCF would have a “quasi” training role, in that he or she would be matched with a new mHealth technology user to conduct a “personalized introductory session.” Prior to the session, the CCF would do a pre-assessment of the potential user via phone. This pre-assessment would include obtaining information about the user’s diabetes care management plan in order to understand medications and level of diabetes control, as well as his or her current clinical management activities. This baseline collection of clinical and personal information would allow the CCF to tailor and customize the introductory session in a way that best suits the needs of the user. This customization would include both tailoring the usage of the tool so that it best serves the user (i.e. focusing on how to set a medication reminder more than the carbohydrate input if a person notes that they have issues with medication adherence), and knowing what individual user benefits can be emphasized for the user. This pre-assessment also would take into account any barriers that the CCF needs to address for use, or be prepared to mitigate, during the personalized introductory session. There would also be an opportunity to name people who the user

might want to be involved as mHealth support, from his or her social support network. The last piece of the pre-assessment process would be coordinating with the user to ensure the technology application is downloaded and accessible from his or her cell phone prior to the personalize introductory session.

The “personalized introductory session” would be conducted on the user’s turf and time (where and when the user would like); it would be a very self-paced and highly interactive session, with no script or structured lesson plan. Further, the user guide/instruction manuals would be referenced throughout the session, and the session would be based on tasks that each of the users will go through, first alongside the CCF, and then on their own, that are most relevant to the pre-assessed ways in which the user would use the tool for his or her own self-management. At the conclusion of the session, the CCF would give the new user a card for contacting about any difficulties with using the mHealth technology for diabetes self-management, along with the user guides from the session.

Provision of peer support was noted in this study as a way to increase the confidence, comfort and trust of other adults in later life. As such, technology companies and related organizations might consider integrating peer support within the personalized introductory session from a program that has been implemented and validated globally called Peers for Progress.(Fisher et al., 2010) Implementation of the three key functions of peer support into the role of the CCF, in concert with the mHealth technology tool, might look like this:

1. The CCF could consult with and assist the user in applying their current diabetes management plan within the scope of their mHealth technology tool. This includes

collaborative determination of how to integrate both habits and use of mHealth technology into a user's activities of daily life.

2. The CCF could provide social and emotional support during this introductory process, especially with regard to positive behavioral reinforcement. In the vein of social support, the CCF can also give the option of establishing and including the user in networks that could be helpful in sustaining technology use.
3. The CCF could use mHealth technology to support clinical care through personal demonstration of benefits of use. Specifically, the CCF could convey how using the tool has been most beneficial to his or her own self-management, as encouragement for the new user. Lastly, encouraging use of appropriate clinical care through text/emails messages and appointment reminders are other ways that the CCF could continue to support the new user's clinical care.

C. mHealth D²: Marketing

Related Findings:

Finding 2 Adults in later life in this study are self-reliant in the final decision to use mHealth technology, though they will consider the opinions of their family members and doctors who think they should use it, and those who might help them use it.

Finding 4 Adults in later life in this study exhibit a patient-provider trust relationship that could serve as a positive influence on mHealth technology trust, thus influencing acceptance and use (barring few security and privacy-related issues).

Finding 7 Adults in later life in this study cite specific strategies for advertising and marketing as it relates to what is influential for them and their peers for mHealth technology acceptance.

The first marketing tactic that might be gleaned for mHealth D² from this study's findings is the focus of the target audience. If technology companies find that this target audience of adults in later life considers the opinions of others, but ultimately makes their own decisions around use, then the mHealth technology product advertisement messaging could reflect this as a way to appeal to the audience of interest. As an example, messaging might include suggestions for adults in later life to consult with their close family members and friends about the potential to use mHealth, and end with an empowering statement that conveys that the final decision is "in their hands." Also, since this study's findings suggest that members of this target audience have input on what would influence them and their peers for acceptance, then mHealth technology companies might want to use this as rationale for further involving them directly in marketing planning and outreach efforts. A third tactic that could be considered based on the findings of this study is using the patient-provider trust relationship as leverage for marketing the technology tool to providers. If providers introduce the tool to patients with whom they have trusting relationships, these patients might be more apt to serve as early adopters or champions of product uptake and use. Ultimately, having these champions visible and advocating for use is vital for adoption and diffusion on the small, and eventually large, scale(Wang, Redington, Steinmetz, & Lindeman, 2011). Further, having a champion is important, according to a team that works with technology diffusion for older adults, because:

"...it is necessary to have a champion who believes in the technology, is committed to its implementation, and has the resources to help overcome inevitable barriers and failures in the adoption process"(Wang et al., 2011).

D. Evaluation of mHealth D²

The pilot project for mHealth D² would need an evaluation plan in order to determine the effectiveness of implementation of the three components of mHealth technology design, marketing, and training, as aforementioned. An evaluation plan would be included in grant proposals to potential funders of projects with an mHealth technology focus. Currently, there is a rolling cycle for an R01 grant application from the National Institutes of Health (NIH), for a funding opportunity titled, “mHealth Tools to Promote Effective Patient-Provider Communication, Adherence to Treatment and Self-Management of Chronic Diseases in Underserved Populations” (PA-11-330). If developed in collaboration with the right organization, this funding would provide the ideal opportunity to further investigate future ideas for mHealth technology research in this specific population. Table 9 below proposes specific evaluation measures that might be considered based on the mHealth D² pilot project components.

