# ROLE OF MOBILE TECHNOLOGIES IN DIABETES SELF MANAGEMENT:

# TECHNOLOGY AFFORDANCE PERSPECTIVE

by

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# DEDICATION

न हि ज्ञानेन सदृशं पवित्रमिह विद्यते |

There is nothing as purifying as knowledge.

ज्ञानं परम् धीमहि |

We meditate upon the sublime and supreme knowledge

I dedicate this disseration to my family: my wife Madhuri, my sons Subbu and Srikrishna, my father-in-law and mother-in-law. They were with me through out this difficult, but enriching journey. Without their support, encouragement, and sacrifices, this Ph.D. would not have been possible.

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Abstract

ROLE OF MOBILE TECHNOLOGIES IN DIABETES SELF-MANAGEMENT:

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Diabetes is costly and a leading cause of death and disability in the United States (CDC, 2015). There is no known cure for the disease, however, it can be managed and controlled through self-management. This process involves patients managing a complex set of distinct but related tasks including, but not limited to, monitoring health conditions, tracking medication dosages, food intake, physical activities, complying with treatment regimens, and solving problems that may arise due to illness (Clark et al., 1991; Hill-Briggs, 2003). In recent years, mobile apps and devices (henceforth labeled mobile technologies) have emerged as a promising means to help diabetics manage their conditions. While the number and variety of mobile apps and devices for diabetes self-management continue to rise, their role and effectiveness in helping diabetics self-manage their conditions are relatively unknown (Caburnay et al., 2015; Eng and Lee, 2013).

The following dissertation, comprised of three essays, aims at supplying the research with answers by investigating the role of mobile technologies in diabetes self-management. To assist, technology affordances (Gibson, 1986), the self-regulation model of illness representation (Leventhal et al., 2003; 2008), and the self-care behavior framework as advocated by the American Association of Diabetes Educators (AADE7, 2010) act as theoretical foundations. The purpose of this dissertation is to advance the concept of technology affordances in the field of diabetes self-management using mobile technologies.

In the first essay, we report on the development and validation of an instrument to measure Perceived and Realized Affordances of Mobile Technologies for Diabetes Self-Management (AMTDS) with a nomological network. It is argued that mobile technology affordances play a significant role in influencing a patient's perception of the usefulness and ease of using mobile technologies for diabetes management. In the second essay, using the self-regulation model of illness representation and coping behavior, two models are developed. One for users and one for non-users of mobile technologies, where a patient's illness perceptions are shown to influence their intention to adopt and continue to use mobile technologies for diabetes management. In the third essay, a model of patient empowerment has been developed where technology affordances are theorized to influence patient empowerment, which in turn influences a patient's well-being. Survey methodology is utilized to collect data and empirically test the models in all the three papers. Relyng on the data collected from over 450 diabetes patients (200 non-users and over 250 users of mobile technologies), we test the hypothesized relationships.

This research contributes to the literature by supplying a new instrument for measuring the  affordances of mobile technologies for diabetes management. The insights from this study also contribute to the design and development of mobile technology while offering new insights into the role of affordances in influencing a diabetic's adoption and use of mobile technologies for diabetes management. All efforts are in support of inspiring others to further explore and measure the effects of technology affordances for other chronic illnesses.

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Paper-I

# Use of Mobile Technologies in Diabetes Self-Management: Influence of Technology Affordances

## 1.1 Introduction

Chronic diseases and conditions are leading causes of death and disability in the United States and they pose a serious threat to population health and the overall economy of the country. Among all the chronic illnesses, diabetes is considered as one of the most costly chronic conditions in terms of healthcare dollars and its incidence continues to rise. In 2012, the total estimated cost of diagnosed diabetes alone was $245 billion of which 72% was for direct medical care and the remainder for decreased productivity (Centers for Disease Control and Prevention, 2015a). Self-management of diabetes can play an essential role in lowering healthcare expenses and improving quality of life. Self-management, in which the patient plays an active and persistent role in managing his/her health condition, has been found to be highly effective in the overall improvement of health status of chronically ill patients (Barlow et al., 2002). Self-management has the potential to reduce healthcare costs and improve self-efficacy and ability of the patient to lead a healthy life (Kass-Bartelmes, 2002; National Institutes of Health, 2010).

In today's digital and networked world, mobile apps and/or devices (henceforth referred to as mobile technologies) have emerged as a promising means to help diabetics manage their condition. While the number and variety of mobile technologies for diabetes self-management continue to rise, their role as well as effectiveness in helping diabetics self-manage their conditions are not well understood (Caburnay et al., 2015; Eng and Lee, 2013). Their value will be realized only when these technologies are designed such that they afford necessary functions in a manner that contributes to the goals of their intended users (diabetes patients). Adoption and continued use of these mobile technologies for diabetes self-management is essential in improving patient well-being and reducing healthcare costs. Among several theoretical models that were developed and studied in the IS literature to explain individual adoption and use of information technology, an important one is the technology acceptance model (TAM; Davis 1989; Davis et al. 1989), according to which, individuals' perceptions of usefulness and ease of using technology significantly affect their adoption and use behavior. It is important to understand exactly what influences those perceptions of usefulness and ease of use.

Researchers have examined various factors that influence the usefulness and ease of use of an information technology. However, not much attention has been given from the technology affordance perspective. Technology affordances refer to the "potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artifact) and a goal-oriented actor" (Volkoff and Strong, 2013). The concept of technology affordances is important in the current context because (i) affordances are what the technology offers to the user of the technology (Gibson, 1986) and what is afforded by the technology can significantly influence the usefulness and ease of using the technology. A technology can give opportunities for multiple actions, which can further influence individuals' intentions in adopting technology. For diabetes patients, self-care behaviors such as healthy eating, being active, regular monitoring of their blood glucose and other vitals, and taking medication regularly are very important in managing their condition. Technology affordances that can facilitate patients in their self-care behaviors can become motivating factors for adopting and using the technology in managing diabetes; (ii) given the external determinants of perceived usefulness and ease of use that have been studied so far, when it comes to diabetes self-management, adoption and use of mobile technologies, and understanding of what makes individuals to hold usefulness and ease of use beliefs is very important because it impacts their long-term health and well-being. These determining factors would be of value not only to the professionals responsible for the design and development of mobile technologies, but also to the researchers engaged in examining technology adoption and continued usage. Concept of affordances is thus a relevant, important, and interesting topic to study and understand technology adoption and use in context of healthcare.

The objective of this study is to measure affordances of mobile technologies and investigate their role in the adoption and use of mobile technologies for diabetes management. To accomplish this, we draw from affordance theory (Gibson, 1986) and diabetes self-care behavior framework advocated by the American Association of Diabetes Educators (AADE7, 2010) as the foundation. We study the influence of technology affordance on adoption intentions of potential adopters (non-users) of technology and on the intentions of continued use for diabetes patients who currently use the technology. We develop an instrument to measure Affordances of Mobile Technologies for Diabetes Self-Management and validate it through a nomological network. These technology affordances is termed as perceived affordances (PA) for non-users of the technology and realized affordances (RA) for those who currently use the technology in managing their illness. Our findings suggest that technology affordance (both perceived and realized) serve as key antecedent to and positively influence usefulness and ease of using the technology for both users and non-users, thus making the concept important to study in the context of diabetes self-management.

The remainder of this article is organized as follows. In the next section we provide theoretical background on technology affordances and diabetes self-care behaviors that establish the concepts of perceived and realized affordances. This is followed by a review of relevant literature on diabetes self-management and the application of affordance theory in information systems research. Next, we develop a nomological network (research model) of relationships consisting of antecedents and consequences of technology affordances with theoretical arguments supporting the hypothesized relationships and validate them using data collected from a cross-sectional survey of diabetes patients. Finally, we discuss the results and offer theoretical and practical implications.

## 1.2 Prior Research on Technology Affordance

We performed a brief review, although not exhaustive, of extant literature on the application of affordance theory in IS literature (Tables 1.1) and the use of technology in diabetes self-management to build a foundation for the model development. In the literature related to technology affordances, our focus was on the conceptualization of affordance, type of technology studied, the aspect of IT to which affordance concept is applied, and factors that drive or influence technology affordances. In reviewing articles related to the use of technologies in diabetes self-management activities, we focused on understanding various activities involved in the process of diabetes self-management and technology affordances that facilitate these diabetes self-management activities. These activities and technology affordances form the basis for instrument development, and are explained in Appendix A.

Researchers have defined technology affordance as the actions users can perform with the object or technology, under particular circumstances, given the users' capabilities and goals (Markus and Silver 2008; Bloomfield et al. 2010). For example, the actions afforded by any software that displays dashboards to a company executive or manager are contingent upon their capabilities, context, and specific goals. A brief literature review on technology affordances is presented here by keeping four key aspects in view: type of technology used, technology affordance aspect, drivers of affordance, and consequences of affordance.

Affordances are unique to each context and technology. For example, studies have explored the concept of affordances with various technology types such as mobile technologies (Best and Tozer, 2013; Schrock, 2015; Tsai and Ho, 2013); social media (Argyris and Monu, 2015; Tream and Leonardi, 2012; Cabiddu et al., 2014); and enterprise level IT (Zammuto et al., 2007; Goh et al., 2011; Chatterjee et al., 2015). Similarly, studies have investigated technology affordances in various contexts at organizational level (for example, Chatterjee et al., 2015; Cabiddu et al., 2014; Leonardi, 2011), and at the individual level (for example, Grgecic et al., 2015; Schrock, 2015; Jung and Lyytinen, 2013). Technology affordances prompt IT use (for example, Argyris and Monu, 2015; Jung and Lyytinen, 2013; Chatterjee et al., 2015), which indicates that affordances primarily influence use behavior. Studies have shown that, as a consequence of IT use, affordances help in influencing organizational change (Volkoff and Strong 2013, Strong et al. 2014, Leonardi, 2011; Treem and Leonardi 2012). Some articles have studied how affordances evolve through dynamic interactions between technology and organizational structures (Goh et al., 2011; Leonardi, 2011; Volkoff and Strong, 2013).

**Table 1.1: Brief Summary of Review on the Application of Affordance Theory in IS Literature**

| No. | Technology Used | Technology Affordance Aspect | Drivers of Technology Affordances | IT Aspect/ Unit of Analysis/ Domain | Consequences of Technology Affordances | Source |
|---|---|---|---|---|---|---|
| 1. | Wikis, social networking sites, micro-blogging sites, and, video-sharing sites, | Presentability<br>Self-expression<br>Monitorability<br>Reach<br>Engagement<br>Connectivity<br>Recordability<br>Availability | Need for improving stakeholder relationships | IT Use/<br>Individual/<br>No specific domain | Better external communications | Argyris and Monu, 2015 |
| 2. | Social Media | Persistent engagement<br>Customized engagement<br>Triggered engagement | Need for keeping customers engaged on hotels' websites | IT Use/<br>Organization/<br>Tourism | Customer engagement | Cabiddu et al., 2014 |
| 3. | No specific technology. Paper uses the term "computer technology or IT" | Three dimensions of organizational IT affordances: Collaborative Affordance, Organizational Memory Affordance, Process Management Affordance. | Need for improving organizational innovation (Strategic competence). | IT Use/<br>Organization/<br>Cross Organizational | IT affordances positively influence organization's ethical competence | Chatterjee, et al., 2015 |
| 4. | Computerized documentation system | Functional Affordances | Routines in clinical settings<br>User capabilities | IT Implementation and Use/<br>Organizational/<br>Healthcare | Change and evolution of work routines | Goh et al., 2011 |
| 5. | Student Information System | Functional Affordances | System qualities (Communication of meaning and Communication of values) | IT Use/<br>Individual/<br>No domain | Functional affordances positively influence Information quality | Grgecic, Holten, and Rosenkranz, 2015 |
| 6. | Email | Media affordance:<br><br>Reciprocity<br>Emergence<br>Complementarity<br>Re-exploration<br>Actualization | Communication tasks<br>User capabilities | IT Use/<br>Individual/<br>Financial firm and University | N/A | Jung and Lyytinen, 2013 |
| 7. | Autoworks - CrashLab Simulation Technology | Affordances and Constraints.<br><br>CrashLab affords automation and coordination.<br><br>CrashLab constraints by not producing consistent results, not making work comparable, not allowing comparison of multiple iterations | Need to overcome constraints lead to perception of affordances | IT Development and Implementation/<br>Organization/<br>Autoworks | Perception of affordance leads to changes in routines and technology | Leonardi, 2011 |

**Table 1.1: Brief Summary of Review on the Application of Affordance Theory in IS Literature (Continued)**

| No. | Technology Used | Technology Affordance Aspect | Drivers of Technology Affordances | IT Aspect/ Unit of Analysis/ Domain | Consequences of Technology Affordances | Source |
|---|---|---|---|---|---|---|
| 8. | Electronic Patient Record | Affordances of National Care Record Service influence change in healthcare professional work. | Interactions of healthcare professionals with technology (EPR), leads to changes in professional work. | IT Use/ Organization/ Healthcare | Changes in healthcare professional work | Petrakaki, Klecun, and Cornford, 2016 |
| 9. | Social Media | Social media affordances for organizational communication:<br>Visibility<br>Persistence,<br>Editability, and<br>Association | Need for improving organizational processes | IT Use/ Organizational/ No domain | Organizational change | Treem and Leonardi (2012) |
| 10. | Smartphones | Design affordances:<br>Sensory affordance (Sense-ability)<br>Cognitive affordance (Understand-ability)<br>Physical affordance (Operate-ability) | Technology design features (intuition and diversity) | IT Design, Use and adoption/ Individual/ No domain | Attitude towards smartphone usage | Tsai & Ho, 2013 |
| 11. | 1) ERP (SAP) at ACRO<br><br>2) Custom-built software (CrashLab) at Autoworks | Basic Affordances, Standardizing and Integrating Affordances,<br>Visibility Affordances<br>Controlling Affordances<br>Communication Affordances<br>Analysis Affordances | Interaction of organizational structures and IT artifacts lead to affordances | IT Implementation and Use/ Organization/ Manufacturing firm | Organizational change | Volkoff and Strong, 2013 |
| 12. | Organizational level IT<br><br>No particular technology | Five affordances:<br>Visualizing entire work processes<br>Real-time/flexible product and service innovation<br>Virtual collaboration<br>Mass collaboration, and<br>Simulation/synthetic reality | Relationship between IT and organizational features results in new organizational form through affordances. | IT Use/ Organization/ No domain | Organizational change | Zammuto et al., 2007 |

Affordances are driven by the needs and capabilities of the user. In a study by Jung and Lyytinen (2013), authors provide an ecological account of the media choice (email) made by knowledge workers at three different organizations. These knowledge workers make their choice as an evolutionary process based on media affordances, which are communication (action) possibilities, offered by the media to fulfill their communication needs. They arrive at the same choice–email.

Technology affordances influence IT use, which results in affordance enabled outcomes. Through post-hoc analysis of two case studies, Volkoff and Strong (2013) argue that affordances are perceived through a complex interaction between organizational structures and technology artifacts and organizational actors realize these affordances over time, which can lead to various organizational outcomes. They propose that affordances are generative mechanisms in organizational change processes and demonstrate that affordance-based theories help us in understanding organizational changes caused by the use of IT. Argyris and Monu (2015), in their conceptual work, identify eight social media affordances that facilitate organizations in their communication activities with external stakeholders. Similarly, social media affordances positively influence customer engagement (Cabiddu et al., 2014). IT affordances positively influence organizational virtues (IT enabled ethical competence), which in turn influence organizational improvisational capabilities, thus improving organizational innovation (strategic competence) (Chatterjee et al., 2015). Values, meaning, and functional affordances provided by an IT system positively affect information quality and system quality (Grgecic et al., 2015). In a review of existing studies with regard to social media use in organizations, Treem and Leonardi (2012) suggest four types of social media affordances related to organizational communications that can influence organizational changes significantly. In a study on smartphone adoption and use, authors show that design affordance influence users' attitude toward smartphone usage (Tsai and Ho, 2013).

Technology affordances evolve in a dynamic interaction between the user, technology, and organizational structures. New affordances are perceived and realized as the technology and work practices undergo changes because of dynamic interaction between the uses and technology. Users tailor their practices and technology according to their need, preference, and context by modifying them as they interact with technologies (Best and Tozer, 2013). Technology affordances change organizational routines (patterns of clinical work) and vice versa through rich interactions between routines and technology. Managing evolving processes between routines and HIT is the key to successful implementation of IT (Goh et al., 2011). Changes in technology are constantly linked to the routines that precede and follow them and vice versa. Human and material agencies (the source of routines and technology) are intertwined and overlapped and the perceptions of affordances/constraints lead to changes in their routines and technologies respectively (Leonardi, 2011). Neither technology nor individual perception alone can bring change in professional work. It happens through a dynamic interaction between technology and the user. In a case of healthcare professionals' interaction with electronic patient record (EPR), a study finds that affordances of EPR help in standardizing healthcare professionals' conduct and practice, restrict professional autonomy, expand the role of nurses, and redistribute clinical work. In a review of articles published in a special issue, Zammuto et al., (2007) identify how interaction between IT and organizational features give rise to five types of affordances that can help explain the creation of new forms of organizational structures.

The articles presented in this brief literature review are unique in their own nature. However, we can find one common theme across all these studies: technology affordances do influence organizational outcomes such as organizational change, customer engagement, organizational communication, and changes in work routines through IT use. These affordances are unique with respect to technology type and context, and they depend on the organization or individual needs or goals. Although these articles do not explicitly discuss the factors that influence perception or realization of affordances, we can observe that individual or organizational goals and capabilities do influence technology affordances.

In summary, three key aspects emerge from the literature on technology affordances. One, technology affordances are unique to the technology and context specific; two, affordances influence technology use, which in turn leads to individual or organizational level outcomes; three, individual or organizational goals and capabilities influence technology affordances. Our work augments this body of research by developing an instrument to measure the affordances of mobile apps and devices to support diabetes self-management. The instrument development process is presented in the next section.

## 1.3 Background Theory

### *1.3.1 Technology Affordances*

American psychologist James Jerome Gibson was influential in the field of visual perception. He first introduced the term "affordance" to refer to what an object offers from the viewpoint of an actor. With its roots in perceptual and ecological psychology, affordances (Gibson, 1986) of the environment are "what it offers the animal, what it provides or furnishes, either for good or ill" (p. 127). In discussing the relationship between an animal and the environment with which the animal interacts, specifically how animals perceive the environment, he argues that objects and surfaces offer affordances for the animal to take action. The fundamental premise of the theory of affordance is that affordances stimulate action. Considering a surface that affords animals to stand on it, Gibson (1986) writes:

> "If a … surface is … horizontal, … flat, … extended, and … rigid, then the surface affords support…. It is stand-on-able… As an affordance of support for…animal…they have to be measured relative to the animal. They are unique for the animal (p. 127)."

The aspects horizontal, flat, extended, and rigid are physical properties of the surface. He argues that when we look at objects, we do not see the properties of the objects; instead, we actually perceive their affordances. That is, people see in what way the object can be used (e.g., sitting, climbing, standing) rather than its physical properties (e.g., flat, hard, round, or tall). The above formulation of affordance makes it clear that affordances are some kind of clues in the world around us that indicate possibilities for action "relative to the posture and behavior of the animal being considered (pp. 127-128)." So, affordances, the actions that are potentially made possible by the properties of the environment or objects and are always in relation to an animal that is making use of those properties. Thus, affordance is neither the property of the object nor that of the individual alone using the object. Instead, it is the property of the relationship between the object and the individual (Hutchby, 2001; Chemero, 2003).

Next, affordances only indicate possibilities for action. They determine how the object could possibly be used and are the preconditions for activity. However, presence of affordance in an actor-object system does not imply that the activity will occur (Greeno, 1994). Affordances have to be perceived in order for the person to take action. In his book **The Psychology of Everyday Things**, Norman (1988), introduced the term “perceived affordance” to indicate the “actions user perceives to be possible.” One key aspect of affordance is that it exists even if an individual does not perceive it or make use of it (Volkoff and Strong, 2013). However, unless an affordance in the object is perceived, the individual is not motivated to take the necessary action or change his behavior. A software application with an icon  for saving the work indicates an affordance of saving. This affordance of “saving” exists even if the user does not notice it. However, it is required for the individual to notice this affordance in order to perform the action of saving. Some affordances are obvious, but some are not. For example, imagine that there is a bookshelf in a room. It is obvious that the bookshelf affords one to keep books. Apart from keeping books, one can also use it for placing a coffee mug or a football. However, the affordance of the bookshelf supporting a coffee mug or football may not be obvious. The affordance of supporting objects other than books must be perceived in order to actually place the mug in the bookshelf.

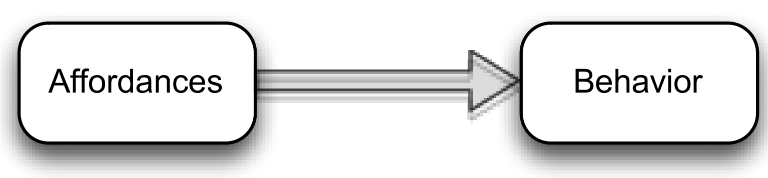



**Figure 1.1. Affordances Prompt Action**

Perceiving affordances depends on the abilities of an individual. Affordances of the environment contribute to the interaction and they are closely related to the abilities of the individual to make a particular behavior possible (Greeno, 1994; Thompson et al., 2011). When an individual looks around, he or she gets a direct perception of the actions that are made possible by the affordances of objects given their properties or characteristics and capabilities of the individual (Gaver, 1991). For example, consider there is a gap in fencing. This gap affords passing through. However, it is only possible given the capabilities of the individual (e.g., the height and size of the individual). The concept of affordance is also useful in understanding interaction of the users with technology. For example, consider a software application for creating documents such as Microsoft Word®. This software application affords multiple actions to the individuals depending on their ability to use the software. An individual with higher capabilities of using the software will have higher possibilities for action.

Further, affordances are driven by one's needs or goals. When there is a need, the individual will look around to perceive affordances in objects to fulfill his or her goal. Affordances arise when an individual views technology according to ones needs or goals. Markus and Silver (2008) call this functional affordance, which according to them is "possibilities for goal-oriented action afforded to specified user groups by technical objects" (p. 622). They posit that, given the user's requirements and abilities, functional affordance is the relationship between the technical object and the user. Within the context of information systems, technology artifacts have properties (features) and utility (affordance). For example, a personal computer can have word-processing software (can be considered as a feature of the personal computer) that allows individuals to prepare documents differently (its utility or affordance as perceived and enacted by the user) according to their ability and needs. So, affordances indicate a "relationship between a technical object and a specified user (or user group) that identifies what the user may be able to do with the object, given the user's capabilities and goals (p. 622)". For example, in the diabetes management, a blood glucose-measuring device may afford the patients who want to share their blood glucose measurements the opportunity to transmit them to their health care provider, but the same device may offer nothing to a patient who just wants to measure blood glucose level, but has no need or objective to transmit the data. A word processing software application affords printing documents and is indicated by the icon. However, one may not perceive this affordance unless one has a need or goal for printing the document. An object may offer several opportunities for different kinds of behavior for the individual and the perception of the affordances drives various kinds of behavior depending on the type of affordance (for example creating, saving, and printing). From the above discussion, two things become clear – capabilities and need or goal of a person influences affordances.

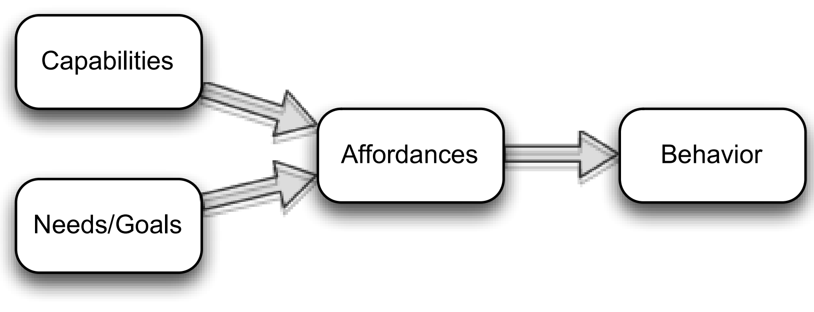



**Figure 1.2. Goals Capabilities Influence Affordance**

As discussed before, affordances are what the object offers to the individual and make possible a given activity. These affordances can be virtually unlimited. Affordances exist whether or not an individual perceives it. However, one must perceive it to make use of it. To perceive an affordance, one must discover this potential for action through perceptual learning and this knowledge about action possibilities offered by the objects around us varies among individuals (Gibson and Pick, 2000). The word-processing software application can afford printing documents whether or not the user perceives it. One individual may immediately notice the possibility of using printing, but another might not. This perceived affordance, once actually acted upon, becomes a realized affordance. Perceived affordances motivate action resulting in realized affordance, which in turn provides clues for discovering new affordances (Gibson and Pick, 2000). Discovering or perceiving new affordances may not be immediate or simple. It is possible to easily perceive some affordances, but others may require some time, effort, and exploration. Extending this analogy to the context of information technology, envisage the use of a word-processing software or a spreadsheet. Initially one may not see all the possible affordances offered by the software. The user may perceive an initial set of affordances, but as the individual continues using the software, with time, effort, and exploration, he or she will discover new affordances depending on one's capabilities and needs.

For instance, imagine that a spreadsheet software application allows different ways of calculations or statistical analysis. A user who perceived and realized the affordance of one type of calculation may now discover that the application software affords other ways to calculate data. This reciprocity between the perception of affordance and action indicates that a perceived affordance will be realized based on the properties of the object in relation to the capabilities and needs of the individual (Gibson and Pick, 2000). Considering the relational nature of affordances, users will appropriate the features of the technology only when they perceive that those features offer them opportunities for action (Leonardi, 2013). Thus, the realization of affordances (e.g., blood sugar monitoring) offered by the technology depends on the user's (patient) perception of potential actions made possible by the technology (e.g., blood glucose-measuring device).

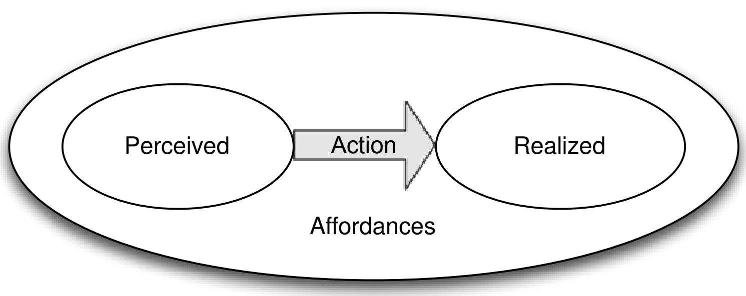



**Figure 1.3. Perceived Affordances are Realized by Taking Action**

In summary, six aspects emerge from the concept of affordance: (1) affordances prompt action or behavior in an actor; (2) affordances must be perceived before one can take action; (3) in order to take action based on affordances, one must possess necessary capabilities; (4) some affordances are obvious, but some are perceived depending on the individual needs and goals; (5) affordances can be realized through action; and finally, (6) affordances are leaned, meaning that as one keeps using the object or technology, one can perceive and realize new affordances offered by the object or technology.

## 1.4 Affordances in Diabetes Self-Management Behavior

Self-management of chronic illness involves patients taking an active role in managing their illness. It requires patients to handle their day-to-day treatment process and make decisions on a daily basis to solve their illness-related problems in order to maintain normal daily life activities (Hill-Briggs, 2003). Self-management emphasizes patient responsibility and is a promising strategy for controlling and managing chronic conditions (Grady and Gough, 2014). As with managing any chronic illness, diabetes self-management requires patients managing various complex tasks such as monitoring symptoms, conditions, and vital signs; tracking food intake, medication dosages; actively engaging in physical exercises to keep themselves active; and complying with treatment regimen, to name a few (Clark et al., 1991). Patients must integrate all these tasks into their daily routine.

Support from various sections of the society, such as family and friends, healthcare providers, and social-circles, becomes necessary for the patients to cope with their illness (Rosland et al., 2008). Conscious effort is required to bring necessary behavioral changes for successful diabetes self-management, which requires strong will and self-regulation efforts by the patients (Gonder-Frederick et al., 2002; Petrie et al., 2003; Hill-Briggs, 2003).

Diabetes is a very serious disease with symptoms of frequent urination, being thirsty, feeling hungry, blurred vision, and fatigue (American Diabetes Association, 2015). Managing these symptoms every day to keep diabetes in control can be challenging. To help diabetics in controlling their illness and have a good quality of life, the American Association of Diabetes Educators (AADE7™) developed an evidence-based framework based on the best practices which promote behavioral changes in diabetes patients for healthy living. AADE advocates seven self-care behaviors through this framework (AADE7, 2010): (1) healthy eating, (2) being active, (3) monitoring, (4) taking medications, (5) problem solving, (6) healthy coping, and (7) reducing risks. Literature (see Boren, 2007) suggests that each of these seven behavioral interventions can have a positive effect on diabetes control.

Healthy eating refers to having a diet that is well balanced. It means consuming appropriate food varieties in optimum quantities and portion sizes at right intervals. According to the Dietary Guideline for Americans 2015-2020 from the U.S. Department of Agriculture and the U.S. Department of Health and Human Services (USDA & USDHHS, 2015), healthy eating habits involve limited intake of foods such as sodium and added sugars that are not good for health, and underscores consumption of foods and beverages containing essential nutrients such as vitamins, minerals, and fiber. Anything that we eat affects our blood sugar. Eating healthy helps in keeping blood sugar levels under control and reduces other diabetes-related risks and complications.

Being active means different things to different people. At a fundamental level, it means maintaining a physically active lifestyle. Activities may include anything from walking and jogging to performing household chores, mowing the lawn, and even walking the dog. Physical activity helps in several ways such as reducing the risk of heart disease, controlling weight, strengthening bones and muscles, and improving blood circulation. Most importantly, it helps in reducing the risks of type-2 diabetes by proper use of insulin and food (Centers for Disease Control and Prevention, 2015b).

Abnormal levels of blood sugar can lead to serious complications in diabetes patients. Monitoring primarily involves checking blood sugar levels on a daily or weekly basis depending on the type of diabetes the patient has to make sure the levels are within the allowable range. Recording and tracking blood sugar levels daily allows one to see if and how the food intake, exercises, medication, and other factors affect blood sugar levels. Regular monitoring of blood glucose levels may also improve HbA1C in type-2 diabetes patients (McAndrew et al., 2007). This self-management behavior also helps the patient in taking any remedial action in terms of adjustments to food intake and physical activity if the blood sugar levels to go way outside the normal (70- 120 mg/dl) (Kirk and Stegner, 2010). Monitoring is not just about measuring blood sugar levels. Since diabetes can have impact on the whole body, periodically recording and observing other vitals such as blood pressure, body weight, cholesterol, and sensory testing also help in preventing other risks due to diabetes.

Taking medication regularly and adhering to the treatment regimen to keep blood sugar levels steady is an important part of effective diabetes management (Odegard and Capoccia, 2007). The type of medication, pills versus insulin, one takes depends on the type of diabetes. Because there is an increased risk of other health conditions due to diabetes, medication should also help with those side complications. Medication will have a more positive effect when it is used along with proper physical exercise and healthy diet.

According to the AADE framework of diabetes self-care behaviors, problem solving is defined as “a learned behavior that includes generating a set of potential strategies for problem resolution, selecting the most appropriate strategy, applying the strategy, and evaluating the effectiveness of the strategy (Mulcahy et al., 2003. p. 788).” No matter how small they are, it is important for diabetics to solve the problems otherwise, these problems and resulting stress can lead to fluctuations in blood sugar levels. Good problem-solving measures can facilitate in achieving other self-care behaviors such as eating healthy, maintaining a regular physical exercise, reducing risks, and healthy coping (Toobert and Glasgow, 1991; Hill-Briggs and Gemmell, 2007).

Diabetics are at a higher risk of developing complications to other parts of the body such as heart, kidneys, or eyes. Diabetes patients must periodically take precautionary healthcare services such as performing routine medical checkups for heart conditions, eye examinations, dental examination, and urine/blood testing (Mulcahy et al., 2003). Other things that diabetes patients should do to reduce risks from diabetes include avoiding smoking and taking care of their feet. Risk-reducing behaviors in diabetes self-management help in preventing or slowing the progression of diabetes-related complications (Boren et al., 2007).

Finally, while focusing on other self-care behaviors in the process of diabetes self-management, it is important for the diabetes patient to develop healthy coping skills through positive attitude, and by seeking help from family, friends, and other diabetics. Living with diabetes can be emotionally challenging, so keeping a positive attitude can help overcome daily diabetes-related emotional challenges. Those who positively cope with their conditions and related stress are likely to manage diabetes well.

For the purpose of developing the instrument, we define the seven self-care behaviors as "the extent to which mobile technologies help diabetics in accomplishing these behaviors (see Appendix A)".

Research shows that healthcare interventions that improve these self-care behavioral objectives have a positive effect on diabetes management (see for example, Boren, 2007). Mobile technologies that are designed for diabetes self-management will be more effective when these technologies afford certain functions that help patients accomplish the AADE7 self-care objectives. These affordances of mobile technologies become the motivating factors for the patients to adopt and use the technology for managing their illness. The scale for measuring these affordances has been developed based on the AADE7™ guidelines.

## 1.5 Research Model (Nomological Net)

To understand the role of technology affordances in the bigger context of technology use for diabetes management, we position the construct within a nomological network. While it is possible to conceive of several alternative network relationships for affordances, our objective is to study a possible set of determinants and consequences of technology affordances. We propose and validate nomological networks for both non-users (potential adopters) and current users of mobile technologies in managing diabetes. Figure 1.4 presents one such network for technology affordances for non-users. In the nomological network for users of mobile technologies, the variables perceived affordances, perceived usefulness, perceived ease of use, and intention to use are replaced by realized affordances, usefulness, ease of use, and intention to continue to use. In this section, we offer theoretical arguments and analysis of data from a cross-sectional study of diabetes patients (both users and non-users of mobile technologies) in support of the relationships proposed in the nomological network.

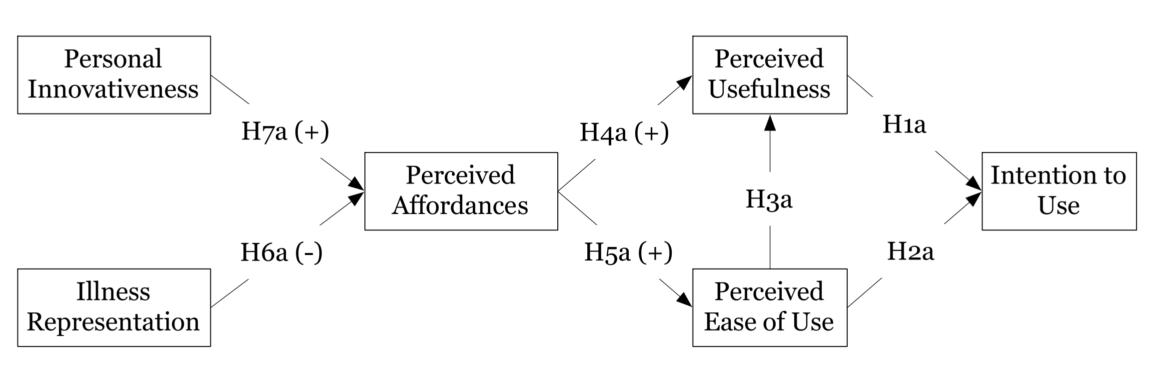



**Figure 1.4. Theoretical Model (Non-Users)**

One can see that the research model (nomological network) presented in Figure 1.4 for non-users hypothesizes that perceptions of usefulness and ease of use predict intentions to use mobile technologies for managing diabetes. Perceptions of affordances of mobile technologies is envisaged as the underlying determinant of perceived usefulness and perceived ease of use. The consequences of perceived affordances involving perceived usefulness, perceived ease of use, and intentions to use are taken from the technology acceptance model (TAM) (Davis, 1989, Davis et al., 1989).

Originated from the theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and its extension, the theory of planned behavior (TPB, Ajzen 1991; 2005), TAM has became a valuable and very well established model in the IS literature in predicting individuals' behavioral intentions of either adopting or rejecting a particular technology. There is a substantial body of work (see reviews Holden & Karsh, 2010; Marangunic & Granic, 2015) on TAM and several empirical studies have clearly demonstrated the positive effect of perceived usefulness and perceived ease of use on an individual's behavioral intentions of using technology. Drawing from the extant TAM literature, we test the following hypotheses:

H1a: Perceptions of usefulness of mobile technologies for diabetes management has a positive effect on the patients' behavioral intentions to use the technology.

H2a: Perceptions of ease of use of mobile technologies for diabetes management has a positive effect on the patients' behavioral intentions to use the technology.

H3a: Perceptions of ease of use of mobile technologies for diabetes management has a positive effect on the patients' perceptions of usefulness of the technology.

Extending the model to diabetes patients who are currently using mobile technologies for managing their illness, a nomological network is presented in Figure 1.5 for users.

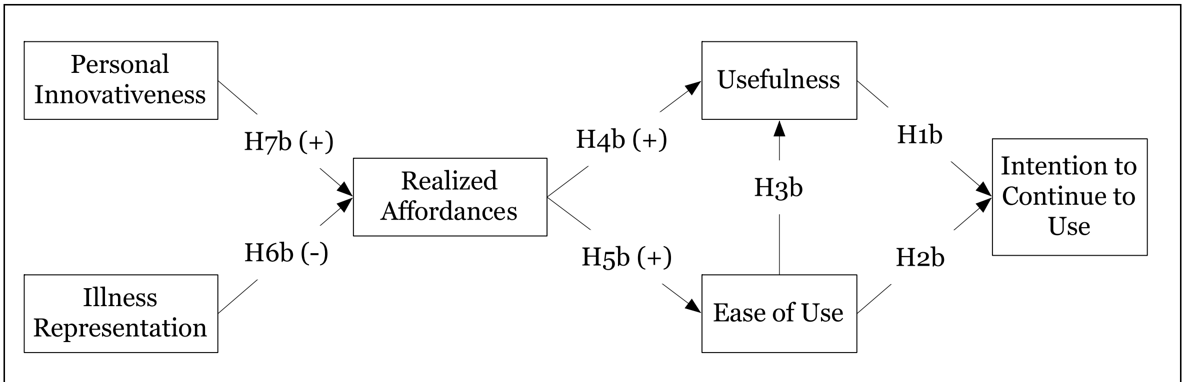



**Figure 1.5. Theoretical Model (Users)**

The research model presented above for users of mobile technologies hypothesizes that usefulness and ease of use actually experienced by the individuals drive their intentions to continue to use the technology in future for managing diabetes. Realized affordances (RA) of mobile technologies are visualized as the determining factor that predicts actual usefulness and ease of use of the technology.

In the IS literature, for predicting the individual's intentions to continue to use a particular technology, usefulness and ease of use have been envisaged as performance expectancy and effort expectancy, respectively (Venkatesh et al., 2003; 2012). Performance expectancy refers to benefits that technology provides to the users and effort expectancy relates to ease with which the technology can be used. These aspects, applied to diabetes patients actually using mobile technologies, refer to the degree of usefulness and ease of use associated with the actual use of mobile technologies in managing their diabetes. Research has shown that these performance and effort expectancy positive effects individuals' intentions to continue to use the system in question. Thus, we test the following hypotheses:

H1b: Usefulness of mobile technologies for diabetes management has a positive effect on the patients' intentions to continue to use the technology.

H2b: The ease with which mobile technologies can be used for diabetes management has a positive effect on the patients' intentions to continue to use the technology.

H3b: The ease with which mobile technologies can be used for diabetes management has a positive effect on the usefulness of the technology.

### *1.5.1 Impact of Affordances on Usefulness (Perceived) and Ease of Use (Perceived)*

Next, we discuss the consequences of technology affordances and see its position and relationship with the constructs underlying TAM. As we have seen in the theoretical background of technology affordances, perception of affordances influences one to act or at least influences one's intentions to act. That is, if one perceives that technology affords something, the individual is motivated to act. We have already seen the support from literature that one must perceive that an object will be useful and/or easy to use before the individual intends to actually use the object. Temporally, before one can say whether a particular technology will be useful or easy to use, one must notice what exactly the technology has to offer. In other words, one must perceive the affordances of technology to estimate its usefulness or ease of use.

Empirical studies show that technology affordance beliefs of smartphone design positively influence perception of usefulness and ease of use in using smartphones (Tsai & Ho, 2013). As we will discuss in the instrument development section (see Appendix A), there are five key aspects of diabetes self-management: being active and eating healthy foods, solving problems and reducing risks of complications from diabetes, monitoring glucose levels and other vital indicators, coping with the illness, and finally taking appropriate medication in a timely manner. Technology affordances along these dimensions are crucial for diabetes patients in managing their illness. For instance, eating healthy and balanced diet at certain frequencies, and choosing right food in right proportions are vital in maintaining blood glucose levels. In order to eat healthy, it would be very useful if the mobile technology provides information on diabetic-friendly foods. A technology that helps individuals in selecting a particular type of food in specific amounts is key to individuals' beliefs on the usefulness or ease of use of the technology. To reduce risks of side effects from diabetes, it might be necessary to periodically share blood glucose or other measurements with a healthcare provider. If the user has to save the data in a different tool and then transmit it to their provider, it might be cumbersome to use the technology. If the technology affords transmission of data along with measuring blood glucose levels, it would be easy for the patient to use the technology. A particular affordance of the technology that enables the patient to transmit data gives a feel for whether the technology would be easy to use. Perceived affordances of mobile technologies for diabetes self-management, through all its five sub-dimensions, is expected to positively effect usefulness and ease of use beliefs. Thus, we hypothesize:

H4a: Perceived affordances of mobile technologies for diabetes management has a positive effect on the patients' perceptions of usefulness of the technology.

H5a: Perceived affordances of mobile technologies for diabetes management has a positive effect on the patients' perceptions of ease of use of the technology.

Extending this argument to users of technology, individuals who use the technology for managing their diabetes actually have realized the affordances they perceive. Once an affordance is realized, the person experiences the usefulness and the ease of using the technology. Thus, we hypothesize

H4b: Realized affordances of mobile technologies for diabetes management has a positive effect on the patient's experience of usefulness of the technology.

H5b: Realized affordances of mobile technologies for diabetes management has a positive effect on the patient's experience of ease of use of the technology.

*1.5.2 Antecedents of Technology Affordances*

Gibson's (1986) stance was that the affordance of an object is invariant regardless of the needs of an actor. That is, an individual may not perceive the affordance, but it always exists. According to Gibson (1986), "an affordance is not bestowed upon an object by the need of an observer and his act of perceiving it. The object offers what it does because it is what it is" (p. 139). However, an affordance must be perceived before one can take any action or change their behavior. An individual must have a need and capability to perceive affordances in the objects (Stoffregen, 2003; Volkoff and Strong, 2013). Once perceived, the person can reify the affordance by individual interacting with an object. In a real world, when we look around, an individual with a need and capability can perceive the actions that are made possible by the objects. Affordances of the environment and abilities of the individual are closely related to each other to make a particular behavior possible (Greeno, 1994; Thompson et al., 2011). From the point of view of effective design of everyday things, Norman (2013) describes affordance as a "relationship between the properties of an object and the capabilities of the agent (p. 11)".

Within the context of information systems, technology artifacts have properties (features) and utility (affordance). For example, a personal computer can have word processing software (can be considered as a feature of the personal computer) that allows individuals to prepare documents differently (its utility or affordance as perceived and enacted by the user) according to their ability and needs. Markus and Silver (2008) call them "functional affordances," which refer to "possibilities for goal-oriented action afforded to specified user groups by technical objects" (p. 622). They posit that, given the user's requirements (needs) and abilities, functional affordances represent the relationship between the technical object and the user. For example, a drawing shapes icon 

in the menu bar of Microsoft® Word™ application indicates a "drawing" affordance. Meaning that the software application affords one to draw pictures. If the person using the software does not have a need, he or she may not notice the affordance. Similarly, consider that a software application affords one to convert a document to Adobe-portable document format (pdf) for which one may have to navigate different menu options. To perceive this affordance, one must have a need and capability.

In diabetes management, a blood glucose-measuring device may afford patients who want to share their blood glucose measurements the opportunity to transmit them to their health care provider, but the individual may not perceive and/or realize this affordance unless he/she doesn't has a need and/or capability of engaging in such an action. According to the self-regulation model (Leventhal et al., 2003), patients' illness perceptions influence their response to some kind of coping behavior. These illness presentations, which represent the patient's belief about health status and/or control, form their needs that drive coping behavior. When there is a technology with affordances that can facilitate patients in their self-management, patients' need for managing their health and lead a better live can influence their perception of whether or not the technology can facilitate them in their coping process. Research has demonstrated that the patient's belief and estimate of his health severity have consistently predicted their compliance with treatment recommendations (Feuerstein et al., 1986). This illustrates that individuals with negative illness perceptions find a need to do something about it and will look for resources for help in getting their health under control. Similarly, patients who think their heath status is good and are in control of their health, meaning those who have positive illness perceptions may not believe that technology or external gadgets will afford anything for them to manage their illness. We theorize that individuals with positive illness representations are less likely to perceive affordances of the technology compared to those who with negative illness perceptions. Thus,

H6a: Positive illness representations will have a negative effect on the perception of affordances of mobile technologies for diabetes management.

As discussed in the background theory, affordances once perceived, motivate action leading to the realization of affordance. These realized affordances might in turn provide opportunities for discovering or perceiving new affordances through effort, learning, and exploration (Gibson and Pick, 2000). This connection between the perception of affordance and action indicates that a perceived affordance will be realized based on the capabilities and needs of the individual (Gibson and Pick, 2000). In the context of information technology, envisage the use of a word-processing software or spreadsheet.

Initially one may not see all the possible affordances of the software application. The user may perceive an initial set of affordances and as the individual continues using the technology, with time, effort, and exploration, he or she will discover new affordances depending on their capabilities and needs. When there is no need, they will not have any inclination to discover and realize additional affordances. Research has shown that once patients begin to experience fewer symptoms, feel better, or believe that their health status is not that severe, their compliance with medical treatment diminishes or they will discontinue following prescribed treatment (Feuerstein et al., 1986). Now, let us extend this analogy to the users of mobile technology for diabetes management. As the patient continues to use technology and as a consequence of that if the health severity decreases or health control increases, meaning illness perceptions become positive, then they do not see any need to discover and realize additional affordances. We believe that individuals who do not have a need, meaning those who have positive illness perceptions will not realize new affordances compared to those who feel otherwise. Thus,

H6b: Positive illness representations will have a negative effect on realized affordances of mobile technologies for diabetes management.

We have seen previously that affordances of the object depend on individual abilities (Chemero, 2003). Personal innovativeness in the field of information technology is conceptualized as an individual's willingness to try out different things with a new technology (Agarwal and Prasad, 1998). Rogers (2003), in his book **Diffusion of Innovations**, states "innovators are active information-seekers about new ideas" (p. 22). While discussing innovativeness and adopter categories, he refers innovativeness as the degree to which an individual is quick in adopting new ideas compared to others who are less innovative. In the marketing literature, Midgley and Dowling (1978) define innovativeness as the "degree to which an individual is receptive to new ideas…" (p. 236). Personal innovativeness, conceptualized as an individual's characteristic, is likely to influence their discovering and realizing new affordances of the technology. For example, consider a spreadsheet like software that affords several possibilities for performing statistical and mathematical operations. An individual who is eager to explore is likely to perceive and realize new affordances of this software more than those who are less innovative. We posit that an individual with greater personal innovativeness, considered as a proxy to an individual's capability in this study, is more likely to perceive and realize new affordances of the technology compared to an individual who is less capable. Thus,

H7a: Personal innovativeness will have a positive effect on perception of affordances of mobile technologies for diabetes management.

H7b: Personal innovativeness will have a positive effect on realized affordances of mobile technologies for diabetes management.

In summary, Table 1.2 and Table 1.3 present all the hypotheses made for non-user and user models, respectively, in this study.

**Table 1.2. Summary of Hypotheses (Non-User Model)**

| # | Hypothesis |
|---|---|
| H1a | *Perceptions of usefulness of mobile technologies for diabetes management have a positive effect on the patients' behavioral intentions to use the technology.* |
| H2a | *Perceptions of ease of use of mobile technologies for diabetes management have a positive effect on the patients' behavioral intentions to use the technology.* |
| H3a | *Perceptions of ease of use of mobile technologies for diabetes management have a positive effect on the patients' perceptions of usefulness of the technology.* |
| H4a | *Perceived affordances of mobile technologies for diabetes management have a positive effect on the patients' perceptions of usefulness of the technology.* |
| H5a | *Perceived affordances of mobile technologies for diabetes management have a positive effect on the patients' perceptions of ease of use of the technology.* |
| H6a | *Positive illness representations will have a negative effect on the perception of affordances of mobile technologies for diabetes management.* |
| H7a | *Personal innovativeness will have a positive effect on perception of affordances of mobile technologies for diabetes management.* |

| Table 1.3. Summary of Hypotheses (User Model) | |
|---|---|
| **#** | **Hypothesis** |
| H1b | *Usefulness of mobile technologies for diabetes management has a positive effect on the patients' intentions to continue to use the technology.* |
| H2b | *Ease of using mobile technologies for diabetes management has a positive effect on the patients' intentions to continue to use the technology.* |
| H3b | *Ease of using mobile technologies for diabetes management has a positive effect on the usefulness of the technology.* |
| H4b | *Realized affordances of mobile technologies for diabetes management have a positive effect on the usefulness of the technology.* |
| H5b | *Realized affordances of mobile technologies for diabetes management have a positive effect on ease of using the technology.* |
| H6b | *Positive illness representations will have a negative effect on realized affordances of mobile technologies for diabetes management.* |
| H7b | *Personal innovativeness will have a positive effect on realized affordances of mobile technologies for diabetes management.* |

## 1.6 Instrument Development

All the variables in the research model have been measured using multi-item scales. We adapted measures for all the variables, except for technology affordances, from prior research studies. We developed a new instrument for measuring affordances of mobile technologies in diabetes management and the process of developing the instrument is briefly described below. Appendix A presents a detailed account of instrument development process used for measuring affordances.

Items for measuring intention to adopt and use for non-users were adapted from Venkatesh et al. (2003) and the items for intention to continue using mobile technologies for users were adapted from Bhattacherjee (2001) and Venkatesh and Goyal (2010). Perceptions of usefulness and ease of use for non-users and actual usefulness and ease of use for users were assessed by adapting items from Venkatesh & Davis (2000) and Venkatesh et al. (2003).

Illness representation refers to the individual's perception of their illness. It is comprised of patients' perception of the severity of their illness and the amount of control they believe they have. We used a brief illness perception questionnaire (Brief IPQ) (Broadbent et al., 2006), which consists of eight items. To assess individuals' willingness to try out any new mobile technologies, we adapted personal innovativeness items from Agarwal and Prasad (1998).

All the items were measured using five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5) with an exception of items for illness representation, which were measured on eleven-point scale. Items for all the remaining constructs in the research model are presented in Appendix A.

A four-stage process, based on the guidelines available in the literature (Moore & Benbasat, 1991; Chu & Chau, 2014; DeVellis, 2012), was used to develop the instrument for mobile technology affordances in diabetes self-management. Figure 1.6 presents various stages and activities performed in the process. Technology affordances for non-users are referred to as perceived affordances (PA) whereas for users they are termed as realized affordances (RA). In stage 1, the domain is specified and constructs are defined. In stage 2, items for each scale are developed. Items are refined through sorting and pretesting in stage 3. Finally, the instrument is validated in stage 4.

In the first stage, domain for the construct is specified and a clear definition of the construct is developed to recognize the boundaries of the phenomenon. AADE7 behavioral objectives are our basis for developing the instrument. Adapting Volkoff and Strong (2013), we define affordances of mobile technologies for diabetes self-management (AMTDS) as "the potential for action required by the individual for accomplishing AADE recommended diabetes self-care behaviors." Three key elements are included here– behavior or potential for behavior, the actor, and the goal. Initially, we conceptualized the construct as consisting of seven dimensions, each one being a self-care objective. In the current context, we define these dimensions as "the extent to which mobile apps and/devices help diabetics realize behavioral goals."

In the second stage, we developed relevant items under each scale (self-care behavior) based on the review of literature on diabetes self-management, and extensive discussions with healthcare practitioners engaged in diabetes management, and experts in the College of Nursing in a major university. We provided input such as construct definitions and scale descriptions to the experts and asked them to describe mobile technology affordances to accomplish diabetes self-care objectives. After rewording and simplifying descriptions, an initial list of 52 items was generated. Other experts reviewed this list further to ensure items described mobile technology affordances accurately.

In stage 3, the instrument was refined through sorting followed by pretesting. Sorting enables placing items into appropriate categories, thus improving construct validity (Moore and Benbasat 1991). A total of nine individuals with experience and/or expertise in diabetes management categorized the items according to how closely they were related to each dimension/scale of the construct. Ambiguous items were eliminated in this step resulting in a list of 37 items (73% of the original list of 52). This list was pre-tested by conducting an online web-based survey with a group of 25 individuals. In addition to filling out the survey, the respondents were also requested to provide feedback on various aspects of the survey instrument, such as clarity of items and time taken to complete the survey. The survey instrument was further refined based on their feedback. The resulting instrument contained 27 items.

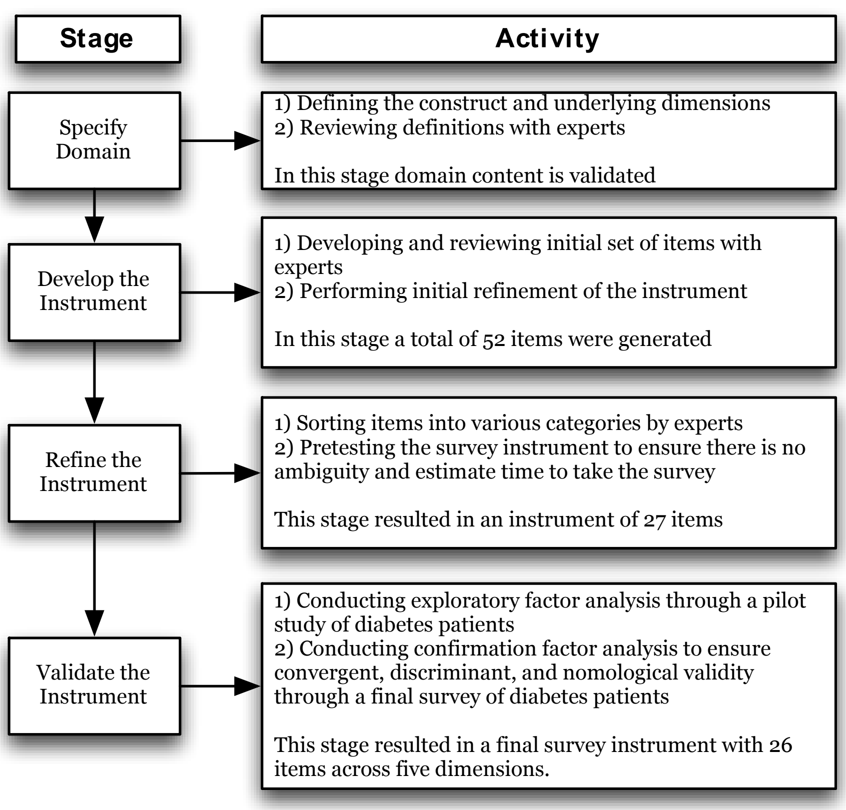



**Figure 1.6. Instrument Development Process**

Finally, in the instrument validation stage, we performed exploratory factor analysis by collecting data through a pilot study of diabetes patients. The final instrument resulted in 26 items with five dimensions. We then tested the instrument for convergent, discriminant, and nomological validity by performing confirmatory factor analysis using the data collected through a final survey of over 450 diabetes patients.

## 1.7 Methodology

The unit of analysis for the study is an individual, the diabetes patient. To empirically test the hypothesized relationships in the research model, we collected data in a cross-sectional study using an online web-based survey methodology. We designed the questionnaires for two groups of population: users and non-users of mobile technologies. Users include diabetes patients who currently are using mobile technologies in managing their illness and non-users comprise of diabetes patients who do not currently use any technology for managing their conditions, but they are familiar and knowledgeable about those technologies. We collected data anonymously using an online survey questionnaire through a third party data collection agency from diabetes patients who are over 18 years of age and live within the United States of America. Other than these two, no restrictions were imposed on the demographics of the survey respondents. The items in the questionnaire were designed such that they captured perceptions from the non-user population and the users of technology provided their actual experience.

A total of 208 and 257 completed and useful responses were returned from non-users and users, respectively. Table 1.4 provides distribution of respondents according to gender, age, usage of smartphone apps in general, and usage of mobile technologies for diabetes management. Distribution of respondents across the gender dimension is more or less similar between users and non-users. In the non-user population, 56.3% of the respondents are female and 43.8% are male and from the user group, representation of female and male is 53.3% and 46.7%, respectively. Seventy five percent (156) of non-users are between 35 and 64 years of age and 82.9%(213) of users are between 25 and 54 years of age. This shows that users are relatively younger than non-users and 48.1% of non-users are over 45 years of age and 69.6% of the users are below 44 years of age indicating that the older population does not use mobile technologies in their diabetes management and the majority of users belong to the younger population. We also captured data related to the respondents' use of mobile apps in general and among the users, we collected data on their use of mobile technologies related to diabetes. One hundred and thirty (62.5%) non-users and 107 (41.63%) users have been using some king of mobile app and smartphones for over tw0 years. From the non-user population, we ensured that all the respondents are familiar and knowledgeable about mobile technologies used for diabetes management. From the user population, 217 (84.44%) respondents have been using mobile technologies for managing diabetes for at least over six months.

**Table 1.4. Data Distribution**

| | | Non-Users | % | Users | % |
|---|---|---|---|---|---|
| Total samples | | 208 | | 257 | |
| | | | | | |
| Gender | Male | 91 | 43.8% | 120 | 46.7% |
| | Female | 117 | 56.3% | 137 | 53.3% |
| | | | | | |
| Age | 18-24 | 11 | 5.3% | 15 | 5.8% |
| | 25-34 | 39 | 18.8% | 71 | 27.6% |
| | 35-44 | 58 | 27.9% | 93 | 36.2% |
| | 45-54 | 47 | 22.6% | 49 | 19.1% |
| | 55-64 | 51 | 24.5% | 24 | 9.3% |
| | 65-74 | 2 | 1.0% | 5 | 1.9% |
| | >74 | 0 | 0.0% | 0 | 0.0% |
| | | | | | |
| General smartphone app usage | 0-6 Mos | 20 | 9.62% | 28 | 10.89% |
| | 6-12 Mos | 22 | 10.58% | 42 | 16.34% |
| | 1-2 Yrs | 36 | 17.31% | 80 | 31.13% |
| | 2-5 Yrs | 64 | 30.77% | 69 | 26.85% |
| | > 5 Yrs | 66 | 31.73% | 38 | 14.79% |
| | | | | | |
| Mobile technologies for managing diabetes | 0-6 Mos | n/a | | 40 | 15.56% |
| | 6-12 Mos | n/a | | 90 | 35.02% |
| | 1-2 Yrs | n/a | | 89 | 34.63% |
| | 2-5 Yrs | n/a | | 33 | 12.84% |
| | > 5 Yrs | n/a | | 5 | 1.95% |

## 1.8 Analysis

The partial least squares (PLS) approach to structural equation modeling (SEM) technique is used for evaluating the measurement of latent variables and testing relationships between them. The PLS is a preferred technique over covariance-based SEM primarily because of its relaxed demands on sample size and normality requirements of the data (Fornell and Bookstein 1982; Hair et al., 2011a). It is also suitable in the initial stages of theory development where the primary objective is to maximize the explained variance in the outcome variables (Fornell and Bookstein 1982; Hair et al., 2011b). To test the hypothesized relationships and establish nomological validity, we used SmartPLS (Ringle et al. 2015) software. We used bootstrapping with 1000 samples and ran the test as one-tailed. The results are presented in two parts–measurement model in which the relationship between the items (indicators or measured variables) and latent variables (factors) are shown, and the structural model where relationships among latent variables are displayed.

We present the results for both non-users and users of mobile technologies. The intention to use (and intention to continue to use), perceived usefulness (and usefulness), perceived ease of use (and ease of use), and personal innovativeness are measured as first-order reflective constructs. Illness representation is measured as second-order formative and first-order reflective constructs. Technology affordances (perceived affordances and realized affordances) are measured as second-order reflective-reflective construct. In the model assessment, internal consistency is evaluated using both Cronbach's alpha and composite reliability and individual indicator reliability. Average variance extracted (AVE) is used to evaluate convergent validity. Discriminant validity is assessed using item cross loadings and Fornell-Larcker criterion.

Table 1.5 provides the measurement model for both non-users and users. Cronbach's alpha, with an acceptable value of 0.70, is usually evaluated as a means of measuring internal consistency. Composite reliability, with a value of over 0.70 is considered satisfactory, is another means of evaluating internal consistency. As it can be seen from the measurement model, composite reliability and

Cronbach's alpha of all constructs is over 0.7, which is considered satisfactory (Nunally and Bernstein, 1994), thus establishing internal consistency of all the variables in both models.