Table 9: Proposed Evaluation Plan for mHealth D²

Evaluation Component	Outcome/Measurement
mHealth Technology Design	Number of error tickets during testing phase of development
	Number of major (negative) findings from human factors usability testing
	Number of bugs during preliminary use period
mHealth Technology Marketing	Number of new prospective users per live marketing event
	Number of new contacts from website per day
	Number of ads placed on billboards, magazines
mHealth Technology Training	Number of “personalized introductory sessions” held
	Participant evaluations of session
	Participant comments and direct feedback during session

E. mHealth D²: Alignment with ADOPT Model

After developing this plan for change, I discovered an article that posits a model for technology diffusion, specific to older adults(Wang et al., 2011). This model also highlights technology adoption factors relevant to older adults, and the elements included in the plan for change are closely aligned with what this group of researchers offers as a general guide to entities that partner with adults in later life and to increase technology diffusion(Wang et al., 2011).

Figure 7 below shows the elements from the ADOPT model, and served as a means of triangulation for this study's findings and components of its plan for change. Table 10 gives a comparison of how the elements of the ADOPT model compare with the findings and the plan for change.

Figure 6: ADOPT for Aging Services

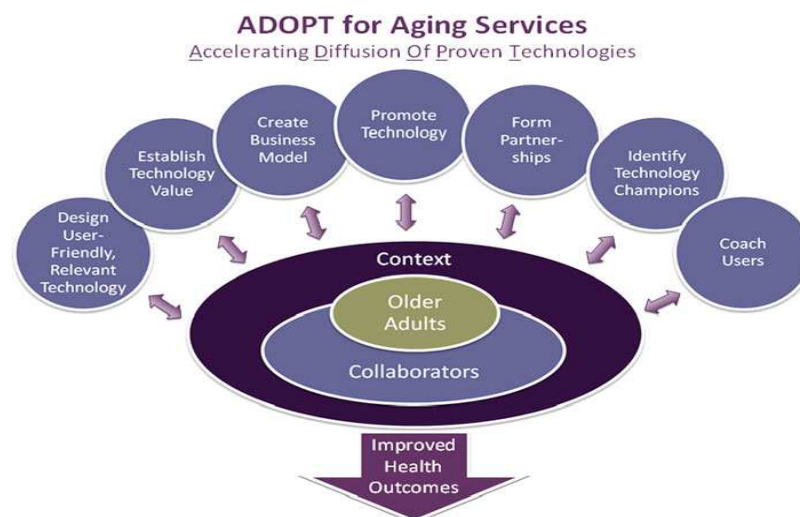


Fig. 1 The ADOPT (Accelerating Diffusion of Proven Technologies) model

Wang, A., Redington, L., Steinmetz, V. & Lindeman, D. The ADOPT Model: Accelerating Diffusion of Proven Technologies for Older Adults. *Ageing International* 36, 29–45 (2011).

Table 10: Comparison of ADOPT model elements with mHealth D²

ADOPT Model	mHealth D²
Older adults	Some of the same barriers for use and acceptance/adoption factors considered
Collaborators identified as key facilitators of older adults' ability to use technology	Social support people could have a similar support role in training for mHealth technology
Privacy considered to have effect on diffusion of the technology	Privacy considerations overview as part of the personalized, introductory session
Design user friendly, relevant technology	Integration of adults in later life into design component of mHealth D ² pilot project
Establish technology value	Not directly applicable to study findings
Create business model	Not directly applicable to study findings
Promote technology	Marketing is a key component of the mHealth D ² pilot project
Form partnerships	Not directly applicable to study findings*
Identify technology champions	Also part of the marketing component of the mHealth D ² pilot project
Coach users	Aligns with what occurs during the "personalized introductory session"

*This element is integral with regard to securing grant opportunities for both research and practical implementation.

F. Leadership Implications for mHealth D²

When taking a holistic view of the plan for change, as well as potential next steps, such as the opportunity to secure funding for an mHealth effort, it is evident that this entire approach has an underpinning of a specific leadership theory. This becomes even more relevant as all components of the pilot project are considered.

That is, if we look at how to best lead others in the mHealth D² pilot project, how we effectively engage partners and community-based agencies that serve the needs of older people, and how we influence the approach that any of the project's Community Care Facilitators (CCFs) take to effectively engage and motivate their peers for technology use, all is affected through transformative leadership. In a transformative leadership model, the behaviors of idealized influence, inspirational motivation, intellectual stimulation, and individual consideration, are key to creating an environment filled with relationships and interactions that are positive, and that motivate all those with whom you interact (Bono & Judge, 2004). I believe that if these four behaviors of transformational leadership are exemplified, taught, and infused into the core foundations and principles of the participating organizations at every level, especially with regard to the components of the mHealth D² pilot project, then the chance for acceptance of the technology has the potential to increase even more.

G. Conclusions and Next Steps

The second aim for this study was to use the qualitative findings for acceptance in application of how health leaders might promote use of mHealth technology for diabetes management among adults in later life who are limited mobile phone users.

Aim 2 was addressed through application of the study's findings in this chapter's

Plan for Change by answering the following research sub-question:

How can health leaders use this information to promote appropriate use of mHealth technology for diabetes management among adults in later life who are limited mobile phone users?

Health leaders can use the information from this plan for change to guide their organizations in developing pilot projects with distinct components of design, marketing, and training processes for mHealth technology in this population of targeted users. Ultimately, these efforts might help promote acceptance of mHealth technology for diabetes management among adults in later life who are limited mobile phone users, since the foundation of the mHealth D² pilot project was developed directly from the study's findings.

In terms of next steps for implementation of this plan for change, I will convene with mHealth technology colleagues and present my findings as a guest practitioner, in order to determine if any of the recommendations could be of strategic interest.

Further, with this core skill set around mHealth technology, I intend to connect with the Office of the National Coordinator (ONC), mHIMSS, the mHealth Summit in Washington, D.C., and the mHealth@Duke conference in North Carolina, to network and collaborate further with others who might have existing or planned research efforts focused on the application.

In summary, a plan for change with foundational elements of partnership and community involvement, along with collaboration and peer support, could affect the way that mHealth technology development companies do business, from developing beneficial partnerships, designing and developing user-centered technologies, marketing and promoting the use of technologies, to actually preparing individuals for use through introduction, empowerment, and interactive demonstration.

Further, if public health leaders who have the capacity to engage and lead through transformational leadership implement this plan for change, it could create more

willingness to think, act and do differently in order to create impactful, sustainable change.

A FINAL WORD from the RESEARCHER

*“As a public health professional and leader, it is my intent through study, research, program creation, policy development and advocacy, to create opportunities that ensure those people who experience barriers due to **availability, affordability, and acceptability**, are supported and offered the empowering resources needed to live their lives to the fullest.”*

Appendix A: Literature Review Highlights and Keywords/Search Terms

	Keywords and MeSH Headings: Diabetes Management AND Mobile Phone, Type 2 Diabetes AND Mobile Health, Diabetes AND Mobile Health, Diabetes AND Cell Phone, Diabetes Management AND Mobile Health, Diabetes AND Information and Communication Technology, Diabetes AND Telemedicine				
mHealth and Diabetes Management *this section of the literature will include mHealth intervention characteristics in order for ease in comparison across studies)	Author, Year	Title	Outcomes	Method, Study Type	mHealth Intervention Characteristics
	Quinn, C.C. et al., 2008	Mobile Diabetes Management Randomized Controlled Trial: Change in Clinical and Behavioral Outcomes an Patient and Physician Satisfaction	<p>Intervention patients saw a clinically and statistically significant average decrease of 2.03% in A1C after 3 months, compared to 0.68% decrease in control group</p> <p>Clinically and statistically significant A1C decreases in intervention patients.</p>	Randomized controlled trial of 26 type 2 diabetes patients with 3 physician practices over 3 month period	<p>Communication modality: Internet (web app) and email</p> <p>Behavioral intervention: Provide data, educate, remind, motivate, advise</p> <p>Patient engagement with system: Patient provided 3 types of data multiple times a day via automatic data upload</p> <p>Clinician role: optional</p> <p>Content and design: High level of real time features; high level of tailoring or adaptability of intervention design; high level of feedback to patient</p>
	Yoo, H.J. et al., 2009	A Ubiquitous Chronic Disease Care System	After 3 months, significant improvements in A1C in intervention compared to control group.	Randomized controlled trial of 123 type 2 diabetes patients over 3 months at university and community	<p>Communication modality: Text and Internet (web app)</p> <p>Behavioral interventions: Provide data, educate, remind, motivate,</p>

mHealth and Diabetes Management		using cellular phones and the internet	Significant reduction in blood pressure, and cholesterol improvements also noted.	public health center	advise Patient engagement with system: Patient provided 4 types of data multiple times a day via automatic data upload Clinician role: optional Content and design: High level of real time features; high level of tailoring or adaptability of intervention design; high level of feedback to patient
	Farmer, A.J. et al., 2005	A Randomized Controlled Trial of the Effect of Real-Time Telemedicine Support on Glycemic Control in Young Adults with Type 1 Diabetes	Insignificant decrease of 0.6% in A1C in the intervention group; and insignificant differences across control and intervention groups Access to real time decision support for meds, diet, and exercise might need to be included.	Randomized controlled 9-month trial of type 1 diabetes patients from a young adult clinic (18-30 years old)	Communication modality: Voice and Internet (web app) Behavioral interventions: Provide data, educate, motivate, advise Patient engagement with system: Patient provided 4 types of data multiple times a day via manual entering Clinician role: Advise, and set goals; 2x/month contact with patient Content and design: High level of real time features; high level of

mHealth and Diabetes Management					tailoring or adaptability of intervention design; high level of feedback to patient
	Rossi, M.C.E. et al., 2009	Interactive diary for diabetes: a useful and easy-to-use new telemedicine system to support the decision-making process in type 1 diabetes	System was easy to use, helpful in over 63% of patients changing eating habits Non-statistically significant reduction in fasting BG, postprandial BG, and A1C after 9 months follow-up.	Two pilots: feasibility/acceptability study AND randomized controlled trial; 50 and 41 patients.	Communication modality: Text, Internet (web app), and photos Behavioral interventions: Provide data, educate, advise Patient engagement with system: Patient provided 4 types of data multiple times a day via manual entering Clinician role: Advise (frequency not specified) Content and design: High level of real time features; high level of tailoring or adaptability of intervention design; high level of feedback to patient
	Turner, J. et al., 2009	Implementation of telehealth support	Baseline A1c was 9.5%, and decrease at 3 months was 0.52%, with insulin dose increase of	Exploratory study of 23 type 2 diabetes patients from nine general practices	Communication modality: Text, voice and Internet (web app) Behavioral interventions: Provide