*1.8.1 Measurement Model*

**Table 1.5. Measurement Model**

| | | Non-Users | | | | | Users | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Construct** | **Dimension** | **Mean** | **SD** | **CR** | **CA** | **AVE** | **Mean** | **SD** | **CR** | **CA** | **AVE** |
| IU/ICU | | 3.644 | 0.916 | 0.951 | 0.931 | 0.828 | 3.872 | 0.488 | 0.946 | 0.923 | 0.813 |
| U/PU | | 3.904 | 0.706 | 0.939 | 0.903 | 0.838 | 4.284 | 0.673 | 0.939 | 0.902 | 0.836 |
| EU/PEU | | 3.726 | 0.658 | 0.864 | 0.767 | 0.680 | 3.969 | 0.661 | 0.861 | 0.759 | 0.679 |
| PA/RA | BAHE | 4.097 | 0.567 | 0.927 | 0.910 | 0.615 | 4.036 | 0.720 | 0.920 | 0.901 | 0.590 |
| | RRPS | 3.931 | 0.687 | 0.935 | 0.920 | 0.642 | 3.956 | 0.672 | 0.929 | 0.911 | 0.621 |
| | MO | 4.064 | 0.636 | 0.900 | 0.849 | 0.693 | 4.087 | 0.611 | 0.844 | 0.749 | 0.581 |
| | HC | 3.857 | 0.669 | 0.900 | 0.833 | 0.750 | 3.672 | 0.984 | 0.943 | 0.910 | 0.847 |
| | TM | 4.059 | 0.607 | 0.839 | 0.712 | 0.636 | 3.946 | 0.833 | 0.873 | 0.781 | 0.696 |
| PI | | 3.383 | 0.614 | 0.901 | 0.837 | 0.753 | 3.925 | 0.780 | 0.909 | 0.849 | 0.768 |
| IR | PHC | 8.139 | 1.803 | 0.836 | 0.762 | 0.635 | 8.452 | 1.505 | 0.859 | 0.749 | 0.661 |
| | PHS | 4.472 | 2.022 | 0.902 | 0.862 | 0.651 | 3.943 | 1.514 | 0.858 | 0.792 | 0.555 |

Note: CA – Cronbach's Alpha; CR – Composite Reliability; AVE – Average Variance Extracted

IU – Intention to Use; ICU – Intention to Continue to Use; U – Usefulness; PU – Perceived Usefulness; EU – Ease of Use; PEU – Perceived Ease of Use; PA – Perceived Affordances; RA – Realized Affordances; BAHE – Being Active and Healthy Eating; RRPS – Reducing Risks and Problem Solving; MO – Monitoring; HC – Healthy Coping; TM – Taking Medication; PI – Personal Innovativeness; IR – Illness Representation; PC – Perception of Control; PH – Perception of Health Status

The outer loadings of the indicators along with the average variance extracted (AVE) are used in assessing convergent validity of the variables. A minimum value of 0.5 for AVE is considered acceptable (Fornell and Larcker, 1981). The outer model loadings of all the items in the respective constructs are shown in Table 1.6. We removed the items PI3 from Personal Innovativeness and ICU5 from Intention to Continue to Use due to their very low factor loadings. The resulting outer loadings of all the indicators are above the acceptable level of 0.708 (Hair Jr. et al., 2014), thus establishing convergent validity. Cross loadings of the indicators and the comparison of average variance extracted for each construct against inter-construct correlations are used to evaluate discriminant validity (Fornell and Larcker 1981). Inter-construct correlations for non-user model and user-model are presented respectively in Tables 1.7 and 1.8. Tables 1.9 and 1.10 show the cross-loadings of the items under non-user model and user models, respectively. We can see that all the items are loading well with respect to their construct indicating that they measure what they are intended to measure. Item cross-loadings and inter-construct correlations illustrate sufficient discriminant validity.

#### 1.8.1.1 Outer Loadings

| **Table 1.6. Outer Model Loadings** | | | |
|---|---|---|---|
| **Non-Users** | | **Users** | |
| **Construct** | **Outer Loading** | **Construct** | **Outer Loading** |
| ***Perceived Affordances*** | | ***Perceived Affordances*** | |
| Being Active and Healthy Eating | 0.919 | Being Active and Healthy Eating | 0.891 |
| Reducing Risks and Problem Solving | 0.855 | Reducing Risks and Problem Solving | 0.901 |
| Monitoring | 0.783 | Monitoring | 0.726 |
| Healthy Coping | 0.729 | Healthy Coping | 0.838 |
| Taking Medication | 0.799 | Taking Medication | 0.771 |
| | | | |
| ***Illness Representation*** | | ***Illness Representation*** | |
| Perception of Control | 0.177 | Perception of Control | 0.356 |
| Perception of Severity | 0.959 | Perception of Severity | 0.883 |
| | | | |
| ***Intention to Use*** | | ***Intention to Continue to Use*** | |
| INT1 | 0.903 | ICU1 | 0.920 |
| INT2 | 0.889 | ICU2 | 0.862 |
| INT3 | 0.918 | ICU3 | 0.920 |
| INT4 | 0.929 | ICU4 | 0.905 |
| | | | |
| ***Perceived Usefulness*** | | ***Usefulness*** | |
| PU1 | 0.945 | U1 | 0.910 |
| PU2 | 0.910 | U2 | 0.931 |
| PU3 | 0.890 | U3 | 0.902 |
| | | | |
| ***Personal Innovativeness*** | | ***Personal Innovativeness*** | |
| PI1 | 0.888 | PI1 | 0.863 |
| PI2 | 0.830 | PI2 | 0.877 |
| PI4 | 0.884 | PI4 | 0.890 |
| | | | |
| ***Perceived Ease of Use*** | | ***Ease of Use*** | |
| PEU1 | 0.723 | EOU1 | 0.651 |
| PEU2 | 0.879 | EOU2 | 0.899 |
| PEU3 | 0.862 | EOU3 | 0.897 |

| Table 1.7. Inter-Construct Correlation Matrix (Non-Users) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | PA: BAHE | PA: RRPS | PA: HC | PA: MO | PA: TM | IR: PC | IR: PH | PI | PU | PEU | IU |
| PA: BAHE | 0.784 | | | | | | | | | | |
| PA: RRPS | 0.672 | 0.801 | | | | | | | | | |
| PA: HC | 0.581 | 0.560 | 0.866 | | | | | | | | |
| PA: MO | 0.712 | 0.496 | 0.528 | 0.833 | | | | | | | |
| PA: TM | 0.716 | 0.581 | 0.560 | 0.611 | 0.797 | | | | | | |
| IR: PC | -0.167 | -0.163 | -0.211 | -0.256 | -0.144 | 0.797 | | | | | |
| IR: PH | -0.207 | -0.320 | -0.122 | -0.218 | -0.261 | 0.145 | 0.807 | | | | |
| PI | 0.439 | 0.549 | 0.307 | 0.400 | 0.443 | 0.042 | -0.269 | 0.868 | | | |
| PU | 0.607 | 0.644 | 0.453 | 0.549 | 0.579 | -0.067 | -0.333 | 0.628 | 0.915 | | |
| PEU | 0.449 | 0.396 | 0.437 | 0.458 | 0.479 | -0.168 | -0.142 | 0.396 | 0.589 | 0.825 | |
| IU | 0.436 | 0.503 | 0.282 | 0.407 | 0.481 | 0.088 | -0.384 | 0.661 | 0.694 | 0.394 | 0.910 |

PA – Perceived Affordances; BAHE – Being Active and Healthy Eating; RRPS – Reducing Risks and Problem Solving; HC – Healthy Coping; MO – Monitoring; TM – Taking Medication; IR – Illness Representation; PC – Perceptions of Control; PH – Perceptions of Health Status; PI – Personal Innovativeness; PU – Perceived Usefulness; PEU – Perceived Ease of Use; ICU – Intention to Use

| Table 1.8. Inter-Construct Correlation Matrix (Users) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | RA: BAHE | RA: RRPS | RA: HC | RA: MO | RA: TM | IR: PC | IR: PH | PI | U | EU | ICU |
| RA: BAHE | 0.768 | | | | | | | | | | |
| RA: RRPS | 0.703 | 0.788 | | | | | | | | | |
| RA: HC | 0.654 | 0.740 | 0.920 | | | | | | | | |
| RA: MO | 0.588 | 0.545 | 0.528 | 0.763 | | | | | | | |
| RA: TM | 0.625 | 0.605 | 0.631 | 0.548 | 0.834 | | | | | | |
| IR: PC | -0.257 | -0.266 | -0.201 | -0.305 | -0.212 | 0.813 | | | | | |
| IR: PH | -0.139 | -0.203 | -0.125 | -0.170 | -0.177 | 0.147 | 0.745 | | | | |
| PI | 0.585 | 0.441 | 0.472 | 0.518 | 0.511 | -0.184 | -0.122 | 0.877 | | | |
| U | 0.503 | 0.499 | 0.400 | 0.616 | 0.516 | -0.356 | -0.153 | 0.552 | 0.914 | | |
| EU | 0.396 | 0.509 | 0.456 | 0.541 | 0.363 | -0.337 | -0.086 | 0.437 | 0.590 | 0.824 | |
| ICU | 0.455 | 0.448 | 0.378 | 0.554 | 0.432 | -0.369 | -0.146 | 0.523 | 0.732 | 0.594 | 0.902 |

RA – Realized Affordances; BAHE – Being Active and Healthy Eating; RRPS – Reducing Risks and Problem Solving; HC – Healthy Coping; MO – Monitoring; TM – Taking Medication; IR – Illness Representation; PC – Perceptions of Control; PH – Perceptions of Health Status; PI – Personal Innovativeness; U – Usefulness; EU – Ease of Use; ICU – Intention to Continue to Use

| Table 1.9. Item Cross-Loadings (Non-Users) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **PA: BAHE** | **PA: RRPS** | **PA: HC** | **PA: MO** | **PA: TM** | **IR: PC** | **IR: PH** | **PI** | **PU** | **PEU** | **IU** |

| | **PA: BAHE** | **PA: RRPS** | **PA: HC** | **PA: MO** | **PA: TM** | **IR: PC** | **IR: PH** | **PI** | **PU** | **PEU** | **IU** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BAHE1 | 0.768 | 0.467 | 0.486 | 0.528 | 0.570 | -0.038 | -0.149 | 0.355 | 0.484 | 0.397 | 0.327 |
| BAHE2 | 0.823 | 0.575 | 0.498 | 0.702 | 0.604 | -0.163 | -0.185 | 0.376 | 0.504 | 0.339 | 0.409 |
| BAHE3 | 0.815 | 0.496 | 0.523 | 0.542 | 0.592 | -0.139 | -0.186 | 0.298 | 0.478 | 0.386 | 0.326 |
| BAHE4 | 0.794 | 0.490 | 0.409 | 0.627 | 0.542 | -0.144 | -0.150 | 0.347 | 0.514 | 0.362 | 0.335 |
| BAHE5 | 0.795 | 0.547 | 0.396 | 0.554 | 0.573 | -0.093 | -0.121 | 0.342 | 0.460 | 0.258 | 0.320 |
| BAHE6 | 0.814 | 0.533 | 0.442 | 0.567 | 0.626 | -0.222 | -0.212 | 0.392 | 0.534 | 0.429 | 0.365 |
| BAHE7 | 0.732 | 0.520 | 0.455 | 0.454 | 0.467 | -0.132 | -0.111 | 0.317 | 0.401 | 0.319 | 0.293 |
| BAHE8 | 0.726 | 0.590 | 0.435 | 0.468 | 0.509 | -0.109 | -0.175 | 0.324 | 0.423 | 0.324 | 0.349 |
| RRPS1 | 0.599 | 0.797 | 0.490 | 0.377 | 0.541 | -0.039 | -0.311 | 0.451 | 0.499 | 0.291 | 0.420 |
| RRPS2 | 0.515 | 0.821 | 0.476 | 0.367 | 0.469 | -0.153 | -0.244 | 0.398 | 0.466 | 0.314 | 0.364 |
| RRPS3 | 0.485 | 0.836 | 0.430 | 0.297 | 0.405 | -0.054 | -0.201 | 0.402 | 0.400 | 0.251 | 0.313 |
| RRPS4 | 0.518 | 0.772 | 0.407 | 0.461 | 0.429 | -0.221 | -0.235 | 0.490 | 0.585 | 0.306 | 0.503 |
| RRPS5 | 0.578 | 0.814 | 0.442 | 0.486 | 0.480 | -0.179 | -0.286 | 0.499 | 0.638 | 0.375 | 0.449 |
| RRPS6 | 0.533 | 0.842 | 0.445 | 0.382 | 0.494 | -0.124 | -0.250 | 0.470 | 0.499 | 0.378 | 0.429 |
| RRPS7 | 0.584 | 0.744 | 0.418 | 0.453 | 0.421 | -0.120 | -0.299 | 0.360 | 0.523 | 0.247 | 0.354 |
| RRPS8 | 0.486 | 0.777 | 0.476 | 0.346 | 0.474 | -0.160 | -0.216 | 0.443 | 0.505 | 0.370 | 0.386 |
| HC1 | 0.488 | 0.489 | 0.841 | 0.420 | 0.494 | -0.173 | -0.134 | 0.281 | 0.407 | 0.381 | 0.267 |
| HC2 | 0.491 | 0.466 | 0.891 | 0.475 | 0.427 | -0.128 | -0.073 | 0.253 | 0.359 | 0.355 | 0.195 |
| HC3 | 0.529 | 0.499 | 0.866 | 0.474 | 0.532 | -0.243 | -0.111 | 0.263 | 0.409 | 0.398 | 0.270 |
| MO1 | 0.613 | 0.450 | 0.464 | 0.882 | 0.527 | -0.212 | -0.152 | 0.293 | 0.457 | 0.366 | 0.333 |
| MO2 | 0.645 | 0.460 | 0.421 | 0.893 | 0.538 | -0.225 | -0.144 | 0.329 | 0.468 | 0.339 | 0.343 |
| MO3 | 0.537 | 0.388 | 0.460 | 0.833 | 0.456 | -0.182 | -0.162 | 0.375 | 0.476 | 0.442 | 0.359 |
| MO4 | 0.568 | 0.346 | 0.414 | 0.710 | 0.511 | -0.234 | -0.279 | 0.344 | 0.430 | 0.388 | 0.320 |
| TM1 | 0.532 | 0.446 | 0.452 | 0.437 | 0.793 | -0.093 | -0.255 | 0.424 | 0.488 | 0.420 | 0.366 |
| TM2 | 0.567 | 0.384 | 0.322 | 0.528 | 0.746 | -0.125 | -0.185 | 0.264 | 0.401 | 0.329 | 0.390 |
| TM3 | 0.613 | 0.548 | 0.549 | 0.499 | 0.849 | -0.127 | -0.189 | 0.369 | 0.492 | 0.395 | 0.396 |
| PC1 | 0.104 | 0.078 | 0.233 | 0.134 | 0.092 | -0.622 | 0.088 | -0.075 | 0.006 | 0.083 | -0.124 |
| PC2 | 0.139 | 0.107 | 0.158 | 0.219 | 0.128 | -0.848 | -0.110 | -0.107 | 0.051 | 0.161 | -0.101 |
| PC3 | 0.152 | 0.174 | 0.195 | 0.230 | 0.124 | -0.894 | -0.158 | 0.025 | 0.069 | 0.137 | -0.049 |
| PH1 | -0.195 | -0.364 | -0.162 | -0.240 | -0.275 | 0.129 | 0.867 | -0.355 | -0.396 | -0.210 | -0.427 |
| PH2 | -0.171 | -0.131 | -0.007 | -0.145 | -0.085 | 0.189 | 0.623 | -0.070 | -0.109 | -0.072 | -0.134 |
| PH3 | -0.150 | -0.300 | -0.120 | -0.170 | -0.287 | 0.085 | 0.854 | -0.289 | -0.306 | -0.094 | -0.364 |
| PH4 | -0.248 | -0.283 | -0.135 | -0.224 | -0.212 | 0.212 | 0.853 | -0.159 | -0.288 | -0.097 | -0.273 |
| PH5 | -0.064 | -0.181 | -0.042 | -0.085 | -0.165 | -0.024 | 0.811 | -0.175 | -0.205 | -0.088 | -0.315 |
| PI1 | 0.423 | 0.535 | 0.306 | 0.442 | 0.439 | 0.063 | -0.253 | 0.888 | 0.618 | 0.373 | 0.663 |
| PI2 | 0.323 | 0.430 | 0.207 | 0.234 | 0.332 | -0.014 | -0.234 | 0.830 | 0.435 | 0.261 | 0.499 |
| PI4 | 0.385 | 0.452 | 0.272 | 0.337 | 0.368 | 0.050 | -0.212 | 0.884 | 0.559 | 0.384 | 0.538 |
| PU1 | 0.545 | 0.594 | 0.401 | 0.489 | 0.526 | -0.057 | -0.317 | 0.634 | 0.945 | 0.535 | 0.667 |
| PU2 | 0.522 | 0.620 | 0.404 | 0.439 | 0.517 | -0.077 | -0.320 | 0.580 | 0.910 | 0.510 | 0.652 |
| PU3 | 0.600 | 0.555 | 0.439 | 0.583 | 0.548 | -0.051 | -0.277 | 0.508 | 0.890 | 0.574 | 0.585 |
| PEU1 | 0.219 | 0.168 | 0.259 | 0.270 | 0.243 | -0.087 | 0.011 | 0.260 | 0.350 | 0.723 | 0.234 |
| PEU2 | 0.439 | 0.368 | 0.399 | 0.425 | 0.458 | -0.138 | -0.139 | 0.359 | 0.563 | 0.879 | 0.394 |
| PEU | 0.410 | 0.399 | 0.399 | 0.412 | 0.442 | -0.178 | -0.183 | 0.348 | 0.511 | 0.862 | 0.324 |
| IU1 | 0.413 | 0.471 | 0.264 | 0.402 | 0.476 | 0.115 | -0.373 | 0.616 | 0.635 | 0.390 | 0.903 |
| IU2 | 0.441 | 0.482 | 0.230 | 0.361 | 0.410 | 0.028 | -0.355 | 0.587 | 0.676 | 0.347 | 0.889 |
| IU3 | 0.318 | 0.402 | 0.223 | 0.310 | 0.401 | 0.134 | -0.290 | 0.594 | 0.574 | 0.344 | 0.918 |
| IU4 | 0.406 | 0.473 | 0.310 | 0.403 | 0.462 | 0.047 | -0.376 | 0.609 | 0.636 | 0.354 | 0.929 |

PA – Perceived Affordances; BAHE – Being Active and Healthy Eating; RRPS – Reducing Risks and Problem Solving; HC – Healthy Coping; MO – Monitoring; TM – Taking Medication; IR – Illness Representation; PC – Perceptions of Control; PH – Perceptions of Health Status; PI – Personal Innovativeness; PU – Perceived Usefulness; PEU – Perceived Ease of Use; IU – Intention to Use

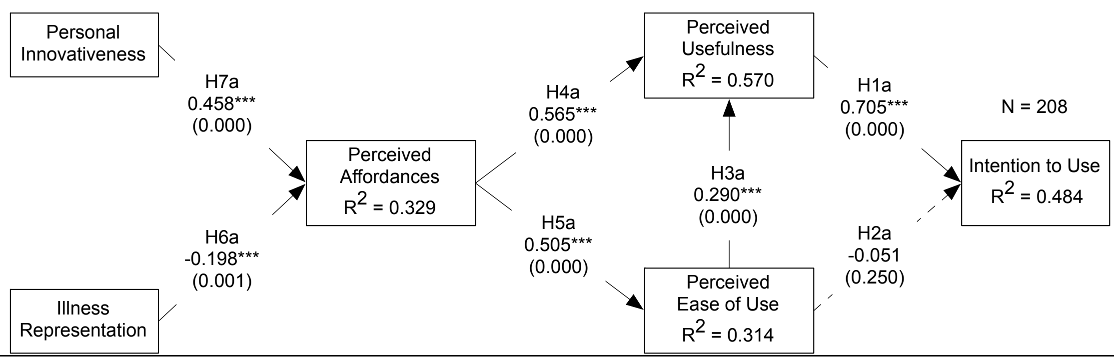
**Table 1.10. Item Cross-Loadings (Users)**

| | RA: BAHE | RA: RRPS | RA: HC | RA: MO | RA: TM | IR: PC | IR: PH | PI | U | EU | ICU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BAHE1 | 0.785 | 0.423 | 0.376 | 0.430 | 0.437 | -0.269 | -0.011 | 0.542 | 0.389 | 0.278 | 0.364 |
| BAHE2 | 0.784 | 0.617 | 0.569 | 0.426 | 0.524 | -0.217 | -0.105 | 0.446 | 0.378 | 0.271 | 0.352 |
| BAHE3 | 0.789 | 0.399 | 0.436 | 0.518 | 0.485 | -0.238 | -0.105 | 0.500 | 0.402 | 0.292 | 0.442 |
| BAHE4 | 0.762 | 0.432 | 0.362 | 0.519 | 0.445 | -0.203 | -0.119 | 0.485 | 0.475 | 0.302 | 0.467 |
| BAHE5 | 0.756 | 0.647 | 0.578 | 0.395 | 0.466 | -0.130 | -0.216 | 0.346 | 0.326 | 0.305 | 0.253 |
| BAHE6 | 0.707 | 0.424 | 0.377 | 0.444 | 0.371 | -0.149 | -0.151 | 0.387 | 0.364 | 0.349 | 0.357 |
| BAHE7 | 0.736 | 0.635 | 0.614 | 0.405 | 0.509 | -0.157 | -0.063 | 0.416 | 0.337 | 0.304 | 0.243 |
| BAHE8 | 0.819 | 0.666 | 0.628 | 0.484 | 0.570 | -0.220 | -0.085 | 0.481 | 0.430 | 0.338 | 0.349 |
| RRPS1 | 0.607 | 0.824 | 0.598 | 0.460 | 0.539 | -0.160 | -0.130 | 0.383 | 0.358 | 0.375 | 0.311 |
| RRPS2 | 0.632 | 0.873 | 0.635 | 0.474 | 0.535 | -0.221 | -0.173 | 0.385 | 0.439 | 0.443 | 0.427 |
| RRPS3 | 0.547 | 0.785 | 0.650 | 0.399 | 0.491 | -0.165 | -0.211 | 0.248 | 0.395 | 0.380 | 0.284 |
| RRPS4 | 0.387 | 0.640 | 0.449 | 0.352 | 0.437 | -0.239 | -0.179 | 0.345 | 0.425 | 0.399 | 0.446 |
| RRPS5 | 0.548 | 0.770 | 0.501 | 0.452 | 0.395 | -0.286 | -0.189 | 0.404 | 0.435 | 0.411 | 0.415 |
| RRPS6 | 0.592 | 0.850 | 0.696 | 0.431 | 0.506 | -0.193 | -0.141 | 0.403 | 0.387 | 0.381 | 0.303 |
| RRPS7 | 0.444 | 0.703 | 0.449 | 0.386 | 0.404 | -0.171 | -0.126 | 0.233 | 0.321 | 0.408 | 0.306 |
| RRPS8 | 0.629 | 0.832 | 0.642 | 0.474 | 0.496 | -0.255 | -0.142 | 0.371 | 0.402 | 0.429 | 0.362 |
| HC1 | 0.584 | 0.625 | 0.922 | 0.480 | 0.548 | -0.160 | -0.105 | 0.438 | 0.329 | 0.377 | 0.304 |
| HC2 | 0.628 | 0.665 | 0.922 | 0.513 | 0.594 | -0.223 | -0.125 | 0.437 | 0.399 | 0.441 | 0.386 |
| HC3 | 0.591 | 0.749 | 0.917 | 0.464 | 0.598 | -0.172 | -0.114 | 0.430 | 0.375 | 0.439 | 0.352 |
| MO1 | 0.535 | 0.430 | 0.364 | 0.858 | 0.483 | -0.272 | -0.142 | 0.494 | 0.606 | 0.450 | 0.548 |
| MO2 | 0.526 | 0.377 | 0.368 | 0.860 | 0.458 | -0.240 | -0.106 | 0.476 | 0.540 | 0.421 | 0.487 |
| MO3 | 0.427 | 0.471 | 0.534 | 0.731 | 0.384 | -0.290 | -0.172 | 0.318 | 0.414 | 0.430 | 0.325 |
| MO4 | 0.261 | 0.388 | 0.340 | 0.562 | 0.332 | -0.098 | -0.090 | 0.260 | 0.270 | 0.338 | 0.302 |
| TM1 | 0.521 | 0.498 | 0.498 | 0.454 | 0.827 | -0.115 | -0.146 | 0.470 | 0.469 | 0.262 | 0.367 |
| TM2 | 0.565 | 0.466 | 0.534 | 0.480 | 0.853 | -0.177 | -0.103 | 0.445 | 0.460 | 0.329 | 0.393 |
| TM3 | 0.477 | 0.550 | 0.546 | 0.437 | 0.822 | -0.239 | -0.196 | 0.364 | 0.361 | 0.316 | 0.322 |
| PC1 | 0.193 | 0.271 | 0.217 | 0.166 | 0.149 | -0.742 | -0.021 | 0.081 | 0.248 | 0.332 | 0.215 |
| PC2 | 0.254 | 0.240 | 0.196 | 0.328 | 0.232 | -0.826 | -0.097 | 0.259 | 0.335 | 0.324 | 0.357 |
| PC3 | 0.188 | 0.170 | 0.111 | 0.241 | 0.144 | -0.867 | -0.199 | 0.109 | 0.287 | 0.205 | 0.312 |
| PH1 | -0.147 | -0.228 | -0.177 | -0.201 | -0.194 | 0.121 | 0.816 | -0.137 | -0.162 | -0.162 | -0.126 |
| PH2 | 0.043 | 0.025 | 0.101 | -0.117 | -0.066 | 0.146 | 0.519 | -0.009 | -0.176 | 0.023 | -0.128 |
| PH3 | -0.146 | -0.194 | -0.164 | -0.114 | -0.184 | 0.031 | 0.757 | -0.139 | -0.039 | -0.050 | -0.059 |
| PH4 | -0.030 | -0.099 | -0.016 | -0.074 | -0.030 | 0.273 | 0.764 | -0.021 | -0.094 | -0.078 | -0.116 |
| PH5 | -0.203 | -0.214 | -0.158 | -0.128 | -0.178 | -0.022 | 0.826 | -0.132 | -0.115 | -0.023 | -0.119 |
| PI1 | 0.525 | 0.364 | 0.424 | 0.455 | 0.438 | -0.171 | -0.134 | 0.863 | 0.468 | 0.347 | 0.452 |
| PI2 | 0.501 | 0.391 | 0.423 | 0.451 | 0.458 | -0.142 | -0.117 | 0.877 | 0.521 | 0.414 | 0.437 |
| PI4 | 0.510 | 0.406 | 0.395 | 0.455 | 0.448 | -0.172 | -0.071 | 0.890 | 0.464 | 0.388 | 0.487 |
| U1 | 0.455 | 0.481 | 0.390 | 0.536 | 0.464 | -0.311 | -0.113 | 0.524 | 0.910 | 0.563 | 0.652 |
| U2 | 0.453 | 0.432 | 0.348 | 0.553 | 0.454 | -0.331 | -0.173 | 0.509 | 0.931 | 0.529 | 0.682 |
| U3 | 0.472 | 0.457 | 0.361 | 0.599 | 0.497 | -0.335 | -0.133 | 0.482 | 0.902 | 0.525 | 0.675 |
| EU1 | 0.195 | 0.248 | 0.274 | 0.355 | 0.246 | -0.215 | 0.011 | 0.306 | 0.346 | 0.651 | 0.357 |
| EU2 | 0.310 | 0.437 | 0.396 | 0.472 | 0.306 | -0.293 | -0.132 | 0.369 | 0.526 | 0.899 | 0.556 |
| EU | 0.439 | 0.527 | 0.436 | 0.497 | 0.339 | -0.313 | -0.066 | 0.402 | 0.557 | 0.897 | 0.531 |
| ICU1 | 0.429 | 0.456 | 0.397 | 0.495 | 0.410 | -0.326 | -0.124 | 0.507 | 0.737 | 0.594 | 0.920 |
| ICU2 | 0.376 | 0.335 | 0.280 | 0.470 | 0.358 | -0.304 | -0.181 | 0.422 | 0.622 | 0.466 | 0.862 |
| ICU3 | 0.390 | 0.370 | 0.285 | 0.493 | 0.376 | -0.340 | -0.090 | 0.471 | 0.635 | 0.518 | 0.920 |
| ICU4 | 0.443 | 0.443 | 0.391 | 0.540 | 0.413 | -0.359 | -0.135 | 0.480 | 0.640 | 0.557 | 0.905 |

RA – Realized Affordances; BAHE – Being Active and Healthy Eating; RRPS – Reducing Risks and Problem Solving; HC – Healthy Coping; MO – Monitoring; TM – Taking Medication; IR – Illness Representation; PC – Perceptions of Control; PH – Perceptions of Health Status; PI – Personal Innovativeness; U – Usefulness; EU – Ease of Use; ICU – Intention to Continue to Use

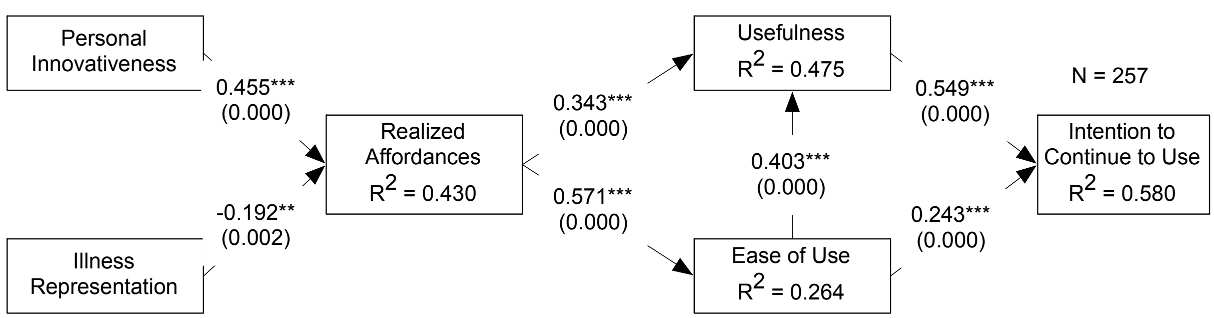
*1.8.2 Structural Model*

The path coefficients and the proportion of variance in the dependent variable explained by the independent variables for non-user and user models are presented in Figures 1.7 and 1.8, respectively. We modeled all the constructs except Illness Representation as reflective and measured them with multiple indicators. Illness Representation is modeled as second-order formative construct with reflective indicators. Survey respondents' demographic characteristics were used as controls to eliminate any confounding of results. None of the controls were significant.