mHealth and Diabetes Management		for patients with type 2 diabetes using insulin treatment: an exploratory study	9 units. Mean of 160 BG readings transmitted per patient in this time; nurses and GPs viewed it as having potential to improve care.		data, educate, remind, advise Patient engagement with system: Patient provided 4 types of data once a day via partially automated system for uploading Clinician role: Advise, and set goals; 2-4x/wk contact with patient Content and design: High level of real time features; assumed high level of tailoring or adaptability of intervention design based on provider feedback; high level of feedback to patient
	Katz and Nordwall, 2008	Interactive Cell-Phone Technology for Health Enhancement	Study demonstrated improved levels of glycosylated hemoglobin, positive changes in diabetes management self-efficacy and self-care activities to support system utility Feasibility of use also established from this	3 month pilot-controlled clinical trial of 30 type 2 diabetes patients - 15 trial, 15 control	Communication modality: Text, Internet (web app), email Behavioral interventions: Provide data, educate, remind, motivate, advise Patient engagement with system: Patient provided 3 types of data once a day via automated system for uploading (other devices, for BP and

mHealth and Diabetes Management			study.		weight) Clinician role: Advise (frequency not specified) Content and design: High level of real time features; high level of tailoring or adaptability of intervention design based on provider feedback; high level of feedback to patient
	Faridi, Z. et al., 2008	Evaluating the impact of mobile telephone technology on type 2 diabetes patients' self-management: the NICHE pilot study	Mean improvement in A1c of -0.1 was apparent in the intervention group, compared to the mean deterioration of 0.3 in the control group. Self-efficacy scores improved significantly in intervention group compared with no improvement in control. Technological barriers were faced for those in intervention (cell phone) group.	Randomized controlled trial with 30 adults from two community health centers with type 2 diabetes	Communication modality: Text Behavioral interventions: Provide data, remind, advise Patient engagement with system: Patient provided 2 types of data once a day (unclear whether auto or manual) Clinician role: Optional Content and design: Low level of real time features; assumed high level of tailoring or adaptability of intervention design based on provider feedback; high level of

mHealth and Diabetes Management					feedback to patient
	Arsand, E. et al., 2008	Designing mobile dietary management support technologies for people with diabetes	5 implications from findings: 1) provide reward at time of food data entry (teach or provide progress info) 2) ensure there is a mobile component 3) ability to self-configure and tailor to meet individual patient needs and goals 4) provide automated display of food's nutritional content upon data entry and selection in food pick list 5) make technology touchscreen for ease and simplicity in use	Two cycles of lab-based usability testing for 3 food registration prototypes using 3 design concepts. Six adults with type 1 diabetes and 3 with type 2 diabetes participated.	<p>Communication modality: Text, Internet (web app), photo</p> <p>Behavioral interventions: Provide data, advise</p> <p>Patient engagement with system: Patient provided various food data multiple times a day (med use and BGs for desktop) entered manually</p> <p>Clinician role: Advise (for food pic blog), optional contact with patient</p> <p>Content and design: High level of real time features</p>
	Vahatalo, M. et al., 2004	Cellular phone transferred self blood glucose monitoring	In a subgroup of 7 patients who use the technology most actively, there was a decrease in A1c results in a .75% difference in the active versus non-	One year randomized control trial of 200 type 1 diabetes patients (100 test group, 100 control) from a diabetes outpatient clinic	<p>Communication modality: Text, voice, Internet (web app)</p> <p>Behavioral interventions: Provide data, educate, remind, advise</p> <p>Patient engagement with system: Patient provided 1 type of data once</p>

		g: prerequisites for positive outcome	active patient groups. A system like this can be expected to be beneficial with motivated patients and doctors; but application without selection seems questionable due to low measurement and transferring activity.		a day manually Clinician role: Advise (1-2x/month) Content and design: Low level of real time features; assumed high level of tailoring or adaptability of intervention design based on provider feedback; high level of feedback to patient
	Curran, K. et al., 2010	An Intensive Insulinotherapy Mobile Phone Application Built on Artificial Intelligence Techniques	Results showed that to a large degree the “intensive insulinotherapy” approach using the neural network (an algorithmic approach) has value and potential implications for future intelligent insulin pumps.	Two week mini feasibility trial with 6 diabetes patients who were insulin dependent	Communication modality: Text Behavioral interventions: Advise Patient engagement with system: Patient provided 4 types of data as needed for insulin dose titration, manually in phone Clinician role: not specified Content and design: (only one level of feedback to patient – amount of insulin needed)

	Ferrer-Roca, O. et al., 2004	Mobile phone text messaging in the management of diabetes	<p>Overall system satisfaction was good, but users wanted ability to enter historical data.</p> <p>Reduction of input in holiday seasons.</p> <p>Elderly had difficulty typing the messages.</p> <p>Financial concerns were a barrier to continued use among younger users.</p>	Eight month system trial for 23 people aged 18-75 who had a diagnosis of diabetes and were SMS users	<p>Communication modality: Text</p> <p>Behavioral interventions: Provide data, advise</p> <p>Patient engagement with system: Patient provided 2 types of data once a day manually</p> <p>Clinician role: Not specified</p> <p>Content and design: High level of real time features; low level of feedback to patient</p>
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	Keywords and MeSH Headings: Diabetes AND Mobile Health AND Elderly; Cell Phones AND Diabetes Management AND Seniors; Information and Communication Technology AND Elderly AND Health; ICT AND Elderly AND Diabetes				
mHealth and the Aging Population: Barriers and Unmet Needs	Author, Year	Title	Purpose	Method, Study Type	Findings
	Kaufman, D.R. et al., 2006	Redesigning a Telehealth Diabetes Management Program for a Digital Divide Seniors Population	To cognitively evaluate a large scale telemedicine project aimed at management of elderly living with diabetes	In home usability study (one hour sessions) with 14 elderly subjects with diabetes in NYC and 11 in Upstate NY	<p>The study uncovered dimensions of the interface that hindered optimal access to system resources.</p> <p>Also were significant obstacles with perceptual-motoric skills, mental-models of the system, and health literacy.</p> <p>15 people had problems with the mouse due to lack of computer experience, all the novice subjects had trouble developing a coherent mental model of the system, and three subjects were unable to interpret a table and other numeracy issues existed.</p>
	Lober, W.B. et al., 2006	Barriers to the use of a Personal Health Record by an Elderly Population	To evaluate the barriers faced by a low income, disabled elderly population in creating and using a personal health record	Descriptive study on the functional usability of a PHR system with 170 residents of a publicly subsidized housing project over a 6-month period.	<p>38 residents participated, and only 11 had their own computer.</p> <p>9 were able to enter and maintain the information in the system without assistance; the remainder required assistance with entering and maintaining their health information.</p> <p>Of the 29 that needed assistance, the</p>

mHealth and the Aging Population: Barriers and Unmet Needs					major barriers identified were computer literacy and anxiety (over half of study population experienced these)
	Lorenz, A. & Oppermann, R., 2009	Mobile health monitoring for the elderly: Designing for diversity .	To develop a mobile system, called senSAVE, to monitor vital parameters where user interface and the interaction are specifically adapted to the needs of the elderly	Description of system development and outcomes evaluation	Two user interfaces (basic and advanced) were usable by the elderly population, and should be adaptable for preferred user experience. The elderly would use an unobtrusive system like this system for diabetes management every day.
	Lv, Z. et al., 2010	iCare: A Mobile Health Monitoring System for the Elderly	To describe a mobile health monitoring system called iCare for the elderly that uses wireless body sensors and smart phones to monitor their wellbeing. It can also offer remote monitoring for the	Descriptive narrative	n/a (descriptive narrative)

mHealth and Health Disparities			elderly anytime anywhere and provide tailored services for each person based on their personal health condition.		
	Bourouis, A. et al., 2011	A Ubiquitous Mobile Health Monitoring System for Elderly (UMHMS E)	To propose a real time mobile health system for monitoring elderly patients from indoor or outdoor environments. The system uses a bio-signal sensor worn by the patient and a Smartphone as a central node.	Descriptive narrative	n/a (descriptive narrative)

Keywords and MeSH Headings: Health Disparities AND Mobile Health; Minorities AND Mobile Health; ICT AND Health Disparities; African Americans AND Mobile Health; African Americans AND Health Disparities AND Mobile Health; African Americans AND Health Disparities AND ICT					
Author, Year	Title	Purpose	Method, Study Type	Findings	
Roblin, D.W. et al., 2009	Disparities in Use of a Personal Health Record in a Managed Care Organization	To assess racial and ethnic differences in rates of registration with (and use of) KP.org, a component of the Kaiser Permanente electronic health record (EHR)	A two-year cohort study of 1,777 25-59 year old Kaiser Permanente Georgia enrollees unregistered for PHR responded to a survey (online and written)	Registrants less likely to be African American (30.1% of African American compared to 41.7% White) Those with internet access and higher education more likely to register.	
Levetan, C.S. et al., 2002	Impact of Computer-Generated Personalized Goals on HbA1c	To evaluate the impact of a system that provides uniquely formatted and personalized reports of diabetes status and goals on changes in HbA1c levels	Randomized controlled trial of 150 diabetes patients to receive/not receive uniquely formatted and personalized reports of their status, goals, and A1c changes	Among patients with baseline A1c greater than or equal to 7%, there was an 8.6% reduction in control group, compared to a 17.0% decline in intervention group (.77 and 1.69%, respectively). The intervention lowered HbA1c in a predominantly minority population (comparable to other medical agents).	
Gerber, B.S. et al., 2005	Implementation and Evaluation of a Low-Literacy	To evaluate a clinic-based multimedia intervention for diabetes education targeting individuals with low health literacy levels	Randomized controlled trial of 244 diabetes patients to receive either supplemental	Increased perceived susceptibility to diabetes complications among those who received the intervention, and specifically among those with lower health	

		Diabetes Education Computer Multimedia Application	in a diverse population, barriers and facilitators for implementation	<p>computer multimedia use for education, information, and support or standard care.</p> <p>Patients were from five public clinics with computer kiosks installed in waiting rooms.</p>	<p>literacy.</p> <p>More personal and organizational barriers (i.e. skills) need to be addressed to improve usability.</p>
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Appendix B

Interview Guide

Introduction

The purpose of this interview is to learn more about the attitudes and beliefs of African Americans in later life with type 2 diabetes for using mobile health (mHealth) technology. Another aim of the interview is to identify facilitators or barriers that might motivate or hinder acceptance of this kind of technology for diabetes self-management. Ten to twelve people living with diabetes who have an interest in mobile technology for diabetes self-management will participate in the interviews, each of which should take about one and a half hours. These interviews will take place in a private setting, and the information exchanged will be confidential. The information you provide during the interview will not be linked to your name or any personal information. Further, this interview will be recorded with your consent, and the tape recordings and any transcribed notes taken during the session will be stored securely during the study, and destroyed when the study is over. The insights and themes that result from this study will inform how entities plan interventions around uptake and use of mHealth technology by older members of African American populations who are living with diabetes. I want you to remember that this is not a test, so there are no right or wrong answers at all – I just want your feelings and opinions.