One-Tailed; ***p < 0.001, **p < 0.01, *p < 0.05

**Figure 1.7. Structural Model (Non-Users)**




One-Tailed; ***p < 0.001, **p < 0.01, *p < 0.05

**Figure 1.8. Structural Model (Users)**

In the structural model for non-users (Figure 1.7), we can see that Perceived Affordances explains 57.0% of variance in perceived usefulness and 31.4% of the variance in perceived ease of use.

Perceived Usefulness and Perceived Ease of Use together explain 48.4% of variance in the Intention to Use mobile technologies for diabetes management. Perceived Ease of Use alone explains 34.4% of variance in Perceived Usefulness, but the addition of Perceived Affordances increases the explained variance by 22.6% to 57.0%. Finally, Personal Innovativeness and Illness Representation explain 32.9% of variance in Perceived Affordances.

The structural model for users, presented in Figure 1.8, shows that Realized Affordances explains 47.5% of variance in Usefulness and 26.4% of the variance in the Ease of Using mobile technologies. Usefulness and Ease of Use together explain 58.0% of variance in Intention to Continue to Use mobile technologies for diabetes management. Ease of Use alone explains 34.4% of variance in Usefulness, but the addition of Realized Affordances increases the explained variance by 13.1% to 47.5%. Finally, Personal Innovativeness and Illness Representation explain 43.0% of variance in Realized Affordances.

It is evident from the PLS results that data provide strong support for hypotheses, essentially drawn from Technology Acceptance Model (Davis 1989), H1a, H2a, H1b, and H2b. For non-users, the finding that hypothesis H3a was not supported is consistent with that obtained by Davis et al. (1989). However, for the users of mobile technologies, hypothesis H3b, which posited that Ease of Use of mobile technologies would positively influence their Usefulness, was supported. This indicates that diabetes patients who are already using mobile technologies in managing their illness do feel the effortlessness in using technology and believe that their usefulness depends on the ease with which these technologies can be operated. Hypotheses H4a and H4b were strongly supported indicating that Perceived Affordances significantly impact Perceived Usefulness (H4a) and Perceived Ease of Use (H5a). Similarly, Realized Affordances impacts Usefulness and Ease of Use of mobile technologies significantly as indicated by strong support of hypotheses H4b and H5b. Likewise, Illness Representation and Personal Innovativeness have significant effects on Perceived Affordances (H6a and H7a) in the case of non-users. In the case of users, Personal Innovativeness does influence Realized Affordances indicating strong support for hypothesis H7b. The effect of Illness Representation on Realized Affordances is significant as hypothesized (H6b) indicating that as illness perceptions improve due to continued use of technology, it is less likely that individuals realize new affordances. Summary of hypotheses results for non-user and user models are shown in Tables 1.11 and 1.12, respectively.

**Table 1.11. Summary of Hypothesis Tests (Non-User Model)**

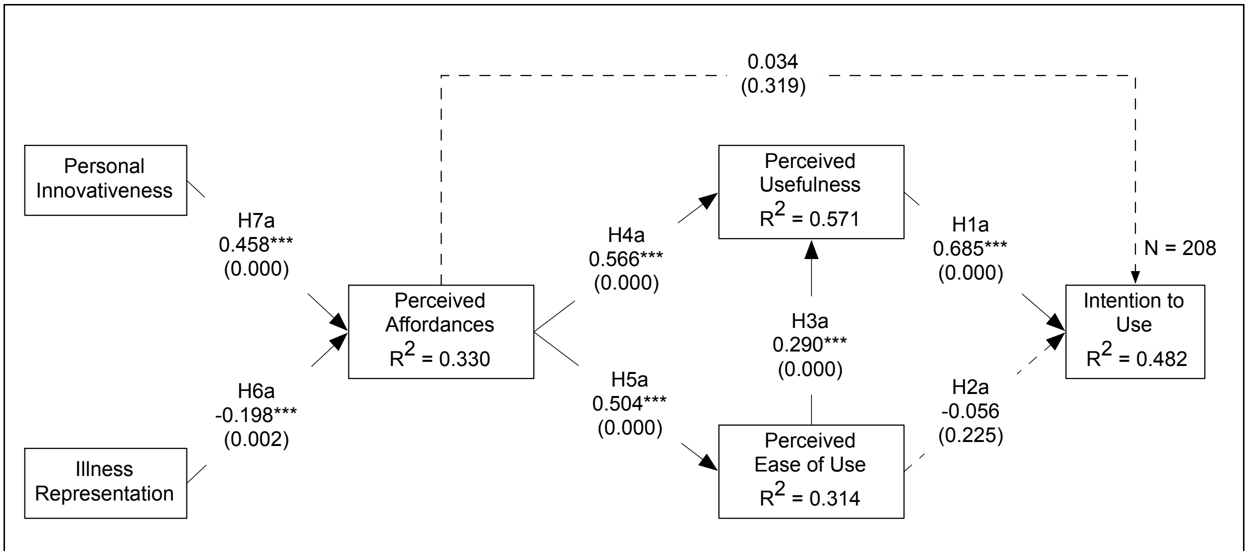
| # | Relationship | β | t | p | Support |
|---|---|---|---|---|---|
| H1a | Perceived Usefulness --> Intention to Use | 0.705 | 9.754 | 0.000 | Yes |
| H2a | Perceived Ease of Use --> Intention to Use | -0.051 | -0.676 | 0.250 | No |
| H3a | Perceived Ease of Use --> Perceived Usefulness | 0.290 | 4.084 | 0.000 | Yes |
| H4a | Perceived Affordances --> Perceived Usefulness | 0.565 | 9.113 | 0.000 | Yes |
| H5a | Perceived Affordances --> Perceived Ease of Use | 0.505 | 6.578 | 0.000 | Yes |
| H6a | Illness Representation --> Perceived Affordances | -0.198 | -3.007 | 0.001 | Yes |
| H7a | Personal Innovativeness --> Perceived Affordances | 0.458 | 7.284 | 0.000 | Yes |

**Table 1.12. Summary of Hypothesis Tests (User Model)**

| # | Relationship | β | t | p | Support |
|---|---|---|---|---|---|
| H1b | Usefulness --> Intention to Continue to Use | 0.549 | 2.013 | 0.000 | Yes |
| H2b | Ease of Use --> Intention to Continue to Use | 0.243 | 0.629 | 0.000 | Yes |
| H3b | Ease of Use --> Usefulness | 0.403 | 6.265 | 0.000 | Yes |
| H4b | Realized Affordances --> Usefulness | 0.343 | 3.649 | 0.000 | Yes |
| H5b | Realized Affordances --> Ease of Use | 0.571 | 10.417 | 0.000 | Yes |
| H6b | Illness Representation --> Realized Affordances | -0.192 | -2.478 | 0.002 | Yes |
| H7b | Personal Innovativeness --> Realized Affordances | 0.455 | 5.638 | 0.000 | Yes |

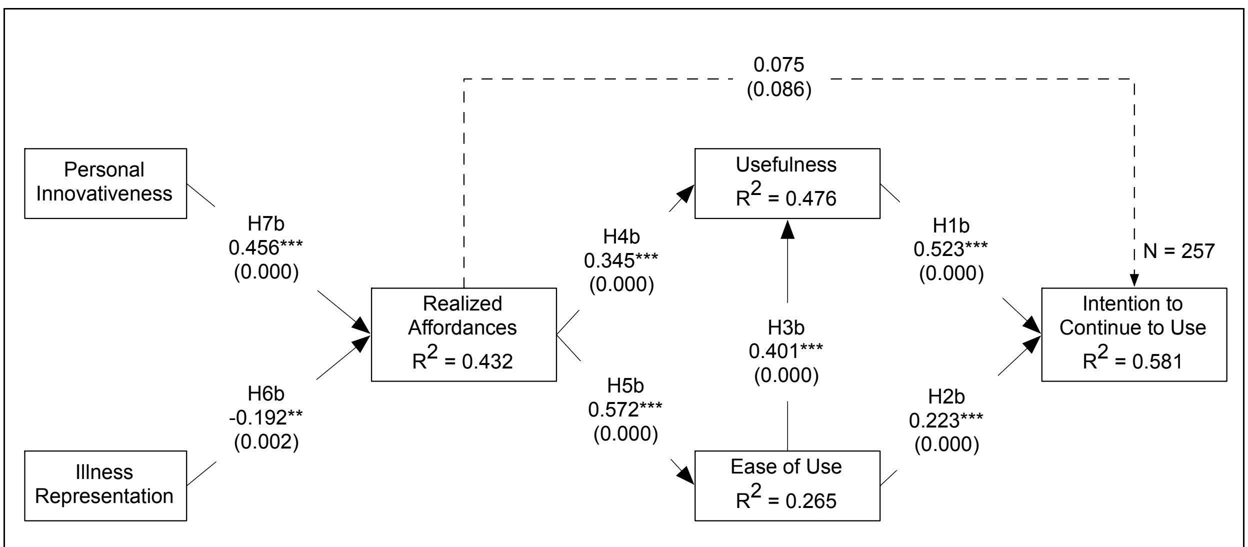
1.8.2.1 Testing for Mediating Effects

In addition to the models tested above, we examined whether there is a full mediation of the effects of Affordances on Intention in both non-user and user models. To perform this, we added the direct effect of Perceived Affordance on Intention to Use in the non-user model and the effect of Realized Affordance on Intention to Continue to Use in the user model. Results of full mediation tests for non-users and users are shown in Figures 1.9 and 1.10, respectively. Both effects were insignificant. The direct effect of Perceived Affordances on Intention to Use (p = 0.319) in the non-user model and the direct effect of Realized Affordances on the Intention to Continue to Use (p = 0.086) in the user model were insignificant.




One-Tailed; ***p < 0.001, **p < 0.01, *p < 0.05

**Figure 1.9. Structural Model with Direct Effect (Non-Users)**




One-Tailed; ***p < 0.001, **p < 0.01, *p < 0.05

**Figure 1.10. Structural Model with Direct Effect (Users)**

## 1.9 Limitations

We intend to acknowledge the limitations of this study before delving into discussions and the implications of our research findings. The survey respondents and the context of the study are two important aspects that influence the generalizability, the external validity, of the study (Cook and Campbell, 1979). External validity is the extent to which the findings of the study can be generalized across individuals (population) and settings. In this research the survey respondents were any diabetes patients who are over 18 years of age, and are currently using mobile technologies for managing their illness. If they are not current users, they should at least be familiar with those technologies. Thus, the generalizability of the respondents' behavior to the population of diabetes patients needs to be understood. Generalizability to the entire population depends on whether the sample is representative of the population. In this study, there are factors that mitigate the concern of generalizability to population. This study, in which the unit of analysis was individual (as against organizational), examines a phenomenon of interaction of an individual with technology about which they are very familiar and have formed well-informed perceptions. Our study sample consists of a fairly decent size of 208 non-users and 257 users of mobile technologies. Further, the phenomenon, diabetes patients' behavioral intentions of adopting and/or using technology for diabetes management, studied here is expected to be manifest in diabetes patient population. Regarding the concern of generalizability across other chronic illnesses, each chronic disease has its own idiosyncrasies and our study does not make any claims of generalizability of research findings across other chronic illnesses. However, we believe that technology affordances do positively influence adoption and usage intentions of individuals regardless of the type of chronic illness. The issue of external validity to other chronic illnesses can be best addressed by conducting research in other contexts and it would be interesting to examine this phenomenon across other illness types and populations. While this study involved only diabetes patients, the invaluable knowledge and insights gained within this context will be helpful in extending this line of research into other areas.

Another threat to external validity usually expressed in the literature is the age of survey respondents. In this study, age is not a continuous variable and we used age categories. While the data shows that users of mobile technologies for diabetes management are relatively younger than non-users, which is expected because the elderly population is usually more resistant to change and adoption of technologies compared to a younger generation, there is not much difference in the sample distribution across age categories between users and non-users. Over 90% of the sample respondents fall in the ages between 25 and 64 years. So, age does not seem be a threat to external validity.

Generalizing our results across all ethnic groups could be a possible threat. In both the samples of our data, close to 75% of the respondents are whites. Under-representation of respondents from minority ethnic groups could be due to lack of awareness of the technology, or income levels to afford technology for managing diabetes, or could be because of general education. We used all the demographic variables as controls in interpreting our study results. However, it would be interesting to study any moderating effects of education and/or ethnicity on the effects of hypothesized relationships.

Conclusions in the study are drawn based not on a single technology, but on various mobile technologies used for managing diabetes. So, generalizing results across technologies is not an issue. There is a potential for common method variance because measures of perceived affordances, perceived usefulness, perceived ease of use, and intention to use for non-user model and the measures of realized affordances, usefulness, ease of use, and intention to continue to use were gathered at the same point in time. However, causality cannot be inferred from the results due to the cross-sectional nature of the study.

## 1.10 Discussion and Conclusion

We first briefly discuss our work and then describe key contributions of our study. Followed by this, we present theoretical and practical implications.

In the United States, every one in eleven people had diabetes in 2012 (CDC, 2015a) and its occurrence is on the rise. Mobile technologies for helping with diabetes self-management is also on the rise, however, their efficacy is not clear. Given the increase in diabetes patients, continuing to explore technology affordances that can facilitate diabetes self-management is very important. In this study, we have contributed to the growing literature on the use of technology in healthcare. Specifically, we drew from affordance literature to investigate the role of mobile technologies in chronic illness management. The key driver for this research was our keen interest in understanding the role of technology in helping people experiencing chronic illnesses to actively participate in their own care process. Self-management, one of the important aspects of chronic illness care, has been advocated as a means of engaging patients and improving healthcare in terms of lowering cost and enhancing patient wellbeing. Information technologies, in general, and mobile technologies, in particular, have great potential in facilitating self-management of chronic illnesses. In this process it is essential to understand user behavior toward adoption and use of mobile technologies for managing their illness. Among all the chronic illnesses, we chose diabetes because of its widespread occurrence. Diabetes is very common in the United States and it lends relatively easy access to the individuals experiencing it.

The nature of information technologies has undergone considerable change and there is a need to focus on the aspects that technology offers, called affordances. In recent times there has been proliferation of mobile technologies that promise to help in self-management. What technologies can afford will have a strong influence on individual behavior. However, there was no effective means of measuring those affordances. To this end, drawing on the theory of affordances from the ecological and perceptual psychology, we described a conceptual construct named technology affordances of mobile technologies for diabetes self-management. These affordances are conceptualized as perceived affordances and realized affordances for non-users and users of the technology, respectively. For potential adopters, perceived affordances influence their intentions of adopting new technology and realized affordances influence the intentions to continue to use the technology for the individuals who already are using the technology.

Two nomological networks were proposed for technology affordances: one for the users and one for the non-users of mobile technologies for managing diabetes. These nomological networks for technology affordances included behavioral intentions of adoption and continued use of technology as consequences and the individual traits of personal innovativeness and illness representation as antecedents. Data were collected from two different groups of diabetes patients–users and non-users of mobile technologies. Results of data analysis showed strong support for hypothesized relationships. In the case of users, ease of using mobile technologies positively influences their usefulness. In addition, there is strong support for the direct relationship between realized affordances and intentions to continue to use the technology, indicating that once individuals start using technology for managing their illness, what is afforded by the technology becomes crucial in influencing their continued use behavior. Significant relationship of realized affordances with behavioral intentions of continued use affirms the value of this new construct in extending our understanding of technology adoption and usage.

*1.10.1 Contribution*

Through this study, we make key contributions to the growing body of literature on technology affordances and use of use of technology in healthcare. Specifically, we investigate the role of technology affordances in the context of mobile technology use for diabetes self-management. Within the IS literature, several influencing factors of usefulness and ease of use have been studied. For example, perceived enjoyment (Davis et al. 1992), system design characteristics (Davis 1993), self-efficacy (Compeau and Higgins 1995a, 1995b; Venkatesh and Davis 1996), gender (Gefen and Straub, 1997), personality traits (Venkatesh, 2000), social and cognitive factors (Venkatesh and Davis, 2000), and education level and prior system experience (Burton-Jones and Hubona, 2006). However, influence of technology affordances, particularly in the context of diabetes self-management, on diabetes patients' beliefs of adoption and use has not been studied. The new knowledge from this research contributes to researchers, technology developers, and mobile technology consumer, the patient and overall healthcare. The first contribution of our study is development of an instrument for measuring mobile technology affordances for diabetes management and testing of a theoretical model (nomological network). In the process, we demonstrate the key role of affordances in the technology acceptance model.

The second contribution of this study is to mobile technology developers. Our findings suggest that affordances strongly influence patients' beliefs about usefulness and ease of using technology. This helps designers and developers to focus on those aspects that matter most to the patients, who ultimately consume the products. A thorough understanding of mobile technology affordances in diabetes management helps in the design and development of more useful technologies, which can help in their proliferation.

The third contribution is to the consumer of mobile technologies in diabetes management and overall healthcare. When the technologies are developed in such a way that they can help manage diabetes better, more diabetes patients are likely to adopt and use them. As patients manage their diabetes well and avoid illness-related complications with the use of technology, they are less likely to be hospitalized. This will have a positive impact on overall healthcare in society.

*1.10.2 Theoretical Implications*

Regarding theory development, one critical issue relates to the items of the construct. Affordances by their very nature are highly contextual, meaning that affordances of mobile technologies will be different based on the type of illness. In this study, technology affordance construct was conceptualized as consisting of five dimensions and we developed the items under each dimension for diabetes self-management. All the scales exhibited greater convergence and a high degree of discriminant validity. Since each type of chronic illness is unique in its nature, some of the self-management activities required for other illnesses might be different from those performed in diabetes. Researchers willing to further the measurement of affordances in other contexts can easily use the process used in our research for developing items for the particular type of illness under study.

Next, application of affordance theory in IS literature is nascent. Theory says that perception and/or realization of affordances depend on an individual’s need and capabilities. Hence we focused on two aspects–personal innovativeness, an individual’s innovativeness in using technology, and illness representation, an individual’s belief about their health status or severity and the amount of control they think they have. Personal innovativeness was used as a proxy for the individual’s capability in detecting technology affordances. Since our research was related to technology use for chronic illness management, individual’s health conditions become a determining factor. So, we used illness representation as a proxy for the individual’s need that drives the detection of affordances. However, there could be other factors that may be relevant. Thus, the nomological networks for perceived and realized affordances of mobile technologies for diabetes management deserve continued development. It would be worthy and interesting to investigate if other factors such as technology characteristics based on the type of technology or context such as other chronic illnesses that might influence technology affordances. Further, future research on extending the nomological network may concentrate on investigating additional consequences of technology affordances.

Another idea for future research is to investigate the possibility of second-order factors for the dimensions of perceived and realized affordances of mobile technologies for diabetes management. One can test the research model using covariance-based techniques that allow us to examine the effects of each individual dimension on behavioral intentions and beliefs of usefulness and ease of use. It would also be interesting to perform longitudinal studies of diabetes or other chronic illness patients, as opposed to cross-sectional studies, to understand how perceived affordances are realized over time.

### *1.10.3 Practical Implications*

Regarding implications for practice, the first one that is very important is patients' active engagement in their own care process. It is imperative to make more diabetes patients use technologies for better self-management leading to healthy life. As mobile technologies for diabetes management proliferate and become more advanced, many diabetics will likely adopt them and improve their lives. According to Norman (2013), affordances are designed into the technology artifacts. Making affordances easily perceivable is critical to the utility of the artifact. If the affordances are more visible, they make operations of technology easier. If the technologies are designed properly, technology affordances can make diabetics more engaged in their own personal care.

A next practical implication of this study is in the software design and development. Historically, software development has been a group effort with constant interaction between the users and developers throughout the development process. Developers used to know the requirements of the users upfront and while developing the applications. In the case of mobile technologies, particularly mobile app development, there is not much interaction with the end-users. Developers develop the apps, independently, without much knowledge about end-users' needs. Particularly in the case of diabetes patients, it is very important to know up front, the affordances of mobile technologies so that they can be more useful to the patients in their self-management. If the mobile technologies are developed with clear understanding of diabetic patient needs, their adoption and use will likely increase and thereby positively impacts overall healthcare.

The third implication for practice is training and development. Results show that personal innovativeness, used as proxy for capabilities, positively influences detection of affordances in the technology. Meaning that if an individual is technically skillful, he or she will be able to perceive and realize affordances. If the developers of apps and devices and healthcare providers offer some kind of training and educational programs that can make diabetes patients more skillful in using the technology, it is possible that they can make better use of the technology through perception and realization of affordances.

#### *1.10.4 Conclusion*

To conclude, the central objective of this paper was to explore an understanding of technology affordances and their effects on technology adoption and usage. We developed constructs called perceived affordances and realized affordances of mobile technologies in diabetes self-management for non-users and users, respectively. These constructs were tested in a nomological network that included other key constructs from extant literature. Two new constructs developed in our study have shown to play an important role in advancing our understanding of technology adoption and usage beliefs. We firmly believe that our research makes a noteworthy contribution for theory development and practice and hope that the findings and ideas generated through our study will encourage others to advance this technology affordance research to other areas.

Paper-2

# From Intention to Adopt to Continued Usage: Role of Illness Representation in Adoption and Continued Use of Mobile Technologies for Diabetes Self-Management

## 2.1 Introduction

Chronic illnesses take a serious toll on healthcare in terms of cost and patient wellbeing. Currently there is no known cure for diabetes, a relatively permanent malady, which levies direct and indirect costs to healthcare and deteriorates an individual's quality of life. In 2012, estimates indicated 1 in 11 people had diabetes with $245 billion in associated healthcare expenses (CDC, 2015a). The illness requires continuous care and management in order to maintain quality of life, and if not managed well, will lead to other complications often resulting in hospitalization and increases in cost of healthcare. Self-management of chronic illnesses, which involve eating a healthy diet, using medications as prescribed, exercising regularly, and monitoring blood glucose, have been shown to improve quality of life and overall wellbeing (Barlow et al., 2002; Kass-Bartelmes, 2002; National Institutes of Health, 2010). Mobile apps and devices (henceforth termed mobile technologies) have emerged as promising health information technology tools for supporting diabetes self-management (Whitehead and Seaton, 2016). Developments in mobile technologies can help patients manage their health, however, one must embrace and make technology a part of their daily routine to achieve overall well-being and help reduce the burden on the nation's healthcare.

Within IS literature, one of the popular theoretical models explaining an individual's behavioral intentions towards technology adoption and use is the technology acceptance model (TAM; Davis 1989; Davis et al. 1989). The model theorizes that an individuals' perception of two important aspects of technology – usefulness and ease of use – influence their intentional beliefs of adoption and use. However, from an individual's health point of view, it is of utmost importance to understand a patient's health related beliefs due to their ability to influence their intent to adopt and use technology for disease management; and differential effects may apply to people who alter their behavior and those who do not, maintaining the status quo.

In the United States, undiagnosed diabetes represents nearly one fourth of all diabetes cases. Typically, people with diabetes experience symptoms such as weight loss, heightened hunger, blurry vision, frequent urination and in early stages, high blood glucose levels. Unless complications develop, diabetes remains mostly a symptomless condition. Symptoms develop so gradually that they are difficult to recognize and people may live for months and years without knowing they have diabetes. An individual's motivation to assume self-care activities for managing diabetes does not directly depend on the symptoms. Their motivation to alter their behavior depends on their perceptions of their diabetes related complications. For example, they are motivated by aspects, called illness representations or health beliefs, such as their views on the adverse consequences of diabetes on their daily life, their perceptions of control on themselves, and perceptions of the effectiveness of treatment. These beliefs about one's own health can motivate the adoption and use of technology for managing illness. Patients' perceptions of their illness (Leventhal et al., 1984) guide their attempts to manage their illness by adhering to a particular treatment regimen or seeking medical help. Research over the past few decades demonstrated the significance of illness perceptions on patent behavior (Petrie and Weinman, 1997). It is thus important to take into consideration these illness representations, consisting of patients' perceptions of health threat and the control they believe they have on their health, because they can affect a patient's willingness to adopt and use the technology for managing their illness.

Next, individuals who believe they are in control of their health or if don't sense the severity of their health condition and consequences may not see the real need for altering their behavior. They will not be motivated enough to take assistance of external gadgets or using any technology for managing their illness. Perceptions of their illness or their health beliefs influence their attitude toward technology usage. Once individuals alter their health behavior by adopting a coping strategy, the self-regulatory model (Leventhal et al., 2003) suggests that coping strategies or health behaviors for managing illness result in updating their illness representations. These perceptions will further influence their coping strategies. Self-regulation behaviors, such as individuals' adopting and using technology for diabetes self-management are sustained or altered based one's illness perceptions. Individuals would like to continue using if the technology provides a positive impact on the illness representation, otherwise not. As such, at any point in time, illness representations of users and non-users of technology will have differential influence on their behavioral intentions of adopting and using the technology. In order to capture unique healthcare contextual aspects of diabetes management on individuals' technology beliefs, it would be value adding to extend TAM. Driven by the need to address this gap in the literature and to investigate the impact of individuals' health beliefs, this study explicates the effect of individuals' illness perceptions on adoption and continued use of mobile technologies for managing diabetes.

Relying on the data collected from close to 470 diabetes patients comprising of users and non-users of mobile technologies we investigated the influence of their illness representation on the adoption and use of mobile technologies. Results indicate the perceptions of an individual's health status and health control do influence their perceptions of usefulness and ease of using mobile technologies for diabetes management. Further, we demonstrate that TAM constructs – usefulness and ease of use of technology – partially mediate the relationship between illness representation and intention to adopt and use technology, indicating that illness perceptions directly influence technology adoption and use decisions, and provide insights into the nature and impact of illness representation on the adoption and use of technology for diabetes self-management.

The organization of this research paper is as follows. A brief review of prior studies on illness representation, the technology acceptance model, and use of technology in diabetes self-management is presented in the next section. This is followed by a discussion on the theoretical background of illness representation and diabetes self-management. Subsequently, a research model and hypotheses are described. The data collection process, analysis, and model validation are presented next. Finally, limitations, discussion, and conclusions, which include implications for theory and practice, are discussed.

## 2.2 Prior Studies on Illness Representation and Self-Management

In this section, we present a brief summary of some of the studies related to patients' illness representations and their self-management activities. Table 2.1 summarizes prior studies related to patients' illness representations and key findings. According to Levanthal's Common Sense Model of Illness Representation (Leventhal et al., 2003), chronic illness patients' coping behaviors depend on how individuals perceive their illness. In other words, perceptions of their illness influence their self-management behaviors. The Illness Representations have been categorized into eight dimensions: identity, timeline, consequences, personal control, treatment control, concern, comprehensibility, and emotional representation. Each of these dimensions influence an individual's self-management behavior. In the brief literature review presented here, we try to capture the extent to which these illness perceptions do actually influence individual's behaviors.

**Table 2.1: Brief Summary of Prior Studies related to Illness Representation (IR) and Self-Management (SM)**

| No. | Self-Management Aspect | Methodology | Objective/Key Findings | Source |
|---|---|---|---|---|
| 1. | Treatment adherence | Semi-structured interviews | Treatment control → Insulin therapy (+) | Bogatean and Hancu, 2004 |
| 2. | Diabetes Self-management | Survey of adolescents with diabetes | Treatment control →<br>Diet control (+), Blood glucose monitoring (+)<br>Perceived consequence →<br>Diet control (–), Blood glucose monitoring (+)<br>Identity → Diet control (–)<br>Timeline → Blood glucose monitoring (–) | Gaston et al., 2011 |
| 3. | Diabetes self-care behaviors | Systematic Review | Treatment control →<br>Glycemic control (+), Physical activity (+) Diet control (+), Adherence to treatment (+)<br>Personal control →<br>Treatment adherence (+)<br>Consequence →<br>Self-care behaviors (–), Diet control (+) | Harvey and Lawson, 2009 |
| 4. | Self-management of chronic illnesses | Systematic Review | This article reviewed empirical studies on the influence of illness perceptions on chronic illness self-management in children and young people. The study finds that control beliefs (perceived health control) are more strongly associated with self-management than other aspects of illness representation. Overall, the results are mixed and contradicted the theory. | Law et al., 2014 |
| 5. | Monitoring, Treatment Adherence Food intake Exercise | Observational study of type-1 diabetes adolescents | Control (Treatment and Personal) →<br>Blood glucose monitoring (+), Treatment adherence (+), Emergency precautions (+), Insulin intake (–), Diet (–), Exercise (–)<br>Consequence →<br>Blood glucose monitoring (+), Treatment adherence (+), Emergency precautions (+), Insulin intake (–), Diet (–), Exercise (–) | McGrady et al., 2014 |
| 6. | Glycemic control | Systematic Review | Identity, Consequences, Timeline, Concern, and Emotional representation →<br>Glycemic control (–)<br>Personal control →<br>Glycemic control (+) | Mc Sharry et al., 2011 |

In a qualitative study involving semi-structured interviews of 18 patients with type-2 diabetes (Bogatean and Hancu, 2004), one study found among other factors, that perceived consequences of the treatment was prevalent for the patients to resist insulin treatment. If the patient has low treatment control, that is low perceptions health control, he or she is likely to resist a particular treatment process. In another study investigating whether adherence to treatment and blood glucose monitoring is influenced by illness representations (McGrady et al., 2014), the authors observed 99 young adults and adolescents with type-1 diabetes. The study found that greater perceptions of control and perceptions of impact of their illness (consequence) significantly predicted patients' increased blood glucose monitoring frequency, adherence to treatment recommendations and emergency precautions. However, the study did not find associations between illness representation and adherence to diet, exercise, and insulin intake.

A systematic review by Harvey and Lawson (2009) on the effect of health belief models on diabetes self-care behaviors, authors summarized that patients' perception of treatment effectiveness (treatment control) positively related to outcome measures such as quality of life, glycemic control, better diet control and management, adherence to recommended treatment, and exercise. Perceptions of control over their illness were positively associated with their treatment adherence. Perceptions of negative consequences of their illness were associated to poorer adherence to self-care behaviors and non-attendance at the diabetic clinic. Associations of illness perceptions with blood glucose monitoring were more contradictory as some illness representations predicted better blood glucose monitoring whereas others found poorer adherence to blood glucose monitoring.

In a study by Gaston et al. (2011) on how adolescents' illness representations influence their diabetes self-management behavior, the authors found that greater perceived impact of the illness or threat of diabetes (consequence), was correlated with poorer diet management, better blood glucose monitoring. Their beliefs of higher symptoms (identity), was correlated with poorer self-management related to diet. Similarly, patients' belief in the treatment effectiveness (treatment control) was correlated with stricter diet control, better blood glucose monitoring. In contrast, the longer the patients think their disease is going to last, the poorer was their blood glucose monitoring.

In a meta-analysis (Mc Sharry et al., 2011) of the studies that used various illness perceptions questionnaires to measure diabetes patients' beliefs about their illness, higher levels of perceived health status (identity, consequence, timeline, concern, and emotional representation) had positive associations with glycemic control. However, greater personal control was negatively correlated with glycemic control. Law et al., (2014), in their systematic review on the studies investigating the effect of illness representations on self-management behaviors among children and young people with chronic illness, found control beliefs (perceived health control) have a more consistent and stronger influence on self-management behaviors than other dimensions of illness representation. The studies investigated by Law et al., (2014) found mixed results in terms of associations between illness representations and self-management behaviors.