- Please feel free to ask me any questions about this study or the interview at any time during this session. Do you have any questions at this time?

- Do I have your permission to record this interview, and take notes during the session?

First, I want to provide you with a brief intro about mHealth, since it's such a new concept:

mHealth is an application (or software) on your cell phone that would allow you to manage your health, specifically your diabetes, using your cell phone. At times during this interview I might also refer to it as an mHealth system. With an mHealth system, you might keep track of your blood glucose (BGs) by entering them on your phone. You could receive messages about high and low BGs, and support in taking care of those highs and lows (or general health information specific to your diabetes). Your doctor, and others in your support network, might receive information about how well you are doing with your diabetes. Lastly, you might receive other messages about how to live healthier, such as motivation for exercising more and healthier eating.

(Show concept stimuli – 5 minutes for participant exploration on phone – I will show a BG flow, show a motivational message, show images, and show learning library for information)

Beliefs and Attitudes as mHealth Technology Acceptance Predictors

So, the technology that you have seen here is called mHealth or an mHealth system – I'll use both of these terms during our interview to refer to the same thing. I'll let you explore/play with it a little more at the end of the session, but for now, we will begin by talking about how you use your current cell phone and other technologies, and then we'll talk about why you might or might not use the type mHealth system that I've shown you.

- **So, what kind of cell phone do you have?**
- **Tell me a little about how you use your cell phone.**

Probe: Do you use your cell phone mostly to make and receive phone calls? Do you send/receive text messages? Do you access the internet/email?

- **How comfortable are you with using your cell phone, and those functions and features you described? (By comfort, I mean that you are able to see and understand what buttons or icons you need to press in order to access certain features on your phone, and it's easy for you to do so by yourself).**

Probe: How long did it take you to get used to /get comfortable with using your cell phone in the ways that your described? Is it easy for you to do or do you need help?

- **What motivates you to use these various functions and features that you described on your cell phone? (specify one(s) that they pointed out previously)**

Probe: What makes you want to use those functions and features that you told me about?

- **Do you use any of those functions and features on your cell phone to support/help you with managing your diabetes? (If yes, how?)**

Probe: Have you ever used it to remember doctor appointments? To take medications? To check BGs? Record information/take notes? What about to support/help you to manage any other aspects of your health (outside of diabetes)?

- **Aside from your cell phone, there are other technologies that can also be used to help manage your health. Do you use any other technologies to help you manage your health? How?**

(Examples of technologies include other alarms for medication-taking, electronic calendars, BG monitors)

Probe: How long did it take you to get used to /get comfortable with using these other technologies to help manage your health?

- **(Refer to concept stimuli) Again, the example of mHealth that I showed you earlier on this cell phone is for diabetes management. What benefits do you think that this specific type of mHealth system could have for you?**
- **What would make this useful for you?**

*Probe: What would it have to do **for you** to make you feel that “it works?”*

- **Do you think this would be easy or hard to use? Why?**
- **Would the opinions of others (who are important to you) affect whether you use this or not?**

Probe: Whose opinions would matter? Why?

- **Who else might think that you should use this mHealth system?**

Probe: Family members? Church members? People with whom you work or are in other groups/organizations? How much will their opinions influence whether or not you use something like this?

- **If you were not comfortable with using this type of mHealth system to help manage your diabetes, what might increase your comfort?**
- **What might improve your confidence, or your belief in your ability to use this by yourself?**
- **Think about the mHealth system that I showed you earlier. Is there anything about it that would make you nervous about using it?**

Probe: Would anything make you hesitant or skeptical about using a cell phone to help manage your diabetes?

- **Would you trust new technology like mHealth? Why or why not?**

Probe: Would you have issues with security or privacy of information?

- **What might increase your trust in this kind of mHealth system?**

External Facilitating Conditions for mHealth Technology Acceptance

Next, we'll talk more about what might influence your decision to use the kind of mHealth that I showed you, and what might help you to use it.

- **First, what do you think you would need to help you get started with using this type of mHealth system?**

Probe: Would you need a user manual? Instructions? Teaching/training?

- **Do you think you would need training on how to use it?**

Probe, if yes: What kind of training do you think you might need? Would you need group training or direct one-on-one teaching? What about videos/multimedia instruction?

- **So let's say that you decide to start using mHealth to help manage your diabetes. How long do you think you might need help/support in the beginning, when you first start using it?**
- **Now imagine that you have been on the system for some time, and are getting comfortable with using it. What kind of help/support do you think you might need at that point, when you begin to use this mHealth system by yourself?**
- **What barriers or difficulties could you see yourself facing with using this kind of mHealth system?**
- **Are there other people who might help you to use this system?**

Probe: Who are they and how might they help you?

(Examples of ways others might help you include entering information, helping you when you run into barriers on the mHealth system, helping you to start using the mHealth system)

- **Would the advice or suggestion of your doctor influence your decision to use mHealth? Why or why not?**

Probe: What would you think about your doctor's suggestion or advice to use an mHealth system like this? As a result of the suggestion or advice, would you use it? Why or why not? Would you trust the recommendation by your doctor?

- **How much would your doctor's endorsement/recommendation influence your decision to use this kind of mHealth system?**

Probe: What would your doctor have to say/do for you to decide to use it?

Patient-Centered Precedent Factors for mHealth Technology Acceptance

There are aspects of a person's health that might make it difficult or prevent them from using this kind of mHealth system, especially when they are living with diabetes. I want to ask you some questions directly related to your health and how that might affect whether or not you would use mHealth.

- **Overall, how would you describe your health now?**

Probe: How is your physical health? Your mental health?

- **Is there anything going on with you physically that might prevent you from using this kind of mHealth system?**

Probe: With diabetes, some people experience problems with eyesight or with using their fingers/fingertips to do certain things. Do you experience any of these?

Probes, if yes to any vision problems: Okay, so let's talk about your vision. How is it? What do you experience with your vision that would make it difficult to use an mHealth system? Does it affect your ability to see colors or text on the cell phone? How do you deal with this when you use your own cell phone?

Probes, if yes to any problems with using fingers/fingertips: Okay, so let's talk about your fingers/fingertips. What do you experience that would make it difficult to use an mHealth system? Are you losing the feeling in your

fingertips? Is it hard to use your fingers due to pain? Does it affect your ability to press buttons/icons on the cell phone? How do you deal with this when you use your own cell phone?

- **What might help you or someone else who has problems with their eyesight to still be able to use mHealth?**
- **What might help you or someone else who has problems with their fingers/fingertips to still be able to use this type of mHealth system?**
- **Are there any other health or physical issues that you think might hinder your or someone else's ability to use mHealth?**

Closing

Thank you for your time for this interview on today. Can you think of any other comments you might have about the attitudes and beliefs of yourself or adults in later life using mobile health (mHealth) for diabetes self-management? Have we talked about everything that you feel is important? Here is some educational information that might help you to continue to stay healthy and manage your diabetes – this, along with the healthy snack, is my way to thank you for your time on today. If you think of any questions after you leave, please feel free to call me at the number on the consent form that you have.

Appendix C

Interview Consent Form

Title of Study:

Exploring the Use of mHealth Technology for Diabetes Self-Management among Low-Tech Adults in Later Life

Investigators:

Tia Simmons, MPH, Department of Health Policy and Management, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Sandra Greene, DrPH, Professor of the Practice of Health Policy, Department of Health Policy and Management, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Purpose:

The purpose of this study is to explore the attitudes and beliefs that low-tech adults in later life have about using mobile health (mHealth) technology for their type 2 diabetes management. There is particular emphasis on identifying barriers that might hinder acceptance of this kind of technology for diabetes self-management. This knowledge would inform how entities plan interventions around uptake and use of mHealth technology by low-tech members of older populations who are living with type 2 diabetes.

Potential Benefits and Harms:

There is no direct or indirect harm that could come from your participation in this study; the only potential risk is minimal psychological discomfort from the questions being asked. You might benefit from this study by learning about a “new” technology that will be available in the future for diabetes self-management, and similar products that might be useful for you.

Anonymity:

Your identity will remain anonymous at all times. None of the information that you share with me today will be able to be traced back to you as an individual. Any information reported will be grouped with the responses of others. All data will be stored confidentially and securely during the study (i.e. on a password-protected laptop), and destroyed once the study is over.

Consent

I, _____ (interviewee's name), understand that I am being asked to participate in a University of North Carolina study to answer questions related to the attitudes and beliefs that low-tech adults in later life have about using mobile health (mHealth) technology for their type 2 diabetes management, and to identify barriers that hinder (as well as facilitators for) acceptance of this kind of technology for diabetes self-management.

I understand that it is my voluntary choice to participate in this study, and that I may refuse to participate or stop/withdraw from this interview session or the study at any time.

I also understand that a summary of the results will be made available to me at the end of the study, if I request a copy. My signature below indicates that I understand what this study involves and I agree to take part in this interview. Also, I have been given a copy of this signed consent form.

Signature of Participant

Name (please print)

Date

Signature of Witness

Name (please print)

Date

If you have any questions or concerns, either before or after your participations, please do not hesitate to contact us.

Tia Simmons, MPH, at (910)578-3365 or by email at tiajanel@email.unc.edu

Sandra Greene, DrPH, at (919)966-0993 or by email at sandraB.Greene@unc.edu

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Appendix D

Pew Internet and American life Project Technology User Typology

Questionnaire

What Kind of Tech User Are You?

1. Some people say they feel overloaded with information these days, considering all the TV news shows, magazines, newspapers, and computer information services. Others say they like having so much information to choose from. Do you feel overloaded, or do you like having so much information available?
 - a. Feel overloaded
 - b. Like having so much information
2. Overall, do you think that computers and technology give people MORE control over their lives, LESS control over their lives, or don't you think it makes any difference?
 - a. MORE control over their lives
 - b. LESS control over their lives
 - c. Makes NO DIFFERENCE
3. About how often do you go online from home? Several times a day, about once a day, 3-5 days a week, 1-2 days a week, every few weeks, or less often?
 - a. Several times a days
 - b. About once a day
 - c. 3-5 days a week
 - d. 1-2 days a week
 - e. Every few weeks
 - f. Less often
4. As I read the following list of items, please tell me if you happen to have each one, or not. Do you have... ?