In summary, the brief literature review presented above demonstrates that patients' illness perceptions do influence their self-management behaviors. However, the associates of illness representations with self-management behaviors are mixed and are sometimes not in line with the theory of common sense model of illness representations. Many of these studies are either qualitative or quantitative with just descriptive statistics of the results. These studies show mixed results and neither have a strong theoretical basis nor provide statistical rigor in the analysis.

Nonetheless, the brief literature review presented here provides us with an opportunity to see that a patient's perception of illness influences their coping and/or self-management behavior. The findings highlight the fact that there are opportunities for investigating further. This study makes use of the fact that patients' illness perceptions influence their behavior and investigates their influence on technology adoption and use.

## 2.3 Theoretical Background

### *2.3.1 Illness Representation and Self-Regulation*

The self-regulation or commonsense model of health and illness behavior (Leventhal et al., 2003; 2008) holds that people develop commonsense beliefs about their illness and related symptoms. These beliefs about their illness are stored in their memory as mental models called illness representations or schemas. These representations are developed through personal experience of the illness, family and friends who themselves have experienced the conditions, or from the information available in the media. These representations are logically connected and important to a person's overall understandability of their illness. As such they carry information that can drive subsequent actions (see Petrie and Weinman, 1997; Cameron and Leventhal, 2003; Cameron and Moss-Morris, 2004). The self-regulation model of illness cognition and behavior (Leventhal et al., 1984) examines this relationship i.e. an individual's representation of the illness and subsequent behavior to cope.

To gain a clear understanding of the components that make up a patient's illness perception, considerable research has been conducted. At the core, illness perceptions consist of five components: identity, cause, timeline, consequences, and cure/control. Together, these components provide a logically connected view of an individual's illness. Identity refers to the signs and symptoms that the individual ascribes to their health condition. Consequences are the patient's perception of physical, social, and economic impacts or outcome on the individual's life and the emotional feelings due to the disease. Causes refer to the individual's perceptions about the origin of their health condition. Timeline refers to the perceived duration (e.g., acute, chronic, cyclical) of the illness and how long it might take to cure. Finally, cure/control refers to the individual believing the illness may be cured or controlled by a treatment process (Lau and Hartman, 1983; Leventhal et al., 2003). To these five dimensions of cognitive illness representation, Moss-Morris et al. (2002) added coherence and emotional representations. Coherence refers to a patient's comprehensibility about the illness and how well these dimensions hang together (Leventhal et al., 2003). Emotional representations include elements such as anger, anxiety, fear, and depression.

Self-regulation theory suggests an individual builds cognitive and emotional models (representations) of their illness when they are faced with health threats (Figure 2.1.). These illness representations drive their response strategies to cope with the threats (Leventhal et al., 1997; 2003). In the context of chronic illness, health behavior is a dynamic process of coping and appraisal. The individual's illness representations influence their coping behavior, which in turn affect health outcomes

(Cameron & Leventhal, 2003; Leventhal et al., 1984). By using coping strategies or health behaviors, self-regulation is initiated and modified based on self-appraisal of the outcomes and/or feedback from the environment (Clark et al., 1991).

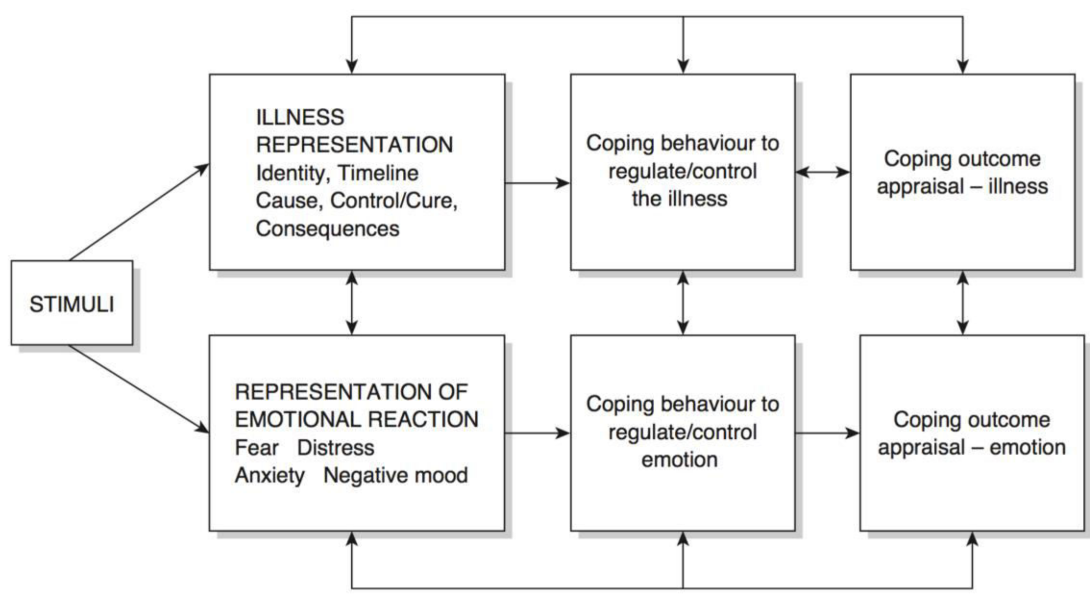



**Figure 2.1. Self-regulatory model of illness behavior (Source: Leventhal et al., 1984)**

Coping has been defined differentially in the literature. The most popular stems from Richard Lazarus, who defines coping as “constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person” (Lazarus & Folkman, 1984, p. 141). In this definition, coping is viewed as process oriented, fitting well with self-management where an individual engages in activities to manage/mitigate the illness. Among several categories of coping styles discussed in the literature, “active coping” involves taking steps to control the illness or condition and “passive coping” is surrendering or withdrawing from the situation. Similarly, researchers have used other terms such as “approach or engagement coping” (focuses on taking steps to deal with the stressor or related emotions) versus “avoidance or disengagement coping” (involving escaping the threat or the related emotions) (Moos & Schaefer, 1993; Carver and Connor-

Smith, 2010); “problem-focused” (strategies used to control or modify the problem or the root cause) and “emotion-focused” (focused on managing emotional responses to a stressor) (Lazarus and Folkman, 1984).

*2.3.2 Chronic Illness (Diabetes) Self-Management*

There is no single consistent definition for self-management in the literature, however, there are several definitions and views available (see Corbin and Strauss, 1988; Barlow et al., 2002; IOM, 2003 as cited in Adams et al., 2004, p.57; Lorig and Holman, 2003; Wilkinson and Whitehead, 2009). At the core of these definitions lie the individual’s engagement in activities that manage illness, promote health, and maintain a satisfactory quality of life.

Self-management of chronic illness has become a significant aspect of the healthcare system and sufficient attention has been given to this aspect for several decades (Novak et al., 2013). Self-management lies at the core of chronic illnesses, such as diabetes, where patients take an active role in taking necessary measures to keep their illness and conditions under control (Levich, 2007). This includes day-to-day tasks chronically ill patients perform between scheduled visits to health care providers to manage symptoms (including taking medications, treating the illness, following diet and exercise plans, and coping with the physical and psychological health impacts (Clark et al., 1991; Lorig and Holman, 1993; Glasgow et al. 2003 as cited in Nolte and McKee, 2008)). This further requires self-control, autonomy, problem solving, and conscious decision-making by patients to gain control of their disease (Gallant, 2003; Thorne et al., 2003). There is sufficient empirical evidence supporting the physical and psychological wellbeing of patients relative to successful self-management of chronic illnesses (Clark et al., 1991).

Creer and Christian (1976) first introduced the term self-management in their book on rehabilitation of chronically ill children, which has theoretical roots in Bandura’s (1986) social cognitive theory (SCT). According to SCT, behavioral change is determined by a sense of personal control over the environment. One of the key concepts of SCT is self-regulation (Bandura, 1991), which is particularly applicable to self-management. It is defined as “controlling oneself through self-monitoring, goal-setting, feedback, self-reward, self-instruction, and enlistment of social support" (McAlister et al., 2008, p. 171). Through the process of self-regulation, which involves three sub-functions – self-observation, self-judgment, and self-reaction, individuals attempt to control personal, behavioral, and environmental factors to accomplish their goals. Within the context of chronic illness management, self-regulation begins through behavior (e.g., following self-management tasks) and monitoring the condition (self-observation). The behavior is sustained or modified based on the individual's appraisal (self-judgment). The behavior is repeated (self-reaction) if it results in positive outcomes i.e. health improvement or control over the illness (Bandura, 1991; Clark et al., 1991).

There are several common activities that require attention as part of a successful chronic illness management program. Diabetes self-management for example, requires among other things monitoring blood glucose periodically. Mobile technologies have the potential to facilitate patients in their day-to-day self-management activities. Technologies that can support effective self-management behavior can significantly increase the likelihood for individuals to adopt those technologies and become more self-regulating. Theoretically, this should help individuals gain better control over the manageable aspects of chronic disease.

## 2.4 Research Model

### *2.4.1 Effect of Illness Representation on Behavioral Intentions to Adopt and Continued use of Mobile Technologies for Diabetes Management*

Research over the past few decades has demonstrated the significance of illness representations on patient behavior (Petrie and Weinman, 1997). Leventhal's common sense or self-regulation model (Leventhal et al., 1984) of illness perceptions provides a theoretical basis for understanding the influence of patients' conceptualization of their illness on coping behaviors. The model posits that illness representations of health threats invoke patients to adopt coping mechanisms. These illness representation forms the basis for the patient to choose coping processes or procedures to control the illness or condition (Leventhal et al., 2003).

In Leventhal's self-regulatory model, given a situation or a problem or a change in the normal state, an individual will be motivated to engage in problem-solving (active coping/ approach or passive/avoidance coping) strategies to re-establish his/her normal state. In the context of diabetes, this approach can be viewed as patient taking to self-management where the individual takes charge and engages in the activities necessary for managing the illness. Research has demonstrated that information technology can facilitate self-management activities such as self-monitoring of vital signs, interactions with healthcare providers, and accessing information related to diseases, which results in improvements in patient adherence to treatment and health outcomes (Solomon, 2008; Celler et al., 2003).

Broadly, a patient's illness representation consists of two components, which we call perceived health status and perceived health control. Identity, Timeline, Consequences, Severity, and Emotional Representation represent perceived health status; perceived health control consists of Personal Control, Treatment Control, and Comprehensibility. We present research models for two groups of populations: the non-users and users of mobile technologies for diabetes management. The research model for each group is developed in two levels. In the first level (Figures 2.2a and 2.2b) components of illness representation are hypothesized to influence patients' behavioral intentions to adopt and use mobile technologies for managing their illness.

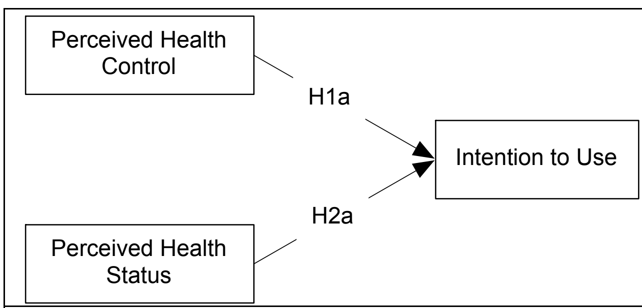



**Figure 2.2a. Research Model – First Level – Non-Users**

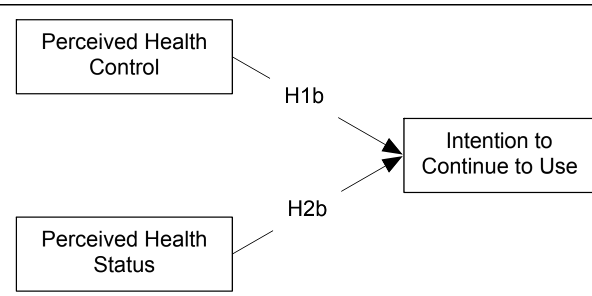



**Figure 2.2b. Research Model – First Level – Users**

In general, positive perceptions of health control includes more control over the disease, and a stronger belief that treatment will prove effective. Similarly, perceptions of negative health status are indicated by perceptions of strong illness identity, chronic timeline, severe consequences, high concerns, and more symptoms. People with positive perceived health control tend to exhibit approach active coping styles such as problem-focused coping, cognitive reappraisal, and seeking social support. Negative perceptions of health status were associated with more avoidance coping strategies. Hagger and Orbell (2003) performed a meta-analysis of 45 empirical studies based on the Common Sense Model (CSM) involving 23 types of chronic illnesses. The study found support for several apriori hypotheses on the relationship between illness perceptions and coping strategies. Higher perceptions of consequence and strong illness identity were positively associated with avoidance coping strategies. On the other hand, the greater perceptions of control were associated with problem-focused coping strategies and seeking social support. However, these are extremes of perceived health control and perceived health status.

Literature review on the effect of illness perceptions on self-management indicated studies have found positive as well as negative correlations between perceptions of health status and active self-management behaviors. Similarly, associations between perceived health control and self-management behaviors have also been mixed. Although the self-regulation model suggests negative perceptions of health status lead to patients engaging in avoidance coping and positive perceptions of health control lead to more active coping strategies, these are extreme cases where patients have given up (maintaining a pessimistic attitude) or are highly motivated.

Within the illness perception questionnaire, typically higher scores on the Identity, Timeline, Consequences, and Emotional Representations indicate more negative perceptions of health status. On the other hand, the high scores on Personal Control, Treatment Control, and Coherence indicate positive perceptions of health control (Mc Sharry et al., 2011). Whereas a patient with a positive perception of health control will avoid using technology, a person with negative perceptions of health status will adopt and use technology for managing their illness.

Perceptions of personal control in which an individual believes that one’s health is in their control determine health behaviors. Research shows that those who believe they are in control of their health indulge in and practice good health care behaviors compared to those who defer their situation to chance (Taylor, 2015). However, we believe if an individual understands their illness well (comprehensibility), is in control of the situation (personal control), and believes treatment works (treatment control), they are less motivated to use external tools such as mobile technologies for managing their illness. Thus,

H1a: Positive perceptions of health control (high scores on IPQ) will have a negative effect on the patients' intention to use mobile technologies for diabetes self-management.

According to Protection Motivation Theory (PMT; Rogers, 1975; 1983), an individual's motivation to protect him or herself partially depends on their perception of severity (health threat). We believe that an individual with negative perceptions of health status, that is, if an individual is genuinely concerned about their health, strongly identifies (symptoms), understands the negative consequences and potential timeline, and is emotionally concerned, he or she will feel motivated to seek support from external gadgets and technologies to get better. Thus,

H2a: Negative perceptions of health status (high scores on IPQ) will have positive effect on the patients' intention to use mobile technologies for diabetes self-management.

The self-regulation model indicates that illness representations induce coping strategies and influence a patient's health behavior (Leventhal et al., 2003) allowing the transition to the the adoption and use of mobile technologies for illness management. According to the model, these coping strategies and action plans have an effect on illness outcomes and the well-being of patients. As discussed before, the common-sense model of illness representation is a dynamic process where the outcome of coping strategies and health behaviors further influence illness representations (Leventhal et al., 2003). Current users of technology who experience the benefits in managing their illness will alter their illness representation. If, by using the technology, patients are able to stabilize and manage their illness well, they will develop positive perceptions of their health. Similarly, they are likely to gain confidence and believe they are in control. On the other hand, by using technology, if they don't see any improvement or if they cannot control their illness well, their personal control might get weakened and their fear of the health threat might become more severe. At any point in time, these illness perceptions will influence a patient's willingness to continue the use of technology. We argue that patients with positive perceptions of health control would like to continue using the technology and their negative perceptions of health will demotivate them to continue to use the technology. Thus,

H1b: Positive perceptions of health control (high scores on IPQ) will have a positive effect on the patients' intention to continue to use mobile technologies for diabetes self-management.

H2b: Negative perceptions of health status (high scores on IPQ) will have negative effect on the patients' intention to continue to use mobile technologies for diabetes self-management.

*2.4.2 Effect of Usefulness (Perceived) and Ease of Use (Perceived) on Intentional Beliefs*

According to the technology acceptance model (TAM; Davis, 1989, Davis et al., 1989), behavioral intentions of using a particular technology is strongly influenced by an individual's perception of the usefulness and ease of use with the technology. In the next level of our research model, for non-users (Figure 2.3.), the relation between illness representations and intention to use is conceptualized as mediated by individuals' perceptions of usefulness and ease of using the technology. For the users (Figure 2.4.), the relationship between illness representation and intention to continue to use is envisaged as mediated by the users' experience of usefulness and ease of using mobile technologies. Core constructs in the non-user model are Intention to Use, Perceived Usefulness, Perceived Ease of Use, Perceived Health Status, and Perceived Health Control. The principal constructs in the user model are Intention to Continue to Use, Usefulness, Ease of Use, Perceived Health Status, and Perceived Health Control. In this section, we offer theoretical arguments in support of the hypotheses for the proposed relationships in the research model. Definition for each of the construct and its source are listed in Appendix B.

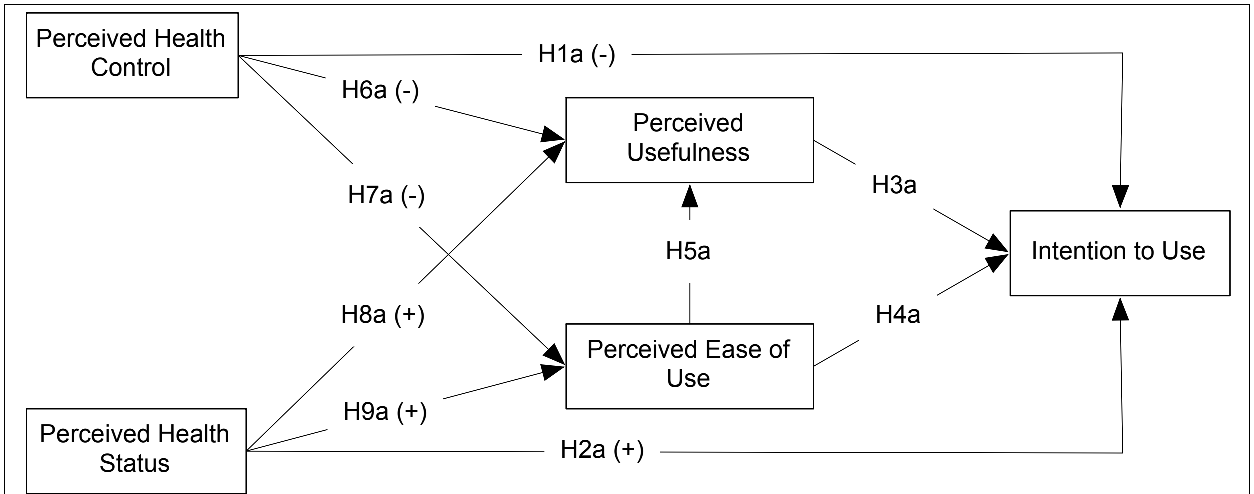



**Figure 2.3. Theoretical Model – Non-Users**

TAM was originated from the theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and the theory of planned behavior (TPB, Ajzen, 1991; 2005). It has been widely used to predict an individual's acceptance of technology. According to TAM, an individual's behavioral intention to use a particular technology is based on their perceptions of usefulness and ease of use of the technology. In the research model presented for non-users of mobile technologies, diabetes patients are likely to adopt and use mobile technologies if they perceive that mobile technologies are easy to use and using them will be useful in managing their illness. Thus, perceptions of usefulness and ease of use positively influence a diabetes patient's intentions to adopt mobile technologies for diabetes management. Several empirical studies (see reviews Holden & Karsh, 2010; Marangunic & Granic, 2015) related to TAM clearly demonstrated the positive effect of perceived usefulness and ease of use on the individual's intentions to using a particular technology. Thus, drawing from the extant literature on TAM, we validate the hypotheses:

H3a: Perceptions of usefulness of mobile technologies for diabetes management has a positive effect on the patients' behavioral intentions to use the technology.

H4a: Perceptions of how ease of use of mobile technologies for diabetes management has a positive effect on the patients' behavioral intentions to use the technology.

H5a: Perceptions of ease of use of mobile technologies for diabetes management has a positive effect on the patients' perceptions of usefulness of the technology.

Extending the argument to the current users of mobile technologies for managing their illness, the model (Figure 2.4) includes intention to continue to use mobile technologies as the dependent variable with the users' experience of usefulness and ease of using the technology as predictors. In the extant literature (Venkatesh et al., 2003; 2012), performance expectancy, an individual's expectations about the benefits of using a particular technology, and effort expectancy, which refers to an individual's expectations of ease with which the technology can be used, have been shown to positively influence the individual's intentions to continue to use the technology. Applying these aspects to the context of diabetes self-management, we believe that usefulness and ease of using mobile technologies as experienced by current users of mobile technologies for diabetes self-management will have an influence on their intentions of continued use of those technologies. Thus, we propose to test the hypotheses:

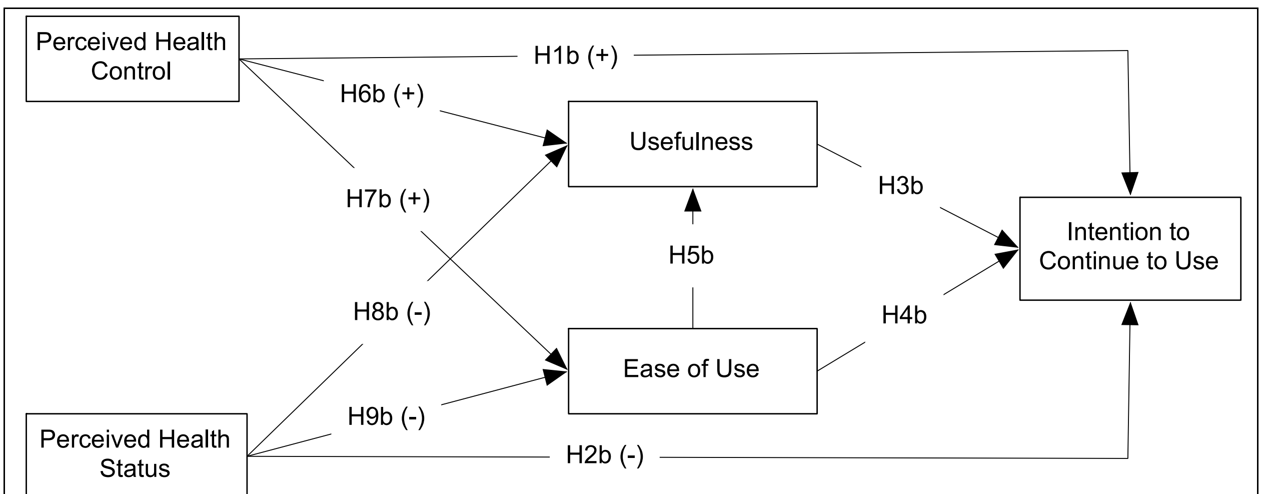



**Figure 2.4. Theoretical Model – Users**

H3b: Usefulness of mobile technologies for diabetes management has a positive effect on the patients' intentions to continue to use the technology.

H4b: The ease with which mobile technologies can be used for diabetes management has a positive effect on the patients' intentions to continue use the technology.

H5b: The ease with which mobile technologies can be used for diabetes management has a positive effect on the usefulness of the technology.

*2.4.3 Impact of Illness Representation on Perceived Usefulness and Perceived Ease of Use (Non-Users)*

An individual's beliefs about his or her health status and control are envisioned as the underlying predictors of perceived usefulness and perceived ease of use. Diabetes patients need to take care of a multitude of things in the process of managing their illness. For instance, they need to regularly monitor blood glucose levels; track their diet in terms of calories, portion sizes, and nutrition; take timely medication; keep track of physical activities; and several others.

Research has shown mixed results on the effect of patients' perceived health control on self-management. Consider that a diabetes patient believes he or she is in control of their illness; they have a very clear understanding about their illness; and believe the recommended treatment will be effective. These perceptions on health control can influence diabetes self-management. For example, patients' treatment control beliefs were significantly associated with most self-management activities (Law et al., 2014). Studies have shown that patients' treatment control had significant positive effect on blood glucose monitoring (Gaston et al., 2011), diet control (Gaston et al., 2011; Harvey and Lawson, 2009), and glycemic control (Harvey and Lawson, 2009; Mc Sharry et al., 2011). However, the same treatment control beliefs were not significantly associated with self-management in other diabetes studies (Fortenberry et al., 2012; Law et al., 2002). Similarly, the studies did not find any significant associations of personal control beliefs with any self-management aspect (Law et al., 2014). These mixed results suggest that an individual who has positive perceptions of health control may not believe in the usefulness or ease of use in external gadgets for managing their diabetes. Overall, given the mixed results on the effect of patients' perceived health control on self-management activities, research shows that individuals who believe that they are in control of their lives and have a higher sense of control adapted well with chronic illnesses compared to those who had low personal control (Livneh et al., 2004).

We should consider two aspects here in the process of self-management using mobile technologies: one, the actual task of managing diabetes and two, use of technology as a tool in the process. An individual with a strong sense of personal control, who believes the treatment works great, and who has a clear understanding about his or her illness symptoms, might manage the illness well, but might not believe in the need for external tools to help in the process. We believe that these individuals do not really see the usefulness and ease of using the technology. Thus,

H6a: Positive perceptions of health control (high scores on IPQ) will have a negative effect on the perceived usefulness of mobile technologies for diabetes self-management.

H7a: Positive perceptions of health control (high scores on IPQ) will have a negative effect on the perceived ease of use of mobile technologies for diabetes self-management.

Similarly, there is evidence in the research literature that patients' who perceive their illness is severe will adhere to treatment recommendations (Becker and Maiman, 1975). As suggested by protection motivation theory (Rogers, 1975; 1983), perceived severity of health status motivates an individual to believe in the coping strategy. That is, patients who think the consequences of the illness are significant, fear it's prolongment, have severe symptoms, and a strong emotional representation believe technology will be useful and easy to use for managing their illness. The individual's negative attitude about their illness translates into a positive attitude towards the usefulness and ease of using mobile technologies.

H8a: Negative perceptions of health status (high scores on IPQ) will have positive effect on the perceived usefulness of mobile technologies for diabetes self-management.

H9a: Negative perceptions of health status (high scores on IPQ) will have positive effect on the perceived ease-of-use of mobile technologies for diabetes self-management.

*2.4.4 Impact of Illness Representation on Perceived Usefulness and Perceived Ease of Use (Users)*

As with the non-user model, an individuals' perception of health status and health control is envisaged to influence usefulness and ease of using mobile technologies. As discussed earlier, illness representations prompt individuals to formulate coping behaviors which reshape the illness representation. The self-regulatory model includes a feedback loop between illness representations and behavioral actions and acknowledges that illness perceptions change based on the experience and outcomes of coping behaviors. The use of technology for diabetes management will have an impact on the illness representations of users. If a patient is able to manage his or her illness with improvement using technology, the individual will form a positive opinion about the usefulness of the technology. As the patient continues, he or she gets used to the technology and finds it effortless (even if switching to alternate technologies due to prior use). If using the technology boosts diabetes patients' control over their health, they are likely to develop a positive attitude toward the usefulness and ease of using the technology. Thus,

H6b: Positive perceptions of health control (high scores on IPQ) will have a positive effect on the perceived usefulness of mobile technologies for diabetes self-management.

H7b: Positive perceptions of health control (high scores on IPQ) will have a positive effect on the perceived ease of use of mobile technologies for diabetes self-management.

Similarly, if the patient's health condition remains unchanged even after using the technology, their illness perceptions remain either unchanged or they may feel more concerned about their health. The outcome may cast doubts on the usefulness of the technology. It is highly likely they will develop a negative perception about the usefulness or ease of using the technology. Thus,

H8b: Negative perceptions of health status (high scores on IPQ) will have negative effect on the perceived usefulness of mobile technologies for diabetes self-management.

H9b: Negative perceptions of health status (high scores on IPQ) will have negative effect on the perceived ease-of-use of mobile technologies for diabetes self-management.

In Tables 2.2 and 2.3, a summary of all hypothesized relationships under non-user and user models is presented.

| Table 2.2. Summary of hypotheses (Non-Users) | |
|---|---|
| H1a | *Positive perceptions of health control (high scores on IPQ) will have a negative effect on the patients' intention to use mobile technologies for diabetes self-management.* |
| H2a | *Negative perceptions of health status (high scores on IPQ) will have positive effect on the patients' intention to use mobile technologies for diabetes self-management.* |
| H3a | *Perception of usefulness of mobile technologies for diabetes management has a positive effect on the patients' behavioral intentions to use the technology.* |
| H4a | *Perception of ease of using mobile technologies for diabetes management has a positive effect on the patients' intentions to use the technology.* |
| H5a | *Perception of ease of using of mobile technologies for diabetes management has a positive effect on the patients' perception of usefulness of the technology.* |
| H6a | *Positive perceptions of health control (high scores on IPQ) will have a negative effect on the perceived usefulness of mobile technologies for diabetes self-management.* |
| H7a | *Positive perceptions of health control (high scores on IPQ) will have a negative effect on the perceived ease of use of mobile technologies for diabetes self-management.* |
| H8a | *Negative perceptions of health status (high scores on IPQ) will have positive effect on the perceived usefulness of mobile technologies for diabetes self-management.* |
| H9a | *Negative perceptions of health status (high scores on IPQ) will have positive effect on the perceived ease-of-use of mobile technologies for diabetes self-management.* |

| Table 2.3. Summary of hypotheses (Users) | |
|---|---|
| H1b | *Positive perceptions of health control (high scores on IPQ) will have a positive effect on the patients' intention to continue to use mobile technologies for diabetes self-management.* |
| H2b | *Negative perceptions of health status (high scores on IPQ) will have negative effect on the patients' intention to continue to use mobile technologies for diabetes self-management.* |
| H3b | *Usefulness of mobile technologies for diabetes management has a positive effect on the patients' intentions to continue to use the technology.* |
| H4b | *Ease of using mobile technologies for diabetes management has a positive effect on the patients' intentions to continue to use the technology.* |
| H5b | *Ease of using mobile technologies for diabetes management has a positive effect on the usefulness of the technology.* |
| H6b | *Positive perceptions of health control (high scores on IPQ) will have a positive effect on the perceived usefulness of mobile technologies for diabetes self-management.* |
| H7b | *Positive perceptions of health control (high scores on IPQ) will have a positive effect on the perceived ease of use of mobile technologies for diabetes self-management.* |
| H8b | *Negative perceptions of health status (high scores on IPQ) will have negative effect on the perceived usefulness of mobile technologies for diabetes self-management.* |
| H9b | *Negative perceptions of health status (high scores on IPQ) will have negative effect on the perceived ease-of-use of mobile technologies for diabetes self-management.* |

## 2.5 Instrument Development

The items for various constructs in the research model are presented in Appendix B. In this study, we used measures for all the variables from prior literature and the measurement has been done using scales consisting of multiple items. In the non-user model, for measuring intention to use mobile technologies for diabetes management for non-users, we adapted items from Venkatesh et al. (2003). We adapted the items from Venkatesh and Davis (2000) and Venkatesh et al. (2003) for measuring perceptions of usefulness and perceptions of ease of use respectively. In the user model, to measure intention to continue to use mobile technologies, we adapted the items from Bhattacherjee (2001) and Venkatesh and Goyal (2010). Items for measuring actual usefulness and ease of using mobile technologies for diabetes management were developed by adapting from Venkatesh and Davis (2000) and Venkatesh et al. (2003). For measuring patients' illness representation, which refers to patients' view about the severity of their illness and their beliefs about the amount of control they think they have, we adapted items from the brief illness perception questionnaire (Brief IPQ) (Broadbent et al., 2006). Illness representation is conceptualized as consisting of two constructs: perceived health control and perceived health status. Perceived health control consists of three items and perceived health status consists of five. We included the individual characteristics such as gender, age, ethnicity, marital status, educational qualifications, and income levels as control variables.

We measured the items of behavioral intentions to use, usefulness, and ease of use using the 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Items for the illness representation were measured using an 11-point scale.

## 2.6 Methodology

Target population for this research was diabetes patients who were users and non-users of mobile technology for managing diabetes. The study was conducted in the United States with the unit of analysis focused on the individual. Data, for validating hypothesized relationships in this research were collected in a cross-sectional study of diabetes patients using an anonymous web-based survey with the help of a third party data collection agency. The survey questionnaire was designed for two groups: one consisting of diabetes patients who currently use mobile technologies for managing their diabetes and the other with diabetics who are familiar with those technologies, but don't use them for managing their illness. Survey items were created/modified so as to capture perceptions from the non-user group and actual experience from those who use technology. We ensured the survey respondents live in the United States and were over 18 years of age. No other restrictions in particular were enforced on the demographics of the participants.

The number of completed and useful responses received was 227 from the user group and 208 from the non-user group. A high level view of respondent characteristics according to their age, gender, and usage of mobile technologies is presented in Table 2.4. Between the two groups, respondents were distributed more or less equally along the gender dimension. Among the non-users, 56.3% were female and 43.5% were male. In the user group, male and female representation was 46.7% and 53.3% respectively. In the user population, 213 respondents, over 80%, were between the ages of 25 and 54 years and from the non-users, over 75% (156 respondents) belonged to 35 to 64 years of age. The data indicates users were relatively younger than non-users. Of the user population, 69.6% were 44 years and under where as 48.1% of the non-users were 45 and above. A clear indication that mobile technologies for managing diabetes is primarily used by younger generations.

The data collected also contains information about diabetes patients' use of mobile apps and mobile technologies for diabetes management in particular. With regard to general use of mobile apps, 62.5% of non-users and 41.63% of users have been using mobile apps and smartphones for over 2 years. Regarding the user of mobile technologies for diabetes management, 84.44% (217 respondents) of the user population has used the technology for at least 6 months.

| Table 2.4. Data Distribution | | | | | |
|---|---|---|---|---|---|
| | | **Non-Users** | **%** | **Users** | **%** |
| Total samples | | 208 | | 257 | |
| | | | | | |
| Gender | Male | 91 | 43.8% | 120 | 46.7% |
| | Female | 117 | 56.3% | 137 | 53.3% |
| | | | | | |
| Age | 18-24 | 11 | 5.3% | 15 | 5.8% |
| | 25-34 | 39 | 18.8% | 71 | 27.6% |
| | 35-44 | 58 | 27.9% | 93 | 36.2% |
| | 45-54 | 47 | 22.6% | 49 | 19.1% |
| | 55-64 | 51 | 24.5% | 24 | 9.3% |
| | 65-74 | 2 | 1.0% | 5 | 1.9% |
| | >74 | 0 | 0.0% | 0 | 0.0% |
| | | | | | |
| Length of Diabetes | 0-1 Yrs | 10 | 4.81% | 11 | 4.28% |
| | 1-2 Yrs | 33 | 15.87% | 43 | 16.73% |
| | 2-5 Yrs | 65 | 31.25% | 113 | 43.97% |
| | 5-10 Yrs | 40 | 19.23% | 44 | 17.12% |
| | > 10 Yrs | 60 | 28.85% | 46 | 17.90% |
| | | | | | |
| Mobile Technologies for managing diabetes | 0-6 Mos | n/a | | 40 | 15.56% |
| | 6-12 Mos | n/a | | 90 | 35.02% |
| | 1-2 Yrs | n/a | | 89 | 34.63% |
| | 2-5 Yrs | n/a | | 33 | 12.84% |
| | > 5 Yrs | n/a | | 5 | 1.95% |

## 2.7 Analysis

Before proceeding with data analysis, we intend to describe the approach we took in combining the elements of illness representation into two key components. In this research, we used the brief illness perception questionnaire (Brief IPQ) to measure illness representations of diabetes patients. The brief IPQ consists of eight items and an open-ended response item, which asks about three important causes of a patient’s illness. We excluded this ninth question from our study. Exploratory factor analysis performed on the first eight items resulted in two factors, one of which consisted of items related to personal control, treatment control, and an understanding of their illness. These are an individual’s perceptions of level of control and understanding about their health. We call this factor Perceived Health Control. The second factor consists of items related to consequences, timeline, identity, concern, and emotions. These indicate to some extent an individual's perceptions of severity of health. We call this factor Perceived Health Status. We develop our research model with these two factors as separate constructs.

Our research model for non-users consists of intention to use, perceived usefulness and perceived ease of use. The model for users consists of intention to continue to use, usefulness, and ease of use. In addition, both models consist of perceived health control and perceived health status. In both models, all constructs were measured with multiple items as first order reflective constructs.

We used the component-based approach (Lohmöller, 2013), partial least squares (PLS) structural equation modeling technique to analyze our research models. Using PLS, one can simultaneously test the measurement model and the structural model. The advantages of using PLS over covariance-based methods, such as LISREL, are (i) PLS method maximizes the explained variance in the outcome latent variables, and (ii) PLS relaxes the assumption of data normality. We used Smart-PLS software (Ringle et al., 2015) to test our hypothesized relationships corresponding to the users and non-uses of mobile technologies. The results are presented below in two parts: the measurement model and structural model. Using the measurement model, we established validity and reliability by examining the relationships between the latent variables and the underlying measured indicators. With the structural model, we test the proposed hypotheses by examining the effect sizes and p-values and there by assess the relationships among the latent constructs. Cronbach's alpha and composite reliability were used to assess internal consistency. Convergent validity was evaluated using average variance extracted (AVE) and discriminant validity was assessed using item cross loadings and Fornell-Larcker criterion.

### *2.7.1 Measurement Model*

Before proceeding with the discussion on the measurement model, we present a brief account of our conceptualization of illness representation. The brief illness perception questionnaire (Brief IPQ; Broadbent et al., 2006) used in this study for capturing an individual's illness representations consists of eight dimensions: consequence, timeline, personal control, treatment control, identity, concern, illness comprehension, and emotional representation. We performed exploratory factor analysis of the responses from both user and non-user populations on these eight items of illness representation. EFA resulted in two factors with items related to consequence, timeline, identity, concern, and emotional representation loading on one factor and the items related to personal control, treatment control, and illness comprehension loading on another factor. We have named these two factors respectively as Perceived Health Status and Perceived Health Control. The items related to consequence, timeline, identity, concern, and emotional representation are reverse coded. So, higher scores on these dimensions indicate more negative perception of health status. We reverse coded the scores on these items before performing PLS modeling. After reverse coding, higher scores on these items mean positive health perceptions. On the other hand, the items related personal control, treatment control, and illness comprehension normally stated so a higher score on these dimensions indicate positive perceptions of health control.

**Table 2.5. Measurement Model**

| | | Non-Users | | | | | Users | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Construct** | **Dimension** | **Mean** | **SD** | **CR** | **CA** | **AVE** | **Mean** | **SD** | **CR** | **CA** | **AVE** |
| IU/ICU | | 3.644 | 0.916 | 0.951 | 0.931 | 0.828 | 3.872 | 0.488 | 0.946 | 0.923 | 0.813 |
| U/PU | | 3.904 | 0.706 | 0.939 | 0.903 | 0.838 | 4.284 | 0.673 | 0.939 | 0.902 | 0.836 |
| EU/PEU | | 3.726 | 0.658 | 0.864 | 0.767 | 0.681 | 3.969 | 0.661 | 0.862 | 0.759 | 0.679 |
| IR | PHC | 8.139 | 1.803 | 0.861 | 0.762 | 0.675 | 8.452 | 1.505 | 0.856 | 0.749 | 0.665 |
| | PHS | 7.530 | 2.022 | 0.899 | 0.862 | 0.646 | 8.057 | 1.514 | 0.854 | 0.792 | 0.543 |

Note: CA – Cronbach's Alpha; CR – Composite Reliability; AVE – Average Variance Extracted

IU – Intention to Use; ICU – Intention to Continue to Use; U – Usefulness; PU – Perceived Usefulness; EU – Ease of Use; PEU – Perceived Ease of Use; IR – Illness Representation; PHC – Perceived Health Control; PHS – Perceived Health Status

Table 2.5 presents the measurement models for both non-user and user models. As mentioned previously, all the constructs in this study were measured with reflective indicators. Hence the measurement models are assessed on their internal consistency reliability, and convergent and discriminant validity (Hair et al. 2014). Internal consistency, which ensures multiple items that are intended to measure the same latent construct do produce consistent scores, is established by using

Cronbach’s alpha. A value of 0.70 is considered good for internal consistency. Alternatively, composite reliability is also used for evaluating internal consistency. A value of 0.7 is considered satisfactory for establishing internal consistency (Nunally and Bernstein, 1994). As can be seen from the Table 2.5, the composite reliability as well as Cronbach’s alpha for all the constructs is over 0.7.

The outer loadings of the indicators and the average variance extracted (AVE) are used to assess convergent validity, which is the extent to which an indicator positively correlates with other measures of the construct. A value of 0.5 for AVE is considered acceptable (Fornell and Larcker, 1981) and we can see from Table 2.5 that all the constructs in both models have AVE values above 0.5. The other indicator to establish convergent validity is outer loadings of the indicators, which are presented in the Table 2.6. A value of 0.708 and above is considered acceptable (Hair Jr. et al., 2014) because the square of this number (0.7082) equals 0.50, which means about 50% of the variance of the indicator is explained by the latent variable. Usually, a loading value of 0.70 is considered acceptable. As can be seen from the Table 2.6, the outer loadings for all the indicators are above the acceptable value.

2.7.5.1 Outer Loadings

| Table 2.6. Outer Model Loadings | | | |
|---|---|---|---|
| **Non-Users** | | **Users** | |
| **Construct** | **Outer Loading** | **Construct** | **Outer Loading** |
| | | | |
| ***Perceived Health Control*** | | ***Perceived Health Control*** | |
| IR3 | 0.788 | IR3 | 0.781 |
| IR4 | 0.873 | IR4 | 0.860 |
| IR7 | 0.802 | IR7 | 0.674 |
| ***Perceived Health Status*** | | ***Perceived Health Status*** | |
| IR1 | 0.900 | IR1 | 0.844 |
| IR2 | 0.557 | IR2 | 0.605 |
| IR5 | 0.869 | IR5 | 0.674 |
| IR6 | 0.840 | IR6 | 0.743 |
| IR8 | 0.807 | IR8 | 0.793 |
| | | | |
| ***Intention to Use*** | | ***Intention to Continue to Use*** | |
| INT1 | 0.905 | ICU1 | 0.919 |
| INT2 | 0.887 | ICU2 | 0.862 |
| INT3 | 0.919 | ICU3 | 0.920 |
| INT4 | 0.930 | ICU4 | 0.906 |
| | | | |
| ***Perceived Usefulness*** | | ***Usefulness*** | |
| PU1 | 0.946 | U1 | 0.910 |
| PU2 | 0.912 | U2 | 0.932 |
| PU3 | 0.887 | U3 | 0.901 |
| | | | |
| ***Perceived Ease of Use*** | | ***Ease of Use*** | |
| PEU1 | 0.730 | EOU1 | 0.660 |
| PEU2 | 0.877 | EOU2 | 0.897 |
| PEU3 | 0.860 | EOU3 | 0.893 |

Next, discriminant validity, the extent to which a construct is distinct from other constructs, is established with the help of indicator cross loadings. The outer loadings of the indicators associated with a construct under consideration must be greater than any of its cross-loadings on other constructs (Fornell and Larcker, 1981; Hair et al., 2014). From the Table 2.7, we can see that outer loadings of all the measures are distinctly over and above their cross loadings, thus establishing discriminant validity.

| Table 2.7. Discriminant Validity | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-Users | | | | | | | Users | | | | |
| | PHS | PHC | PU | PEU | IU | | PHS | PHC | U | EU | ICU |
| **IR1** | 0.900 | 0.093 | 0.396 | 0.209 | 0.427 | **IR1** | 0.844 | 0.123 | 0.162 | 0.162 | 0.126 |
| **IR2** | 0.557 | 0.112 | 0.109 | 0.071 | 0.134 | **IR2** | 0.605 | 0.119 | 0.176 | -0.022 | 0.128 |
| **IR5** | 0.869 | 0.045 | 0.306 | 0.092 | 0.365 | **IR5** | 0.674 | 0.014 | 0.039 | 0.049 | 0.059 |
| **IR6** | 0.840 | 0.158 | 0.288 | 0.096 | 0.273 | **IR6** | 0.743 | 0.260 | 0.095 | 0.076 | 0.116 |
| **IR8** | 0.807 | -0.068 | 0.205 | 0.086 | 0.315 | **IR8** | 0.793 | -0.040 | 0.115 | 0.022 | 0.119 |
| **IR3** | -0.075 | 0.788 | 0.006 | 0.084 | -0.124 | **IR3** | 0.018 | 0.781 | 0.248 | 0.332 | 0.215 |
| **IR4** | 0.098 | 0.873 | 0.051 | 0.160 | -0.102 | **IR4** | 0.123 | 0.860 | 0.334 | 0.324 | 0.357 |
| **IR7** | 0.150 | 0.802 | 0.069 | 0.137 | -0.049 | **IR7** | 0.210 | 0.803 | 0.287 | 0.205 | 0.313 |
| **PU1** | 0.334 | 0.040 | 0.946 | 0.534 | 0.667 | **U1** | 0.136 | 0.319 | 0.910 | 0.563 | 0.652 |
| **PU2** | 0.338 | 0.061 | 0.912 | 0.509 | 0.652 | **U2** | 0.196 | 0.329 | 0.932 | 0.529 | 0.682 |
| **PU3** | 0.293 | 0.046 | 0.887 | 0.573 | 0.584 | **U3** | 0.152 | 0.335 | 0.901 | 0.524 | 0.675 |
| **PEU1** | 0.000 | 0.091 | 0.349 | 0.730 | 0.235 | **EU1** | 0.004 | 0.223 | 0.346 | 0.660 | 0.357 |
| **PEU2** | 0.144 | 0.125 | 0.563 | 0.877 | 0.394 | **EU2** | 0.137 | 0.310 | 0.526 | 0.897 | 0.556 |
| **PEU3** | 0.192 | 0.169 | 0.510 | 0.860 | 0.324 | **EU3** | 0.058 | 0.331 | 0.557 | 0.893 | 0.531 |
| **IU1** | 0.397 | -0.130 | 0.635 | 0.390 | 0.905 | **ICU1** | 0.133 | 0.328 | 0.737 | 0.593 | 0.919 |
| **IU2** | 0.367 | -0.050 | 0.676 | 0.346 | 0.887 | **ICU2** | 0.197 | 0.294 | 0.622 | 0.466 | 0.862 |
| **IU3** | 0.304 | -0.152 | 0.575 | 0.344 | 0.919 | **ICU3** | 0.104 | 0.341 | 0.635 | 0.517 | 0.920 |
| **IU4** | 0.393 | -0.073 | 0.636 | 0.353 | 0.930 | **ICU4** | 0.139 | 0.359 | 0.640 | 0.557 | 0.906 |
| PHC – Perceived Health Control; PHS – Perceived Health Status; PU – Perceived Usefulness; PEU – Perceived Ease of Use; IU – Intention to Use | | | | | | | PHC – Perceived Health Control; PHS – Perceived Health Status; U – Usefulness; EU –Ease of Use; ICU – Intention to Continue to Use | | | | |

Discriminant validity is also evaluated by comparing the AVE of each construct against their correlations with other constructs (Fornell and Larcker, 1981). From the correlation matrix (Table 2.8), one can see that constructs are distinct and uncorrelated illustrating sufficient discriminant validity.

| Table 2.8. Correlation Matrix | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-Users | | | | | | | Users | | | | |
| | PHS | PHC | PU | PEU | IU | | PHS | PHC | U | EU | ICU |
| **PHS** | 0.822 | | | | | **PHS** | 0.737 | | | | |
| **PHC** | 0.080 | 0.804 | | | | **PHC** | 0.144 | 0.815 | | | |
| **PU** | 0.053 | 0.352 | 0.915 | | | **U** | 0.177 | 0.359 | 0.914 | | |
| **PEU** | 0.159 | 0.150 | 0.587 | 0.825 | | **EU** | 0.088 | 0.354 | 0.589 | 0.824 | |
| **IU** | -0.111 | 0.403 | 0.694 | 0.394 | 0.910 | **ICU** | 0.157 | 0.367 | 0.732 | 0.594 | 0.902 |
| PHC – Perceived Health Control; PHS – Perceived Health Status; PU – Perceived Usefulness; PEU – Perceived Ease of Use; IU – Intention to Use | | | | | | | PHC – Perceived Health Control; PHS – Perceived Health Status; U – Usefulness; EU –Ease of Use; ICU – Intention to Continue to Use | | | | |

*2.7.2 Structural Model*

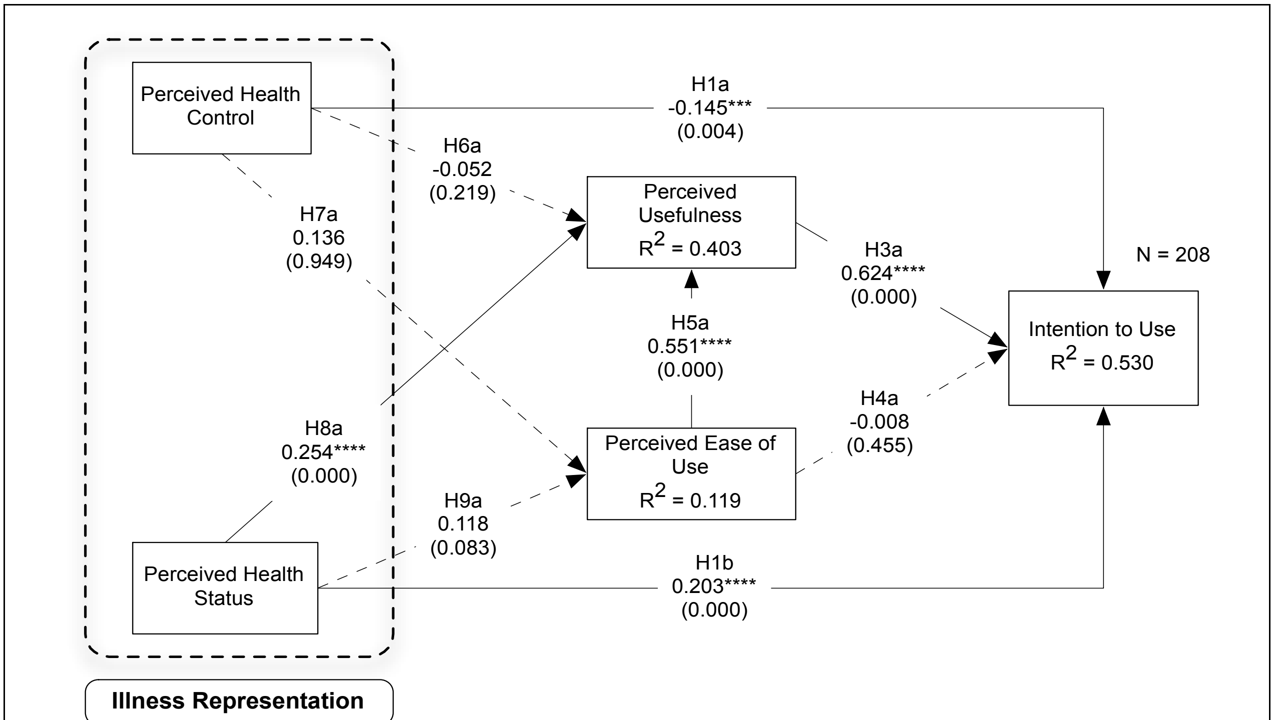
Figures 2.5 and 2.6 provide structural models for non-users and users respectively. The non-user model explains 53.0 percent of variance in the intention to use mobile technologies and the user model explains 58.4 percent of variance in the intention to continue to use mobile technologies for diabetes management. In the non-user model, perceived health status and perceived health control together explain 40.3% and 11.9% of variance in perceived usefulness and perceived ease of use respectively; and in the user model, they explain 43.1% and 12.2% of variance in the usefulness and ease of use constructs respectively. Table 2.9 shows the path coefficients, p-values, and t-statistic for each of the hypothesized relationships in the non-user model and corresponding data in the user model is shown in Table 2.10. We will now analyze the structural model for non-user and user models indicating whether or not our stated hypotheses are supported.

2.7.2.1 Non-User Model

Path coefficients along with p-values for the non-user model are shown in Figure 2.5. Hypothesis H1a posits that positive perceptions health control (high scores on IPQ) will have a positive effect on the patient's intentions to use mobile technologies. Similarly, hypothesis H2a states that negative perceptions of health status (high scores on IPQ) will have a positive effect on the intentions of mobile technology use. PLS analysis on the data shows that perceived health control is negatively correlated ($\beta = -0.145$, $p = 0.004$) and perceived health status is positively correlated ($\beta = 0.203$, $p = 0.000$) with intention to use mobile technologies indicating support for the hypotheses H1a and H2a.

Data provides strong support for the TAM (Davis 1989) hypothesis H3a and H5a. Hypothesis H3a states that perceived usefulness is positively related to intention to use mobile technologies ($\beta = 0.624$, $p = 0.000$). Hypothesis H4a, which hypothesizes a direct positive relationship between perceived ease of use and intention to use mobile technologies, was not supported ($\beta = -0.008$, $p = 0.455$). This result is consistent with the obtained others (Davis et al., 1989). The positive influence of ease of use on perceived usefulness is significant ($\beta = 0.551$, $p = 0.000$) giving support to hypothesis H5a.

The effects of perceived health control are not significant on perceived usefulness (hypothesis H6a; β = -0.052, p = 0.214), and on perceived ease of use (hypothesis H7a; β = 0.136, p = 0.949). Finally, the effect of perceived health status on perceived usefulness (hypothesis H8a) is significant (β = 0.254, p = 0.000, one-tailed), but its influence on perceived ease of use (hypothesis H9a) is not significant at α =0.05 (β = 0.118, p = 0.075), indicating lack of support for our hypothesis.




One-Tailed; ****p < 0.001, ***p < 0.01, **p < 0.05, *p < 0.10

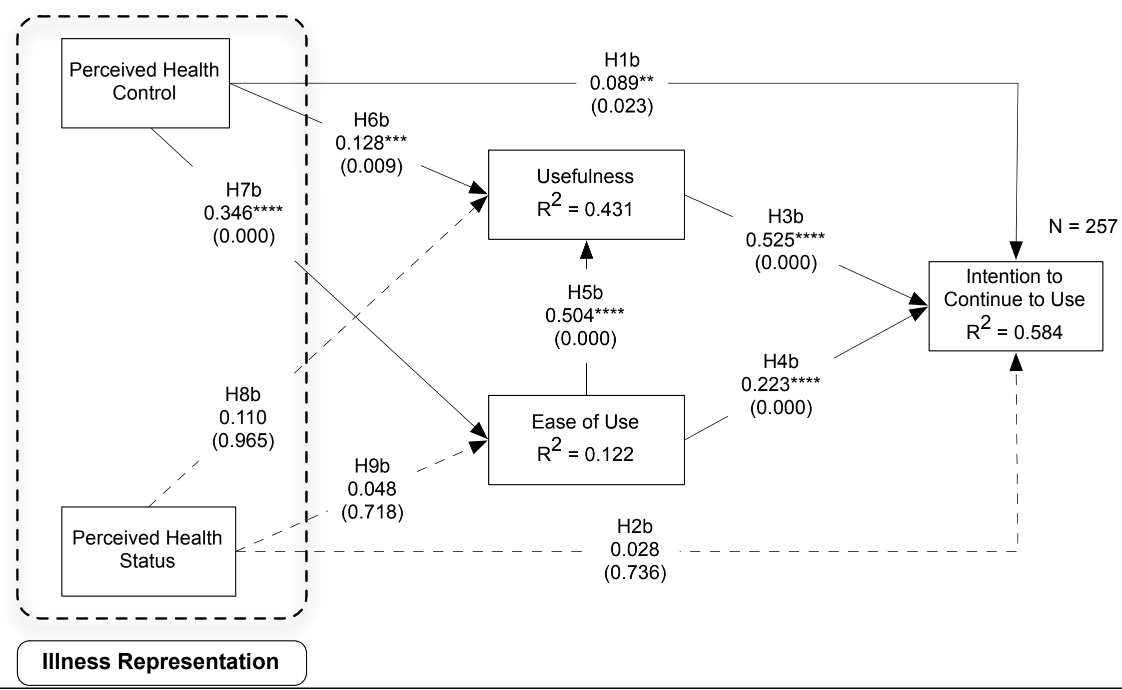
**Figure 2.5. Structural Model with Direct Effect (Non-Users)**

2.7.2.2 User Model

Figure 2.6 shows the details of path coefficients and p-values for the user model. In the user model, hypothesis H1b, which states that perceived health control (high scores on IPQ) would have a positive effect on intention to continue to use mobile technologies, is supported (β = 0.089, p = 0.020). However, hypothesis H2b, which posits a negative relationship between perceived negative health status (high scores on IPQ) and intentions to continue to use mobile technologies, showed an inverse relationship (β = 0.028, p = 0.736) making it insignificant.

The positive effect of usefulness on intention to continue use mobile technologies (hypothesis H3b) was significant (β = 0.525, p = 0.000) and the effect of ease of use on intention to continue to use (hypothesis H4b) mobile technologies was significant (β = 0.223, p = 0.000). The positive influence of ease of use on usefulness is significant (β = 0.505, p = 0.000) lending support to hypothesis H5b.

The effect of perceived health control on usefulness (hypothesis H6b) is significant (β = 0.128, p = 0.009), and its effect on ease of use (hypothesis H7b) is also significant (β = 0.346, p = 0.000). Finally, contrary to what we hypothesized, the effect of perceived negative health status (high scores on IPQ) on usefulness (hypothesis H8b; β = 0.110, p = 0.965) and its influence on ease of use (Hypothesis H9b; β = 0.048, p = 0.736) turned out to be positive making both the relationships insignificant. Thus, our hypothesis H8b and H9b are not supported.




One-Tailed; ****p < 0.001, ***p < 0.01, **p < 0.05, *p < 0.10

**Figure 2.6. Structural Model with Direct Effect (Users)**

Tables 2.9 and 2.10 present a summary of hypotheses results for non-user and user models respectively.

**Table 2.9. Summary of Hypothesis Tests (Non-Users)**

| # | Relationship | β | t | p | Support |
|---|---|---|---|---|---|
| H1a | Perceived Health Control --> Intention to Use | -0.145 | -2.702 | 0.004 | Yes |
| H2a | Perceived Health Status --> Intention to Use | 0.203 | 4.212 | 0.000 | Yes |
| H3a | Perceived Usefulness --> Intention to Use | 0.624 | 8.600 | 0.000 | Yes |
| H4a | Perceived Ease of Use --> Intention to Use | -0.008 | -0.114 | 0.455 | No |
| H5a | Perceived Ease of Use --> Perceived Usefulness | 0.551 | 7.963 | 0.000 | Yes |
| H6a | Perceived Health Control --> Perceived Usefulness | -0.052 | -0.791 | 0.215 | No |
| H7a | Perceived Health Control --> Perceived Ease of Use | 0.136 | 1.633 | 0.949 | No |
| H8a | Perceived Health Status --> Perceived Usefulness | 0.254 | 4.510 | 0.000 | Yes |
| H9a | Perceived Health Status --> Perceived Ease of Use | 0.118 | 1.385 | 0.083 | No |

| Table 2.10. Summary of Hypothesis Tests (Users) | | | | | |
|---|---|---|---|---|---|
| **#** | **Relationship** | **β** | **t** | **p** | **Support** |
| H1b | Perceived Health Control --> Intention to Continue to Use | 0.089 | 2.001 | 0.023 | Yes |
| H2b | Perceived Health Status --> Intention to Continue to Use | 0.028 | 0.631 | 0.736 | No |
| H3b | Usefulness --> Intention to Continue to Use | 0.525 | 6.175 | 0.000 | Yes |
| H4b | Ease of Use --> Intention to Continue to Use | 0.223 | 3.564 | 0.000 | Yes |
| H5b | Ease of Use --> Usefulness | 0.504 | 10.166 | 0.000 | Yes |
| H6b | Perceived Health Control --> Usefulness | 0.128 | 2.381 | 0.009 | Yes |
| H7b | Perceived Health Control --> Ease of Use | 0.346 | 5.574 | 0.000 | Yes |
| H8b | Perceived Health Status --> Usefulness | 0.110 | 1.820 | 0.965 | No |
| H9b | Perceived Health Status --> Ease of Use | 0.048 | 0.576 | 0.736 | No |

## 2.8 Limitations

In this section, we discuss some of the limitations of this study before providing theoretical and practical implications. One of the key limitations that usually comes up in these types of studies is external validity, which is the extent to which findings of the study are applicable to other individuals and settings beyond those that were studied. Usually two important aspects that influence external validity of a study are the context in which the study is conducted and the type of survey respondents (Cook and Campbell, 1979). Our research involved a cross sectional study of diabetes patients over and above 18 years of age who are users and non-users of mobile technologies for managing their illness. The unit of analysis was the individual, a diabetes patient. Generalizability of the findings to the entire population of diabetics, across other chronic illness conditions, and their corresponding population might appear to be limited.