	Yes	No
a. A desktop		
b. A laptop computer or network		
c. An iPod or other MP3 player		
d. A digital camera		
e. A video camera		
f. A Blackberry or iPhone, Palm or other personal digital assistant		
g. An electronic Book device or e-Book reader such as Kindle or Nook		

A tablet computer like an iPad, Samsung Galaxy or Motorola Xoom		
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5. Please tell me if you ever use your **cell phone** (or Blackberry or other device) to do any of the following things

	Yes	No
a. Send or receive text messages		
b. Take a picture		

6. Do you ever use the internet to get news online?

- a. Yes
- b. No

7. Do you ever use the internet to watch a video on a vide-sharing site like YouTube or Google Video?

- a. Yes
- b. No

8. Here's another short list of activities people sometimes do **online**. Please tell me whether you ever do each one, or not.

	Yes	No
a. Create or work on your own webpage		
b. Share something online that you created yourself, such as your own artwork, photos, stories or videos		
c. Post comments to an online news group, website, blog or photo site		

9. Please tell us if each of the following statements describes you very well, somewhat well, not too well, or not at all.

	Very well	Somewhat well	Not too well	Not at all
a. I like that cell phones and other mobile devices allow me to be more available to others				
b. When I get a new electronic device, I usually need someone else to set it up or show me how to use it				
c. When I don't have my cell phone or access to the internet, it is hard to get the information I need				
d. I believe I am more				

productive because of all my electronic devices				
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10. How difficult would it be, if at all, to give up the following things in your life?

	Very hard	Somewhat hard	Not too hard	Not hard at all
a. Your television				
b. Your cell phone				
c. The internet				

11. In the past 12 months, have you EVER accessed the internet from someplace other than from home or from work?

- a. Yes
- b. No

12. Have you ever created your own profile online that others can see, like on a social networking site like MySpace, Facebook or LinkedIn.com

- a. Yes
- b. No

13. How much, if at all, have these current communication and information devices improved...a lot, some, only a little, or not at all?

	A lot	Some	Only a little	Not at all
a. Your ability to share your ideas and creations with others				
b. Your ability to do your job				
c. Your ability to learn new things				
d. Your ability to keep in touch with friends and family				

Appendix E

Codebook/List of Codes for NVivo Analysis

Patient-Centered Antecedent Factors for mHealth Technology Acceptance
Self-reported Health Status
Self-Reported Physical Barriers to Use
Eyesight - Assistance for Use
Fingers - Assistance for Use
Other Health Issues as Barriers to Use
External conditions that affect mHealth Technology Acceptance
Start-up Needs
Training Needs
Time for Start-Up Help and Support
On-going Support Needs
Barriers to Use
Support People for System Use
Provider Influence on Use
Weight of Provider Influence on Use
Beliefs, attitudes, and practices for mHealth Technology Acceptance
What Makes it Useful
Use of Cell for Diabetes Management
Trust in mHealth System
Other Tech Used for Health Management
Time for Comfort
Nervousness of Use
Motivation to Use
Increasing Confidence and Efficacy in Solo Use
Increasing Comfort in Use
Increasing Trust in System
Ease of Use
Comfort with Current Use
Time for Comfort
Benefits of the mHealth System
Effect of Others' Opinions on Use
Use of Cell Phone
Current Health Management Practices (if described)
People who Support Use
Connecting the benefit with what the app is supporting her in doing.
Not afraid to use cell
Neg. Opinions around doctor's lack of support for mHealth
Older People and Technology - Views
Advertising and Marketing
General thoughts about the technology
Thoughts on older vs. newer cell
Other Functions for System (want)
Financial Concerns for securing mHealth

Appendix F

Tables of Emergent Themes

Beliefs, Attitudes, and Practices that Influence mHealth Technology Acceptance

Positive attitudes toward concept and function of mHealth for self-management

More skepticism about use by other adults in later life than that of themselves

Variation in levels of comfort and arrival at comfort level for mobile phone use

Beneficial views of record-keeping and tracking for DM (and for doctor)

Lack of identification with usefulness due to current practices, BG regulation

Importance of reminders of DM practices for self-care and actions for BG regulation

Ease of use, even without previous experience

Value placement on ideals of training, instruction, and practice for others

Peer demonstration of benefits as a mediator of others' comfort and trust

Social influence of adult children for use

Independence in final decisions for use

Comfort, confidence, and lack of nervousness in use

Trust in mHealth

Input around marketing and advertising for mHealth technology

External Facilitating Conditions that Influence mHealth Technology Acceptance

Few to no barriers for use

Cost concerns for securing mHealth

Desire for direction/instruction in start-up phase

Lack of formal training needs

Minimal time for start-up and support

Expectation of contact number/person for on-going support

Family members as help for system use, especially adult children (daughters)

Doctor's advice/suggestion as influence on decision for use

Patient-provider relationship indicates trust (via competence dimension)

Patient-Centered Antecedent Factors that Influence mHealth Technology Acceptance

Good self-reported health status

Self-reported health issues as non-impediments for use

Vision issues as barriers to use for others

Visual display changes to address vision barriers

Sound/voice activation to address dexterity-related barriers

Arthritis-related concerns as barriers for others

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