Generalizability to the entire population of diabetics depends on whether the sample population of this study can be considered to be representative of the population. There are several aspects of the sample population that can alleviate the population related external validity. First, the study consists of decent sample sizes of 257 mobile technology uses and 208 non-users. Second, in this study we investigated the phenomenon of an individual's (diabetes patient) interaction with mobile technologies for diabetes management about which they have clear and informed perceptions. Further, most importantly, illness perceptions: perceived health status and perceived health control are expected to representative of the entire diabetes population. Finally, the behavioral intentions of technology adoption by non-users and continued usage of technology by users are expected to be discernable in the diabetic population.

The other valid concern is generalizability of findings across other chronic illnesses. It is true that chronic illnesses are unique in their nature. However, there are several aspects that are common, an important one being the fact that chronic illnesses are relatively permanent and do not have a cure. They can only be managed and self-management of chronic illnesses is the key to better quality of life and patient well-being. The questionnaire used to measure illness perceptions of diabetes patients has been applied to other illness contexts and found to produce consistent results (Broadbent et al., 2006; Hagger and Orbell, 2003). Moreover, behavioral intentions of adopting technology for chronic illness management or for continue usage should not be much different among other chronic illness populations. However, further studies in contexts of other illnesses and populations would help us in addressing the issue of external validity. The research findings and knowledge gained in this study with diabetes patients can be helpful, extending to other areas.

Other threats to external validity discussed in the literature are demographics, such as age, ethnicity, and educational qualifications of the individuals participating in the study. Age is a categorical variable in our study. The survey questionnaire we used included age categories for survey respondents to select rather than an entry box for them to key-in their age. Our data indicates relatively younger populations use mobile technologies for diabetes management that older populations. This should be the general trend in today's general population with the younger generation using mobile technologies more than the older populations. Our sample data has over 90% of the respondents between ages 25 and 64 years. So, age doesn't seem be a real threat to external validity.

Another possible threat to the generalizability is applying findings across ethnic groups. Both user and non-user respondents in our samples are primarily caucasions (close to 75% of participants). There certainly exists health disparity among minority ethnic groups. Lack of education, lack of awareness about their illness the technologies, or low-income levels could be some of the reasons for under representation of minority groups in study samples. It would indeed be interesting to study the contingent effects of some of the demographic variables on the research outcomes.

Regarding the possible threat to extending the results across other technology types, in this study we considered mobile technologies for diabetes management. We believe generalization of the findings across technology types should not be a major issue. In the case of users, we have examined the effect of their illness perceptions on their intentions to continued use of mobile technologies. It is possible that use of technology can influence diabetes patients' illness perceptions. Our research involved a cross sectional study of diabetes patients with data gathered at one point in time. One can perform a longitudinal study of diabetes patients and investigate the effects of technology usage on illness perceptions. One may argue that there is a potential for common method variance because all the variables in the models were measured at the same point in time. As noted previously, this study uses cross sectional data, which provide information on association among the variables and no causal direction can be inferred from the results.

## 2.9 Discussion and Conclusion

First, we briefly discuss the work done in this study and then our work and then highlight key contributions followed by implications for theory and practice.

Drawing from the theory of self-regulation model in health psychology, and the literature on diabetes self-management, we made an attempt to contribute to the ever-growing literature on acceptance and use of technology in healthcare. We investigated the influence of illness perceptions formed by diabetes patients on the adoption and continued use of mobile technologies for diabetes management. The primary driver of this research is our interest in understanding the role of technology in chronic illness self-management. In this research, we opted to study diabetes patients due to its widespread prevalence in the American population. Self-management of chronic illness in which a patient actively engages in his or her own care has become a means of improving patients' psychological and physical well-being and reducing the cost of healthcare. Mobile technologies can facilitate diabetes self-management and it is important to understand the factors that influence an individual's willingness to adopt and use those technologies.

Illness perceptions, individuals' view of their illness, influence behaviors of coping. In this study, we proposed two models: one for users and one for non-users of mobile technologies for managing diabetes, showing the effect of illness representations on diabetes patient's intentions to adopt (for non-users) and intentions of continued use (for users). Analysis of the models yielded very interesting results with data collected from diabetes patients who are users and non-users of mobile technologies showing support for some of the hypotheses and lack of support for others.

Data was collected from two different groups of diabetics: those who currently do not use mobile technologies for managing their illness and those who use. Differences in perceptions of health control and health status for users and non-users were statistically significant. Data shows that users seem to be more concerned about their illness (mean score of 8.027) than non-users (mean score of 7.530). However, perceptions of health control for users (mean score 8.452) is higher than non-users (mean score 8.139). This shows that users, although more concerned about their health, are more in control of their health. This could be because use of mobile technology having an influence on their illness perceptions.

Data analysis shows support for most of the hypothesized relationships. In the non-user model, perceived usefulness positively influences intention to use the technology, and perceived ease of use positively influences perceived usefulness. However, ease of use doesn't seem to influence the intention of using technology. In the case of users, both usefulness and ease of using technology are important in predicting an individual's intentions to continue to use the technology. In addition, for the users, ease of use positively influences their usefulness.

From the health behavioral aspect, if non-users believe they are in control of their health, they know about their illness well, and the treatment is working, they are less likely to adopt technology for managing their illness. Similarly, if they are concerned about their health, believe their illness is going to last for an extended period of time, perceive severe symptoms, and are emotionally more affected, they are more likely to take the support of external resources such as mobile technologies for making their lives better. We observed mixed results in the case of diabetes patients who are already using technology for managing their illness. As suggested by the self-regulation model, coping behaviors will cast their influence on the illness representations. Thus, as patients perform some coping actions, such as using mobile technologies for illness management, the outcome of those behaviors will influence their illness presentations. As hypothesized, positive perceptions of health control positively influence a user's willingness to continue to use the technology. However, unlike we hypothesized, negative perceptions of their health status does not seem to influence their continued usage intentions. One plausible reason for this could be that diabetes is a long-term disease and there is no choice other than to continuously manage the illness. So, it is possible that using technology might have positively influenced their perceptions of health status, and at the same time, they need to use technology continuously for managing their condition. We will now present some implications for the theory and practice.

*2.9.1 Contribution*

The new knowledge from this research contributes to researchers, healthcare providers, and diabetes patients. Researchers have studied several factors that influence technology usefulness and ease of use, for instance, self-efficacy (Compeau and Higgins 1995a, 1995b; Venkatesh and Davis 1996), social and cognitive factors (Venkatesh and Davis, 2000), and system design characteristics (Davis, 1993). Some studies have looked into demographic factors such as gender (Gefen and Straub, 1997), and education level (Burton-Jones and Hubona, 2006). However, the influence of illness perceptions from a health behavior perspective in the context of diabetes self-management has not been studied before. With this study, we add new determinants to TAM's constructs. Specifically, our findings suggest that illness perceptions do influence individual's behavioral intentions to adopt and use technology beyond TAM's primary variables: usefulness and ease of use.

Apart from the influence of technology related attributes, perceived usefulness and ease of use, one's own illness perceptions have strong and direct impacts on an individuals' behavioral intentions of adopting and using the technology. For non-users, both perceived health control and perceived health status influence behavioral intentions. For users, their control of their health influences their intentions of continued usage. Our findings suggest that prior to adopting the technology for diabetes management, perceptions of health status matters most and once the individual starts using the technology, their perceptions of control are of importance. For non-users, their concerns about health make them see the usefulness of technologies and influence their willingness to adopt them. For users, their perceptions of control influence behavioral intentions and the usefulness of technology. This knowledge is key to healthcare providers and practitioners because by influencing patients' illness perceptions, they can motivate diabetes patients to adopt and use technology for managing their illness better and improve quality of life. If patients can avoid hospitalizations by managing their illness properly through technology use and avoid any related complications, it will be a great benefit to overall healthcare.

### *2.9.2 Theoretical Implications*

Illness perceptions are very critical in predicting an individual's coping behavior. It has not been studied in the context of technology adoption, particularly for diabetes management. Illness representation consists of eight aspects: Identity, Timeline, Personal Control, Treatment Control, Consequence, Concern, Comprehensibility, and Emotional representation. In this research, we used Brief IPQ, which contains eight items each representing one dimension of illness perception. Using these eight items we came up with two broad factors or components, one representing an individual's perceptions of how much control they have on themselves, the other representing an individual's perceptions of their health status. We looked at the influence of these two components on diabetes patients' intentions of adopting and continued usage of technology. Researchers willing to study further into the influence of illness representations could use the full-length questionnaire, rather than Brief IPQ, and investigate the effect of each dimension on the technology adoption and usage. It would be interesting to know how and to what extent each of the illness perception dimensions affect individual beliefs on technology.

Our research was a cross-sectional study of two different groups of diabetes patients: users and non-users of mobile technologies. There may exist some group differences that make it difficult to predict or understand post adoption behaviors. So, future research can perform longitudinal studies with the same group of patients to investigate and understand the pre- and post- adoption behaviors. It would be very interesting to see how their illness perceptions change because of using technology for self-management.

### *2.9.3 Practical Implications*

In the current study, we looked into the illness perceptions of diabetes patients and their beliefs on technology. Although there are common elements among chronic illnesses, each is unique in its own nature. Future research can investigate other chronic illnesses such as arthritis, cancer, asthma, and heart conditions, and examine how the illness perceptions of the patients with other chronic illnesses influence their technology beliefs. Further, in this study we used demographic variables as controls. It is possible that some of these variables moderate the relationships. Reasons for the difference in user and non-user behavior could be their demographic characteristics. Future studies could explore the influence of demographic elements such as age, gender, and education levels in combination with illness perceptions on technology adoption and use behaviors.

*2.9.4 Conclusion*

In conclusion, the primary objective of this study was to examine factors from diabetes patients' illness viewpoint that can influence intentions to adopt and post-adoption continued use behavior of mobile technologies. In the process, we developed two theoretical models for initial adoption by non-users and continued use by users and empirically tested. Identifying a comprehensive list of all the factors that influence their intentions and continued use behavior would be difficult. So, in this study, we selected two important components of diabetes patients' illness perceptions: their perceptions of health status and health control. A notable strength of this study is that our data includes, in addition to non-users' intentions of adoption, actual behavior of continued use of mobile technologies. Findings of the study highlight individual differences. This study emphasizes the importance of pondering the role of technology and integrating health perception factors into the studies related to adoption and use of mobile technologies for diabetes management. A better understanding of factors related to diabetes patients' intention and continued use behavior aids in the design and development of mobile technologies for diabetes self-management. We believe that our study and research makes a key contribution for theory development and practice and hope that the findings and ideas generated will kindle others to advance this line of research in healthcare.

Paper-3

# Empowering Patients in Diabetes Self-Management with Mobile Technologies: An Affordance Perspective

## 3.1 Introduction

Diabetes, one of the major chronic illnesses, was the 7th leading causes of death in the United States in 2010. In 2012, 9.3% of the American population (1 in every 11 people) had diabetes. The overall estimated cost of diabetes was $245 billion, of which 72% was for direct medical care with lost productivity accounting for the rest (CDC, 2015). There is no cure for diabetes, it is relatively permanent often affecting patients for the remainder of their lives. Diabetes alters an individual's quality of life especially whenever certain measures are not taken. A patient's objective is to achieve overall well-being by managing or controlling the illness. The key question this study aims to address is how technology, particularly mobile technologies, can contribute toward accomplishing the subjective well-being of diabetes patients.

In recent years, mobile apps and devices (henceforth called mobile technologies) have emerged as a promising means to help diabetics manage their condition. Rapid developments in these mobile technologies are changing the way people are able to manage their own health. While the number and variety of these technologies pertaining to diabetes and self-management continue to rise, their role as well as effectiveness in helping diabetics self-manage their conditions are not well known (Caburnay et al., 2015; Eng and Lee, 2013). Their contribution to the overall well-being of diabetic patients needs to be understood further.  This study aims at filling this gap in research by investigating how mobile technologies for diabetes self-management enhances patient well-being.

To accomplish this goal, we develop a Technology-Empowerment-Well-being model that explicates the effect of using mobile technologies on patients' subjective welfare through patient empowerment in the process of diabetes self-management.  The importance of the use of technology has been primarily studied in the context of organizations. In our scenario, we argue not only that the level to which mobile technologies are used (i.e., frequency, routinization, infusion) matters, but also how well mobile technologies support diabetes self-care. We therefore develop the notion of the realized affordances of mobile technologies, from affordance theory originally rooted in the ecological and perceptual psychology, in the context of diabetes self-management. Using affordance theory (Gibson, 1986) as its foundation and by drawing on the self-care behavior framework advocated by the American Association of Diabetes Educators (AADE7, 2010), we developed an instrument to measure Realized Affordances of Mobile Technologies for Diabetes Self-Management (RAMTDS). The theory of affordance offers a novel and meaningful way to assess the effectiveness of mobile technologies in general, and for diabetes self-management in particular.

Relying on survey data with a sample of 257 diabetes patients that used mobile technologies for self-management, we demonstrate that the relation between technology use and patient empowerment is actually moderated by the realized affordances of mobile technologies. Empowerment mediates the effect of technology use and actualized affordance on patients' subjective well-being. We provide insights into the nature and impact of technology affordances and technology use on patient's subjective welfare.

This research paper is organized as follows. The next section presents a review of the literature on the use of mobile technologies in chronic illness self-management. Then, we discuss the theoretical background of technology affordances. Subsequently, we describe the development of our research model and hypotheses. In the methodology section, we describe the data collection process, which is followed by the analysis section where we discuss data analysis and model validation. Finally, we present conclusions and offer implications and future opportunities.

## 3.2 Prior Studies on Use of Technology in self-management

Prior studies have explored how SMS, social media, or other technologies change patient self-management behavior. The use and effect of mobile phones and related services such as short message services (SMS) have been studied in the context of Asthma (Anhoj and Moldrup, 2004; Jones et al., 2014; Ryan et al., 2005), diabetes (Jones et al., 2014; Mulvaney et al., 2012), and other chronic conditions.

Overall, these studies show a positive effect regarding mobile phones in aspects such as adherence to appointments and treatments, peak flow monitoring, blood glucose measurements, and medication compliance. The experience of patients using social media to assist self-management has been positive. A literature review by Merolli et al. (2013) revealed that social media enabled patients toshare information and extend peer-support that had a positive impact on their psychological health. However, the authors could not find sufficient evidence on the effect of social media on physical condition management.

In another literature review on the use of Web 2.0 by older adults pertaining to their chronic illness self-management (Stellefson et al., 2013), the authors found patients experienced greater self-efficacy for managing their illnesses, benefitting from receiving feedback from their healthcare providers, and from receiving social support. Social media's asynchronous communication tools and progress tracking features also helped patients self-manage their illnesses. A study by Lorig et al., (2006) on the effect of the Internet and chronic disease self-management, found that the study group consisting of patients with chronic diseases relating to lungs, heart, and diabetes, who used the Internet to assist the management of their illness had significant improvements to their health compared to the control group. This study group used the Internet to engage in activities such as reading weakly posts, participating in self-test activities, communicating in discussion boards, and posting their action plans onto bulletin boards. In a literature review on wearable sensors and tracking devices, authors Appelboom et al., (2014) concluded that these technologies have potential in accurately monitoring conditions such as Cardiopulmonary and vascular monitoring, glucose monitoring, and neurological function monitoring. They also are useful in physical therapy and rehabilitation, however, these technologies are underutilized in the healthcare industry. Incorporating these technologies could help improve physician-patient relationships, increase patient autonomy, and make patients actively engage in their illness management. Adherence to medical treatment is one of the key aspects of chronic illness self-management and failing to do so is one of the causes of rising healthcare costs. It can also lead to early death in patients. A study, conducted by Heinrich and Kuiper (2013) on the use of handheld devices to promote adherence to medication by chronically ill patients, found that among the patients who used handheld devices to deliver reminders as a feedback mechanism, 89.4% of the patients adhered to medication. However, the study did not measure the adherence rate prior to the study, so it was difficult to conclude whether there was any improvement in adherence due to the handheld devices.

A meta-analysis and narrative review by Or & Tao (2014) analyzed 62 studies involving randomized control trials to assess the effect of consumer health information technologies on patient outcomes in the self-management of diabetes. The authors concluded that information technology has potential in improving self-management activities such as self-monitoring, health checkups, physical activities, and diet behaviors. However, these benefits have not been consistent. In another systematic review encompassing 104 studies on the use of IT (Internet, Smartphones, Decision support, and Telemedicine) for diabetes self-management (El-Gayar et al., 2013), the authors found that overall the technologies have potential in assisting diabetes self-management. However, several studies did not demonstrate the desired levels of glucose management, adoption, and patient satisfaction.

Many of these studies show mixed results as they neither have a strong theoretical basis nor statistical rigor in their analysis. Many of these studies are either qualitative or quantitative providing descriptive statistics of the results. However, the underlying message of these and several other studies is that technologies can facilitate chronic illness self-management leading to the greater well-being of patients.

## 3.3 Theoretical Background

### *3.3.1 Diabetes Self-Management*

Although unique in their nature and type, chronic illnesses such as diabetes, arthritis, and heart disease share several common aspects in their management (Grady and Gough, 2014), which include following a medication regimen, monitoring vital signs, managing physical and emotional consequences of illness, maintaining proper diet, exercise, and nutrition, interacting with healthcare providers, and adjusting to lifestyle changes resulting due to illnesses (Clark et al., 1991; Wagner et al., 2001; Barlow et al., 2002). Self-management typically requires patients to manage three levels: medical, role/behavior, and emotional (Corbin and Strauss, 1988; Lorig and Holman, 2003). Medical management involves taking medication on time, eating proper food, and adhering to a regimen. Role management focuses on changing or adjusting lifestyle, which can include taking on new activities or exercising in accordance to one's condition. Emotional management deals with controlling and managing mental health (Lorig and Holman, 2003). The effective self-management of chronic illness requires the empowerment of patients to actively participate in their own care.

Self-management lies at the core of chronic illness management where patients actively participate in taking necessary measures to keep their illness and conditions under control (Levich, 2007). Barlow et al., (2002) defines self-management as the "individual's ability to manage the symptoms, treatment, physical and psychological consequences and lifestyle changes inherent in living with the chronic condition. Efficacious self-management encompasses ability to monitor one's condition and to effect the cognitive, behavioral, and emotional responses necessary to maintain a satisfactory quality of life" (p.178).

Diabetes self-management involves day-to-day tasks that chronically ill patients must perform between scheduled visits to their health care provider to manage the illness, minimize its impact on their physical health, and cope with any psychological effects caused by the illness (Clark et al., 1991; Lorig and Holman, 1993). There is empirical evidence that the physical and psychological well-being of patients depends on successful self-management (Clark et al., 1991). It requires self-control, autonomy, problem solving, and conscious decision making (Gallant, 2003; Thorne et al., 2003) and includes adherence to a treatment regimen, strict monitoring, following diet and exercise plans, managing symptoms, and maintaining relationships with family and friends necessitated in handling some of the clinical aspects of the disease outside of hospital or physician's office (Clark et al., 1991; Glasgow et al. 2003 as cited in Nolte and McKee, 2008). To improve self-management patients require empowerment (Levich, 2007; Bodenheimer et al., 2002).

Mobile technologies must have necessary features and required functions in order to enable the patients with the aforementioned self-management tasks. Technologies that can support effective self-management can significantly increase the well-being of patients by making them gain better control over the maintainable aspects of their disease. To understand the functions that can facilitate the successful self-management of chronic diseases, we now turn to the theory of affordances.

### *3.3.2 Technology Affordances*

The theory of affordances has its roots in perceptual and ecological psychology (Gibson, 1986; Chemero, 2003). The term “Affordance” refers to the properties of an object from the view of an actor and according to Gibson (1986), “affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill” (p.127). People visually perceive what an object affords rather than its physical properties. Affordances are the actionable properties of the environment, and are always in relation to those capable of making use of these properties. Such properties exist whether or not the individual knows about them.

Norman (1999) coined the term “perceived affordance” to indicate the “actions user perceives to be possible”. Unperceived affordances are latent possibilities for action. However, the perception of affordance is required if one has to take action. According to him, affordances of an object can be both real and perceived and the two need not be the same. For example, as Norman (1999) explains, all computer monitors afford touching (perceived affordance), but only screens that are touch-sensitive can respond to or behave (actual affordance) the way the user intended.

IT artifacts have properties (features) and utility (affordance). For example, a personal computer can have a word processor (a feature of the PC) that allows people to prepare documents differently (its utility or affordance as perceived or enacted by the user). Markus and Silver (2008) coin the term “functional affordances” and define them as “possibilities for goal-oriented action afforded to specified user groups by technical objects” (p. 622). They posit that, given the user’s requirements and abilities, functional affordances are the relationship between the technical object and the user. Volkoff and Strong (2013) hold a similar view of the term affordance, which according to them refers to potential for “behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object and a goal-oriented actor”. Applying this to the context of chronic illness management, the objects (mobile technologies) provide opportunities for achieving goal-oriented outcome (patient's well-being) to the actor (patients with chronic illness).

One of the contexts where affordances play a key role is intuitive game design. Without specifying anything in words, a message of how to play the video game is conveyed through the design of the games themselves. Similarly, when one looks at the objects around one will intuitively know what to do with these objects. This is because affordances are built into objects by design. For example a horizontal bar on a door affords one to push it open and a handle on a coffee cup affords one a grasp to pick it up. These affordances, once perceived, prompts one to act. Thus perceived affordances lead to behavior.

Affordances are learned. As seen before, affordances are what technology offers to the individual, making an activity possible or constraining it. These affordances are not fixed in number. They are virtually unlimited. Affordances exist whether or not an individual perceives it. For example, a glucometer is a device typically used for measuring the amount of glucose in blood. The same device may also afford to share the data with others. This affordance exists whether or not the individual perceives the affordance. To perceive an affordance, one must discover this potential for action however this knowledge about the action offered by the objects varies among individuals (Gibson and Pick, 2000). One individual may immediately notice the possibility of using the technology for some action (such as transferring blood glucose data to a healthcare provider), but another might not. Once this perceived affordance is acted upon it becomes what we call a "realized affordance". Affordances once realized may lead to the discovery of another possible action, or affordance. As we continue to use technology, we may discover new affordances of technology.

An affordance once perceived drives or motivates action resulting in realized affordance, which in turn provides clues for discovering new affordances (Gibson and Pick, 2000). Discovering or perceiving new affordances may not be immediate or simple. It is possible to easily perceive some affordances, but others may require time, effort, and exploration. This connection between the perception of affordance and action indicates that a perceived affordance will be realized based on the properties of the object in relation to the capabilities and needs of the individual (Gibson and Pick, 2000). Extending this analogy to the context of information technology, envisage the use of a word-processing software or spreadsheet. Initially one may not see all the affordances (action possibilities) offered by the software. The user may perceive an initial set of affordances, but as the individual continues to use the software, with time, effort, and exploration, s/he will discover new affordances depending on ones capabilities and the needs.

### *3.3.3 Use of Technology*

Our purpose here is to look beyond intention and into the effects of the continued use of mobile technology on individual well-being in the context of diabetes self-management. Researchers have studied the impact of different types of technology use on outcomes such as individual satisfaction (Bhattarcherjee, 2001, Sun and Teng, 2012), salesperson performance (Sundaram et al., 2007), and supply chain coordination (Sanders, 2008), to name a few. Unlike in the organizational context where IT use may or may not be voluntary, use of mobile technologies in ones personal life is completely voluntary and at the discretion of the individual.

Use of technology to its fullest is very important to achieve productivity gains (Venkatesh and Davis, 2000). However, most often the measures of technology use are based on frequency, duration of usage, and/or the functions of the technology used (Barki et al., 2007; Venkatesh et al., 2008). Technology use in an organizational setting requires one to use it for certain duration or for a certain number of times during their time of work. So, these measures are probably appropriate to the context. Unlike in the organizational context, when it comes to health of an individual, using technology a certain number of times (frequency) for a certain duration may not really help in gaining the full benefits of the technology. For example, in the self-management of chronic illnesses such as diabetes, technology use has to be continuous and consistent. In order to be able to perform self-management tasks regularly and gain full benefit of technology use, patients have to appropriate the technology and make it part of their daily lives.

The last two stages, routinization and infusion, of the six-stage IS implementation process model proposed by Zmud and his colleagues (Kwon and Zmud 1987; Cooper and Zmud 1990) is appropriate to the current context of mobile technology use in managing chronic illnesses. These two stages come into picture once the patient makes a commitment to use technology for diabetes management. In the routinization stage, the use of technology becomes a habit where mobile technology use becomes part of an individual's daily routine. The infusion stage involves maximizing the utility of the technologies (Cooper and Zmud 1990; Saga and Zmud 1994). As one continues to use mobile technologies, they learn and discover new affordances, thereby utilizing the technology to its fullest potential, taking complete advantage of technology affordances.

*3.3.4 Patient Empowerment*

Empowerment signifies motivating individuals by boosting their self-efficacy (Conger and Kanungo, 1988). Empowerment also represents a multidimensional and multilevel concept. It is multidimensional because of its variation across time, context, and people, and it also operates at the individual, organizational, and community level (Zimmerman, 1990). At the individual level, it underscores the individuals' ability to take control of life situations and come up with solutions to the problems one is confronting (Peterson, 2014).

Empowerment has been viewed both as a process or an independent variable and as an outcome or dependent variable (Gibson, 1991; Anderson and Funnell, 2010). In healthcare, empowerment, as a process refers to helping people, through education or some other interventions, to think critically, take control of the conditions affecting their health, and to make them act independently (Gibson, 1991; Anderson and Funnell, 2010). As an outcome, empowerment refers to "enhanced sense of self-efficacy" because of some process (Anderson and Funnell, 2010).

Self-efficacy denotes an individual's belief about his or her capabilities in terms of performing certain behaviors. According to Bandura (1986), self-efficacy refers to "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances (p.391)." The concept involves opinions on oneself regarding what they are capable of doing with their skills. In the context of chronic illness management, self-efficacy applies to ones beliefs about their self-management behaviors (Lorig and González, 1992).

In this research paper, focus will be on the individual empowerment in diabetes self-management, which involves individuals' self-efficacy in exercising control of their situation by actively engaging in their own care process (Zimmerman 1990). Thus, for the purpose of this study, we define patient empowerment as the degree to which patients are enabled to actively engage in the self-management of diabetes, which involves aspects such as developing a plan of action by assessing current situation, supporting oneself, seeking support if and when required, making informed decisions, and coping emotionally (Anderson and Funnell, 2000, 2010).

## 3.4 Research Model

We present our research development model in two levels. In the first level, use of technology and realized affordances are hypothesized to positively contribute to a patient's subjective well-being (Figure 3.1). In the second level of the model, the relation between the use of technology and the patient's subjective well-being is conceptualized as mediated by patient empowerment, and further affordances reinforces the effect of technology use on empowerment. The principal constructs of the model are Realized Affordances of Mobile Technologies, Level of Use of Technology, Patient Empowerment, and Subjective Well-being. Definition for each of the construct and its source are listed in Appendix C.

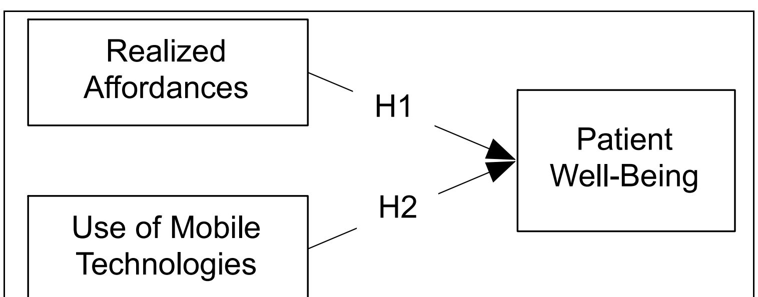



**Figure 3.1. Research Model – First Level**

*3.4.1 Subjective Well-Being*

According to World Health Organization (WHO), health refers to ‘‘a state of complete physical, mental, and social well-being, and not merely the absence of disease and illness’’ (World Health Organization, 2014, p.1). Subjective Well-being can be viewed as a patients' feelings about themselves and their evaluations of their lives. It relates to peoples feelings of happiness and their sense of satisfaction with life. Patients may have emotions of anxiety, worry, stress, or happiness depending on their health situation and condition. Diener and Chan (2011) define subjective well-being as "people's evaluations of their lives, which can be judgments such as life satisfaction, evaluations based on feelings, including moods and emotions." (p.1,2). For the purpose of this study, we define subjective well-being as an individual's assessment of their lives at both emotional and physical level. People who are going through difficult times due to chronic illnesses such as diabetes, can have their subjective well-being positively influenced by the use of technology because of the hope that using technology might improve their condition or at least help manage their illness better.

*3.4.2 Realized Affordances and Patient's Subjective Well-Being*

When viewed from Gibson's (1986) original conception, the affordances of the technology are what it offers the individual. Technology affordances are also viewed as possibilities for action associated with achieving a concrete outcome. Whereas perceived affordances motivate one to take action, realized affordances are those that have already been acted upon. The user knows that those affordances work. Consider the situation of diabetes patients. Blood sugar levels are affected by several factors including food intake, exercise, and medication. It is very important to keep blood sugar levels within the recommended range because uncontrolled blood sugar can lead to other complications. Keeping track of all these factors on a routine basis while taking timely action to keep sugar levels under control is very challenging. In this situation, if s/he finds a tool with required affordances to keep blood sugar levels in balance, the individual will certainly feel better, whether or not the person actually be able to do so, because s/he found a tool that affords something to fulfill the purpose. If these affordances have been realized before, the patient knows for sure that realized affordances allow them to lead better lives. For diabetes patients, what the technology affords for managing their health and for the betterment of their conditions is extremely important to them. Considering mobile technologies for diabetes self-management, their affordances should impact patients' subjective well-being. We believe that the realized affordances of mobile technologies would have a positive impact on the subjective well-being of diabetes patients. Thus,

Hypothesis 1: Realized Affordances of mobile technologies in diabetes self-management has a positive effect on the subjective well-being of diabetes patients.

*3.4.3 Use of Technology and Patient's Subjective Well-Being*

Studies on the use of technology have demonstrated positive impact on performance outcomes whether in the organizational context or at the individual level. For example, at the organizational level, research shows that information technologies can increase productivity by reducing the costs associated with coordination of production, communication, and information processing (Stiroh, 2002; Brynjolfsson and Hitt, 2003). In a healthcare context, there are several cases where information technology has been shown to impact health outcomes positively. For example, in a study on the impact of technology on the quality of care and health outcomes, authors found that health information technology was the key in contributing to the health status of HIV/AIDS patients (Virga et al., 2012). When we talk about physical well-being, emotional well-being is also equally important. Small uplifting events in an individual's life will have favorable effects on physical as well as emotional well-being of the individual (Lazarus et al., 1980). A study on the effect of mobile phones on patients experiencing asthma, found that mobile phones can be effective in managing asthma symptoms and can lead to patient satisfaction (Holtz and Whitten, 2009). Research has shown that individuals' well-being can be positively influenced by their expectations about any particular treatment effectiveness (Sanderson, 2013). Diabetics will have some level of expectation on the effectiveness of using of mobile technologies in diabetes self-management, for the purpose of improving their health and well-being. We believe that diabetes patients who use technology in diabetes self-management will have a positive impact on the subjective well-being of the diabetes patients. Thus, Hypothesis 2: Use of mobile technologies in diabetes self-management has positive effect on the subjective well-being of diabetes patients.

*3.4.4. Patient Empowerment as Mediator*

Our second level research model is shown in Figure 3.2 where we conceptualize that the use of technology and realized affordances influence diabetes patients' subjective well-being through their empowerment. In other words, use of technology in conjunction with realized affordances influences patient empowerment, which further effects patients' subjective well-being.

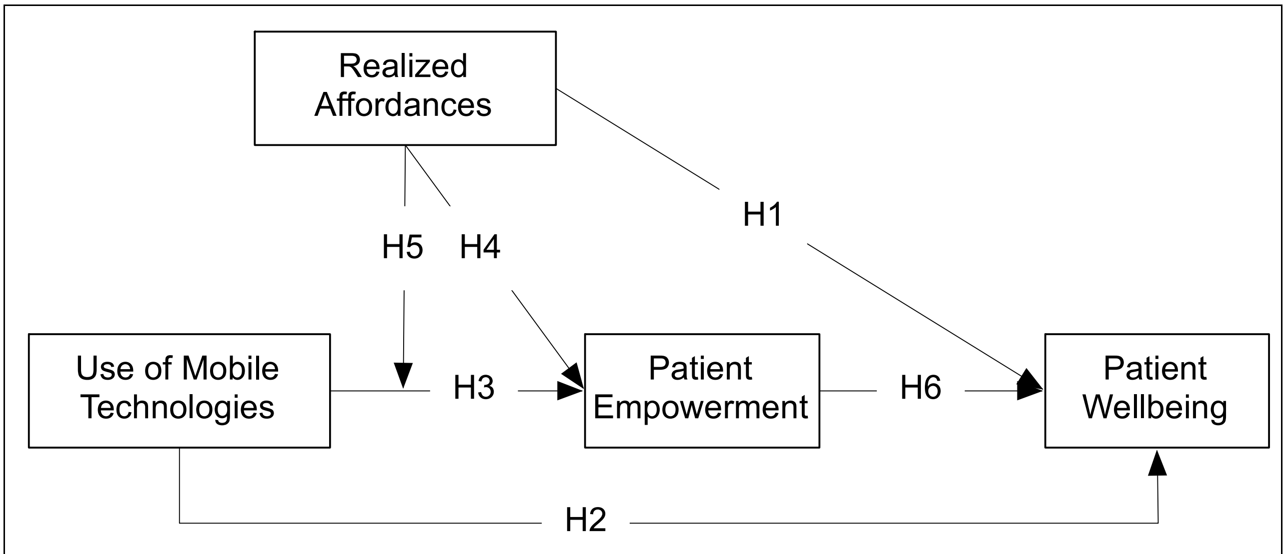



**Figure 3.2. Research Model – Second Level**

*3.4.5 Use of Technology and Patient Empowerment*

Patient empowerment refers to the patient's confidence in performing health related activities. It is paramount to the success of curtailing the risks of chronic illnesses such as diabetes and technology can play a critical role (Calvillo et al., 2015). Technology has potential in empowering individuals in the process. In a literature review on the ways information technology can empower cancer patients, Groen et al., (2015) found that technology can promote various aspects of empowerment such as being autonomous and respected, having knowledge, having psychological and behavioral skills, perceiving support from community, family, and friends, and perceiving oneself to be useful. In another literature review on the use of Web 2.0 by older adults in their chronic illness self-management (Stellefson et al., 2013), authors found that patients experienced greater self-efficacy for managing their illnesses and they also benefited from receiving feedback from their healthcare providers and from social support.

Prior studies have shown that individuals with health concerns use the Internet for various reasons such as for understanding an illness better, finding possible solutions to their health issues, helping their friends and family members, obtaining alternative view points on the problems they face, and seeking advice on how to obtain a healthy lifestyle in order to prevent any potential risks arising from their illness (Lemire et al., 2008). As individuals move into old age, it becomes important for them to understand their healthcare needs and manage their health. The Internet and mobile technologies can potentially make Baby Boomers independent and help them lead quality lives by empowering them to take active roles in managing their health and their disease (LeRouge et al., 2014).

Living with diabetes can be very challenging. Patients need to keep track of so much information related to their nutrition, diet, physical activity, and monitoring, to name a few, and this can become overwhelming. During the process greater patient engagement is needed in managing their chronic conditions well. Mobile technologies can help patients engage more actively in their care process and promise new ways to manage diabetes and other health conditions (Shetty and Hsu, 2013). Thus, we hypothesize:

Hypothesis 3: Use of mobile technologies in diabetes self-management has positive effect on the patient empowerment.

*3.4.6 Direct and Moderating Effect of Realized Affordances*

Diabetes patients have to deal with a myriad of things when managing their illness and preventing their conditions from getting worse. For example, they need to keep track of their food intake in terms of nutrition, portion sizes, calories, make sure they take the medication on time, keep regular visits to their health care providers, measure and monitor blood sugar levels, keep track of their physical activities, and a lot more. In the process of juggling these concerns, it is quite possible that they may forget certain care activities such as following their healthcare provider's instructions to not consume certain types of foods or ingest more than their suggested caloric intake. To what extent or whether or not the technology affords the aforementioned things make a huge difference in the process of diabetes self-management.

As discussed previously, realized affordances are the perceived affordances that have been acted upon or experienced by the user. We have also seen that affordances and the use of technology have a cyclical relationship where one discovers and learns more the longer they engage with the technology. If the patients realize that technology can give them more action possibilities which they can engage with to make their self-management activities better, they should feel more empowered.

Patients expect to be able to access their health records and be able to schedule doctor appointments, and if required, transmit the data to their healthcare provider or family members. Patients need to perform their healthcare activities the same way they currently access and track their online banking transactions while they're on the go... The more the technology affords, the more empowered the patient will be.

Imagine that there is a certain tool that affords only one function of diabetes management. There is not much for this technology to offer. The uses of this technology and the benefits accrued from using such technology also will not be many. This technology cannot really empower the individual in their care process. Similarly, a technology that affords a lot more functions will have the capacity to empower the individuals in more ways. We believe realized affordances directly influence patient empowerment and also enhance the effect of technology use on patient empowerment. Thus

Hypothesis 4: Realized Affordances will have positive effect on patient empowerment.

Hypothesis 5: The positive direct effect of use of technology on patient empowerment will be higher with increase in Realized Affordances.

*3.4.7 Patient Empowerment and Subjective Well-being*

Empowerment enables patients to manage themselves and take control of their lives. Empowered patients actively engage in managing their activities which leads to a better quality of life. Within the context of healthcare, patients who are empowered are healthier than those who are not. Research has shown that empowerment or self-efficacy positively affects a patient's overall quality of life (Pibernik-Okanovic et al., 2004). In a systematic review on the effectiveness of empowerment on outcomes of self-management interventions, authors found that many studies showed positive effects on the patients' well-being in the form of knowledge-based, behavioral, and psychological indicators (Kuo et al., 2014). Studies have also demonstrated that individuals who feel that they are in control of their health situation show better health outcomes, indicating a positive well-being than those who feel powerless (Brannon et al., 2014). Thus,

Hypothesis 6: Patient empowerment has positive effect on the patient's subjective well-being.

Summary of all hypothesized relationships are presented in Table 3.1.

**Table 3.1. Summary of hypotheses**

| # | Hypothesis |
|---|---|
| H1 | *Realized Affordances of mobile technologies in diabetes self-management has a positive effect on the subjective well-being of diabetes patients.* |
| H2 | *Use of mobile technologies in diabetes self-management has positive effect on the subjective well-being of diabetes patients.* |
| H3 | *Use of mobile technologies in diabetes self-management has positive effect on the patient empowerment.* |
| H4 | *Realized Affordances will have positive effect on patient empowerment.* |
| H5 | *The positive direct effect of use of technology on patient empowerment will be higher with increase in Realized Affordances.* |
| H6 | *Patient empowerment has positive effect on the patient's subjective well-being.* |

## 3.5 Instrument Development

In this section, we describe the instrument development process. The unit of analysis for the study was the individual – the patient. Items for all constructs, except for realized affordances, have been adapted from previous studies. The authors of this article developed the items for realized affordances as part of another study. Data was collected from the diabetes patients who are the users of mobile technologies for diabetes management. All the items were measured using 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5) with an exception of two items under frequency dimension of the Level-of-Use of Mobile Technologies, and items under Subjective Well-being. There are two items for frequency, one was measured on a scale of Never (1) to Very Often (5), and the other item was measured on scale of Once a month (1) to Several times a day (5). The final list of items for various constructs is presented in the in Appendix C.

The construct Realized Affordances of Mobile Technologies for Diabetes Management was modeled as a 2nd order reflective latent construct. Using affordance theory (Gibson, 1986) as its foundation and drawing on the self-care behavior framework advocated by the American Association of Diabetes Educators (AADE7, 2010), we developed the instrument, following the guidelines available in the literature (Moore and Benbasat, 1991; Chu and Chau, 2014; DeVellis, 2012). Items for this instrument were developed using a rigorous four-stage instrument development process consisting of domain specification, item generation, item refinement, and instrument validation. In the first stage, the boundaries of the construct and its sub-dimensions were specified. Next, we generated items based on extensive interviews, discussions, and reviews with health care practitioners and experts in the College of Nursing at a major university. In the third stage, we refined items through sorting (Moore and Benbasat 1991) followed by pre-testing using a web-based survey. Finally, the instrument was validated using two pilot studies. The final instrument (Appendix C) consists of a total of 26 items across five sub-dimensions: Reducing Risks and Problem Solving, Being Active and Healthy Eating, Healthy Coping, Monitoring, and Taking Medication.

Following Sundaram et al. (2007), we conceptualized and adapted items by the proficiency of technology use at three levels: (1) frequency, (2) routinization, and (3) infusion. Patient Empowerment is measured using the Diabetes Empowerment Scale (DES-SF) (see Anderson et al., 2003). For measuring subjective well-being, we adapted from Bech (2004), and Michaelson et al.(2012) and developed an eight item scale consisting of emotional and physical aspects. Items are measured on a scale of (1) None of the time, (2) Rarely, (3) Some of the time, (4) Often, (5) All of the time.

## 3.6 Methodology

This study is part of a larger research study conducted to understand the role of mobile technologies in diabetes self-management. As part of this study we surveyed over 1700 diabetes patients who currently use some kind of mobile technology for managing their illness. The survey was conducted anonymously over the Internet during the first quarter of 2016 using a third party data collection agency. This survey, after reviewing all responses and excluding unusable and incomplete responses, resulted in 257 completed responses.

The data sample was inclusive to the United States in order to insure same level of access to medical care and technology across all survey participants. Respondents included in this sample were over 18 years of age and evenly distributed by gender with 47% female and 53% males. The participants covered a full range of educational backgrounds including those who have not completed high school to those who have a Ph.D. Of the surveyed individuals 70% have had diabetes for over a year and less than five years and 70% of the respondents have been using some kind of mobile technology for over 6 months to 2 years to manage their diabetes.

## 3.7 Analysis

Hypotheses were tested using SmartPLS (Ringle et al. 2015). One of the primary reasons PLS was favored over covariance-based SEM is that PLS relaxes the requirement of normality distribution of the data (Fornell and Bookstein 1982; Hair et al., 2011a). PLS-SEM is also appropriate during the early stages of theory development with the primary objective of maximizing the explained variance in the outcome variables (Fornell and Bookstein 1982; Hair et al., 2011b). We present our results in two parts – a measurement model (Table 3.2), which relates measured variables (items or indicators) to latent variables (or factors), and a structural model, which shows relations between latent variables.

All principle constructs in the research model were measured as reflective constructs. To assess the model we include composite reliability to evaluate internal consistency, individual indicator reliability, and average variance extracted (AVE) to evaluate convergent validity. Item cross loadings and Fornell-Larcker criterion are used to assess discriminant validity.

### *3.7.1 Measurement Model*

**Table 3.2. Measurement Model**

| Construct | Scale | Mean | SD | CR | Cronbach's | AVE |
|---|---|---|---|---|---|---|
| Realized Affordances of Mobile Technologies | Reducing Risks and Problem Solving | 3.956 | 0.672 | 0.929 | 0.911 | 0.621 |
| | Being Active and Healthy Eating | 4.036 | 0.720 | 0.920 | 0.901 | 0.589 |
| | Healthy Coping | 3.672 | 0.984 | 0.943 | 0.910 | 0.847 |
| | Monitoring | 4.087 | 0.611 | 0.844 | 0.749 | 0.581 |
| | Taking Medication | 3.946 | 0.833 | 0.873 | 0.781 | 0.695 |
| Level of Technology Use | Frequency | 4.053 | 0.803 | 0.911 | 0.805 | 0.836 |
| | Routinization | 4.128 | 0.861 | 0.936 | 0.898 | 0.831 |
| | Infusion | 3.545 | 0.922 | 0.923 | 0.889 | 0.752 |
| Patient Empowerment | | 4.133 | 0.571 | 0.910 | 0.850 | 0.590 |
| Subjective Well-being | Emotional | 3.578 | 0.666 | 0.776 | 0.616 | 0.468 |
| | Physical | 3.191 | 0.880 | 0.870 | 0.800 | 0.626 |

One means of establishing internal consistency is by using Cronbach's alpha, with an acceptable value of 0.70. The other measure for evaluating internal consistency is composite reliability. As we can see from Table 3.2, composite reliability of all constructs is over 0.7, which is considered satisfactory

(Nunally and Bernstein, 1994). Convergent validity is evaluated using the outer loadings of the indicators and the average variance extracted (AVE) with a minimum acceptable value is 0.5 (Fornell and Larcker, 1981). The outer loadings of all the indicators (Table 3.3) are above the acceptable level of 0.70 (Hair Jr. et al., 2014). One of the dimensions of subjective well-being shows an AVE of less than 0.5, however, convergent validity of the construct is established because its composite reliability is higher than 0.6 (Fornell and Larcker, 1981). Further, discriminant validity was evaluated using the cross loadings of the indicators and comparing the average variance extracted of each construct against their correlations with other constructs (Fornell and Larcker 1981). The cross-loadings of the items (Table 3.4) indicate they are loading well with the respective construct they are intended to measure. Correlations in Table 3.5 illustrate sufficient discriminant validity.

3.7.1.1 Outer Loadings

**Table 3.3. Outer Model Loadings**

| Construct/Dimension/Item | Outer Loading |
|---|---|
| ***Perceived Affordances*** | |
| Being Active and Healthy Eating | 0.889 |
| Reducing Risks and Problem Solving | 0.906 |
| Monitoring | 0.719 |
| Healthy Coping | 0.842 |
| Taking Medication | 0.769 |
| | |
| ***Level of Use*** | |
| Frequency | 0.834 |
| Routinization | 0.916 |
| Infusion | 0.881 |
| | |
| ***Empowerment*** | |
| DEMP2 | 0.770 |
| DEMP3 | 0.739 |
| DEMP4 | 0.726 |
| DEMP5 | 0.764 |
| DEMP6 | 0.753 |
| DEMP7 | 0.813 |
| DEMP8 | 0.811 |
| | |
| ***Well Being*** | |
| Emotional Well Being | 0.849 |
| Physical Well Being | 0.925 |

**Table 3.4. Item Cross-Loadings**

| | RA: RRPS | RA: BAHE | RA: HC | RA: MO | RA: TM | LOU: FREQ | LOU: ROUT | LOU: INFU | DEMP | SWB: ESWB | SWB: PSWB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RRPS1 | 0.824 | 0.607 | 0.598 | 0.460 | 0.539 | 0.367 | 0.403 | 0.525 | 0.435 | 0.200 | 0.284 |
| RRPS2 | 0.873 | 0.632 | 0.635 | 0.474 | 0.535 | 0.369 | 0.424 | 0.574 | 0.464 | 0.232 | 0.238 |
| RRPS3 | 0.785 | 0.548 | 0.650 | 0.399 | 0.491 | 0.298 | 0.325 | 0.511 | 0.413 | 0.267 | 0.284 |
| RRPS4 | 0.640 | 0.387 | 0.449 | 0.352 | 0.437 | 0.387 | 0.449 | 0.455 | 0.479 | 0.271 | 0.254 |
| RRPS5 | 0.770 | 0.548 | 0.501 | 0.452 | 0.395 | 0.390 | 0.428 | 0.501 | 0.462 | 0.297 | 0.268 |
| RRPS6 | 0.850 | 0.593 | 0.696 | 0.431 | 0.506 | 0.274 | 0.332 | 0.558 | 0.458 | 0.236 | 0.291 |
| RRPS7 | 0.704 | 0.445 | 0.449 | 0.386 | 0.404 | 0.262 | 0.297 | 0.398 | 0.367 | 0.285 | 0.201 |
| RRPS8 | 0.832 | 0.630 | 0.642 | 0.474 | 0.496 | 0.301 | 0.390 | 0.534 | 0.430 | 0.223 | 0.230 |
| BAHE1 | 0.423 | 0.785 | 0.376 | 0.429 | 0.437 | 0.268 | 0.447 | 0.510 | 0.373 | 0.167 | 0.273 |
| BAHE2 | 0.617 | 0.785 | 0.569 | 0.426 | 0.524 | 0.283 | 0.416 | 0.480 | 0.448 | 0.104 | 0.222 |
| BAHE3 | 0.399 | 0.788 | 0.436 | 0.518 | 0.484 | 0.339 | 0.457 | 0.467 | 0.333 | 0.094 | 0.158 |
| BAHE4 | 0.432 | 0.761 | 0.362 | 0.518 | 0.444 | 0.395 | 0.564 | 0.448 | 0.412 | 0.043 | 0.164 |
| BAHE5 | 0.647 | 0.757 | 0.578 | 0.395 | 0.466 | 0.310 | 0.372 | 0.543 | 0.337 | 0.173 | 0.197 |
| BAHE6 | 0.424 | 0.706 | 0.377 | 0.444 | 0.371 | 0.310 | 0.367 | 0.436 | 0.303 | 0.163 | 0.120 |
| BAHE7 | 0.635 | 0.736 | 0.614 | 0.405 | 0.509 | 0.216 | 0.313 | 0.505 | 0.358 | 0.190 | 0.237 |
| BAHE8 | 0.666 | 0.819 | 0.628 | 0.484 | 0.570 | 0.324 | 0.461 | 0.573 | 0.433 | 0.140 | 0.276 |
| HC2 | 0.625 | 0.585 | 0.922 | 0.481 | 0.548 | 0.266 | 0.409 | 0.577 | 0.463 | 0.203 | 0.223 |
| HC3 | 0.665 | 0.629 | 0.922 | 0.513 | 0.594 | 0.327 | 0.455 | 0.610 | 0.527 | 0.232 | 0.251 |
| HC4 | 0.749 | 0.592 | 0.917 | 0.465 | 0.598 | 0.286 | 0.358 | 0.584 | 0.490 | 0.209 | 0.243 |
| MO1 | 0.429 | 0.534 | 0.364 | 0.857 | 0.483 | 0.391 | 0.582 | 0.445 | 0.402 | 0.040 | 0.116 |
| MO2 | 0.377 | 0.526 | 0.368 | 0.859 | 0.458 | 0.297 | 0.495 | 0.392 | 0.398 | -0.020 | 0.071 |
| MO3 | 0.471 | 0.427 | 0.534 | 0.732 | 0.384 | 0.318 | 0.402 | 0.452 | 0.373 | 0.240 | 0.098 |
| MO4 | 0.388 | 0.261 | 0.340 | 0.564 | 0.332 | 0.281 | 0.384 | 0.363 | 0.302 | 0.150 | 0.140 |
| TM1 | 0.498 | 0.521 | 0.498 | 0.454 | 0.826 | 0.306 | 0.441 | 0.470 | 0.333 | 0.030 | 0.167 |
| TM2 | 0.466 | 0.565 | 0.534 | 0.480 | 0.853 | 0.389 | 0.498 | 0.473 | 0.331 | 0.081 | 0.134 |
| TM3 | 0.551 | 0.478 | 0.546 | 0.437 | 0.823 | 0.307 | 0.358 | 0.443 | 0.342 | 0.215 | 0.270 |
| FREQ1 | 0.266 | 0.302 | 0.209 | 0.350 | 0.356 | 0.904 | 0.696 | 0.431 | 0.315 | 0.102 | 0.176 |
| FREQ2 | 0.485 | 0.416 | 0.366 | 0.422 | 0.376 | 0.924 | 0.713 | 0.590 | 0.391 | 0.210 | 0.205 |
| ROUT1 | 0.489 | 0.548 | 0.446 | 0.604 | 0.533 | 0.712 | 0.915 | 0.597 | 0.461 | 0.150 | 0.234 |
| ROUT2 | 0.460 | 0.501 | 0.426 | 0.601 | 0.495 | 0.728 | 0.939 | 0.649 | 0.497 | 0.191 | 0.304 |
| ROUT3 | 0.360 | 0.453 | 0.334 | 0.475 | 0.386 | 0.666 | 0.880 | 0.557 | 0.449 | 0.187 | 0.311 |
| INFU1 | 0.548 | 0.569 | 0.529 | 0.520 | 0.499 | 0.535 | 0.639 | 0.901 | 0.451 | 0.280 | 0.280 |
| INFU2 | 0.562 | 0.569 | 0.559 | 0.501 | 0.504 | 0.533 | 0.621 | 0.898 | 0.495 | 0.285 | 0.303 |
| INFU3 | 0.517 | 0.476 | 0.500 | 0.332 | 0.356 | 0.294 | 0.334 | 0.733 | 0.318 | 0.149 | 0.205 |
| INFU4 | 0.620 | 0.628 | 0.639 | 0.505 | 0.539 | 0.544 | 0.638 | 0.925 | 0.586 | 0.315 | 0.367 |

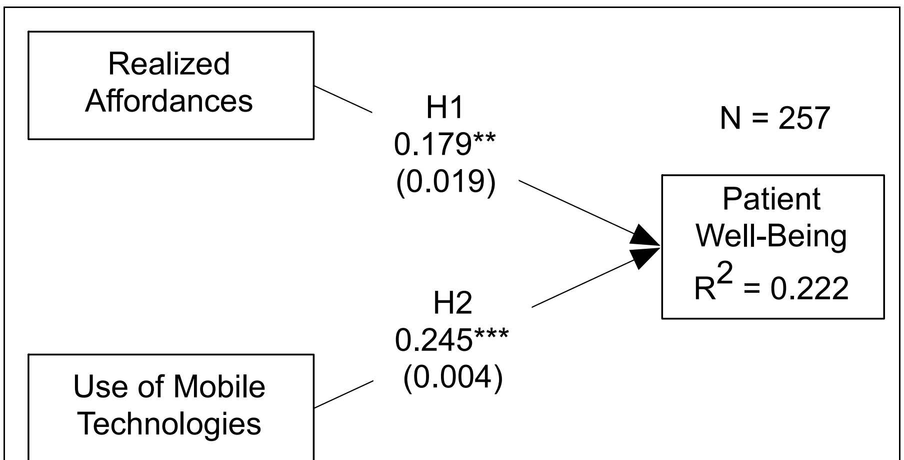
| Table 3.4. Item Cross-Loadings (Continued) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | RA: RRPS | RA: BAHE | RA: HC | RA: MO | RA: TM | LOU: FREQ | LOU: ROUT | LOU: INFU | DEMP | SWB: ESWB | SWB: PSWB |
| DEMP2 | 0.414 | 0.336 | 0.395 | 0.365 | 0.254 | 0.289 | 0.315 | 0.396 | 0.770 | 0.347 | 0.283 |
| DEMP3 | 0.412 | 0.284 | 0.433 | 0.389 | 0.286 | 0.249 | 0.347 | 0.403 | 0.739 | 0.336 | 0.219 |
| DEMP4 | 0.475 | 0.330 | 0.424 | 0.273 | 0.220 | 0.265 | 0.300 | 0.396 | 0.726 | 0.365 | 0.276 |
| DEMP5 | 0.461 | 0.374 | 0.443 | 0.324 | 0.334 | 0.213 | 0.297 | 0.406 | 0.764 | 0.377 | 0.294 |
| DEMP6 | 0.440 | 0.448 | 0.424 | 0.430 | 0.362 | 0.294 | 0.449 | 0.425 | 0.753 | 0.292 | 0.368 |
| DEMP7 | 0.422 | 0.418 | 0.406 | 0.403 | 0.301 | 0.387 | 0.485 | 0.437 | 0.813 | 0.326 | 0.390 |
| DEMP8 | 0.371 | 0.424 | 0.376 | 0.422 | 0.384 | 0.369 | 0.533 | 0.452 | 0.811 | 0.343 | 0.370 |
| ESWB1 | 0.319 | 0.177 | 0.300 | 0.130 | 0.152 | 0.147 | 0.181 | 0.380 | 0.410 | 0.757 | 0.498 |
| ESWB2 | 0.183 | 0.109 | 0.130 | 0.035 | 0.108 | 0.139 | 0.124 | 0.138 | 0.229 | 0.661 | 0.330 |
| ESWB3 | 0.320 | 0.127 | 0.187 | 0.126 | 0.089 | 0.141 | 0.103 | 0.271 | 0.389 | 0.767 | 0.383 |
| ESWB4 | -0.034 | 0.046 | -0.044 | 0.040 | -0.020 | 0.031 | 0.112 | -0.039 | 0.123 | 0.523 | 0.374 |
| PSWB1 | 0.114 | 0.078 | 0.088 | -0.045 | 0.079 | 0.117 | 0.137 | 0.093 | 0.162 | 0.538 | 0.760 |
| PSWB2 | 0.345 | 0.235 | 0.278 | 0.108 | 0.214 | 0.120 | 0.230 | 0.353 | 0.398 | 0.519 | 0.823 |
| PSWB3 | 0.249 | 0.262 | 0.190 | 0.173 | 0.223 | 0.238 | 0.301 | 0.251 | 0.341 | 0.415 | 0.824 |
| PSWB4 | 0.318 | 0.293 | 0.267 | 0.202 | 0.208 | 0.195 | 0.324 | 0.378 | 0.414 | 0.369 | 0.756 |

RA – Realized Affordances; BAHE – Being Active and Healthy Eating; RRPS – Reducing Risks and Problem Solving; HC – Healthy Coping; MO – Monitoring; TM – Taking Medication; LOU – Level of Use; FREQ – Frequency; ROUT – Routinization; INFU – Infusion; DEMP – Diabetes Empowerment; SWB – Subjective Well-Being; ESWB – Emotional Subjective Well-being; PSWB – Physical Subjective Well-being

| Table 3.5. Inter-Construct Correlation Matrix | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | RRPS | BAHE | HC | MO | TM | FREQ | ROUT | INFU | DEMP | ESWB | PSWB |
| **RRPS** | 0.788 | | | | | | | | | | |
| **BAHE** | 0.704 | 0.768 | | | | | | | | | |
| **HC** | 0.740 | 0.654 | 0.920 | | | | | | | | |
| **MO** | 0.546 | 0.587 | 0.528 | 0.762 | | | | | | | |
| **TM** | 0.605 | 0.625 | 0.631 | 0.548 | 0.834 | | | | | | |
| **FREQ** | 0.417 | 0.396 | 0.319 | 0.424 | 0.401 | 0.914 | | | | | |
| **ROUT** | 0.480 | 0.550 | 0.442 | 0.616 | 0.518 | 0.771 | 0.912 | | | | |
| **INFU** | 0.646 | 0.649 | 0.642 | 0.544 | 0.554 | 0.563 | 0.660 | 0.868 | | | |
| **DEMP** | 0.554 | 0.491 | 0.537 | 0.487 | 0.402 | 0.389 | 0.515 | 0.543 | 0.768 | | |
| **ESWB** | 0.314 | 0.176 | 0.233 | 0.129 | 0.130 | 0.174 | 0.193 | 0.305 | 0.442 | 0.684 | |
| **PSWB** | 0.324 | 0.272 | 0.260 | 0.136 | 0.228 | 0.209 | 0.310 | 0.338 | 0.414 | 0.585 | 0.791 |

*3.7.2 Structural Model*

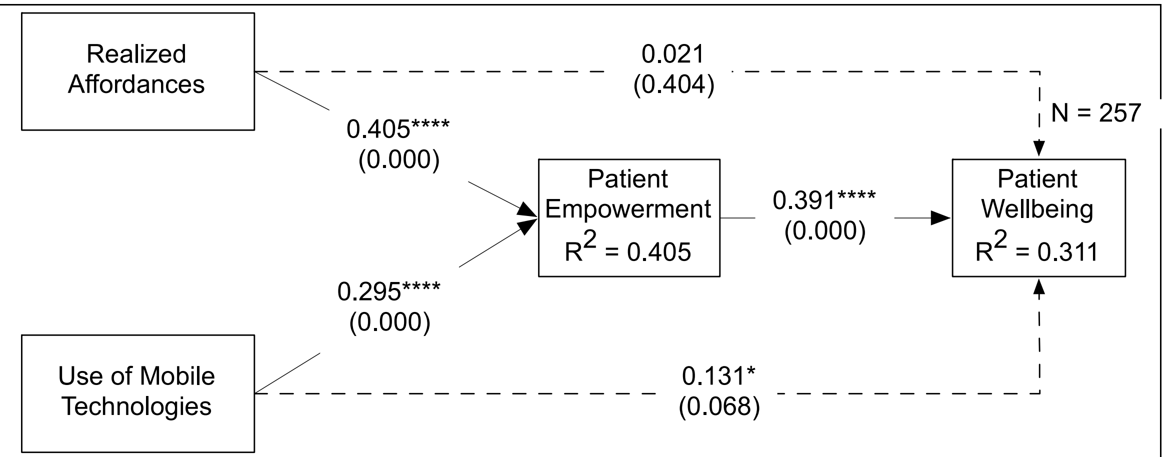
All the hypotheses in our research model are supported except for H1, which is partially supported. A patient's well-being might be impacted by components such as income, education, or age. To control for the effects of demographic variables, we performed model tests with age, gender, education, income levels, marital status, and ethnicity as control variables. The variance explained for a patient's subjective well-being is 17.1 percent. The significance of path coefficients was determined by the bootstrapping method. The path coefficient between the use of mobile technologies and subjective well-being and was deemed significant with a value of 0.289 (p=0.002). Thus, H2 is supported. Whereas the path coefficient between realized affordances and patient's subjective well-being is significant at a 90% confidence level (effect size = 0.160, p = 0.095). Figure 3.3 shows the structural model for the overall data set.




One-Tailed; ****p < 0.001, ***p < 0.01, **p < 0.05, *p < 0.10

**Figure 3.3. Structural Model First Level**

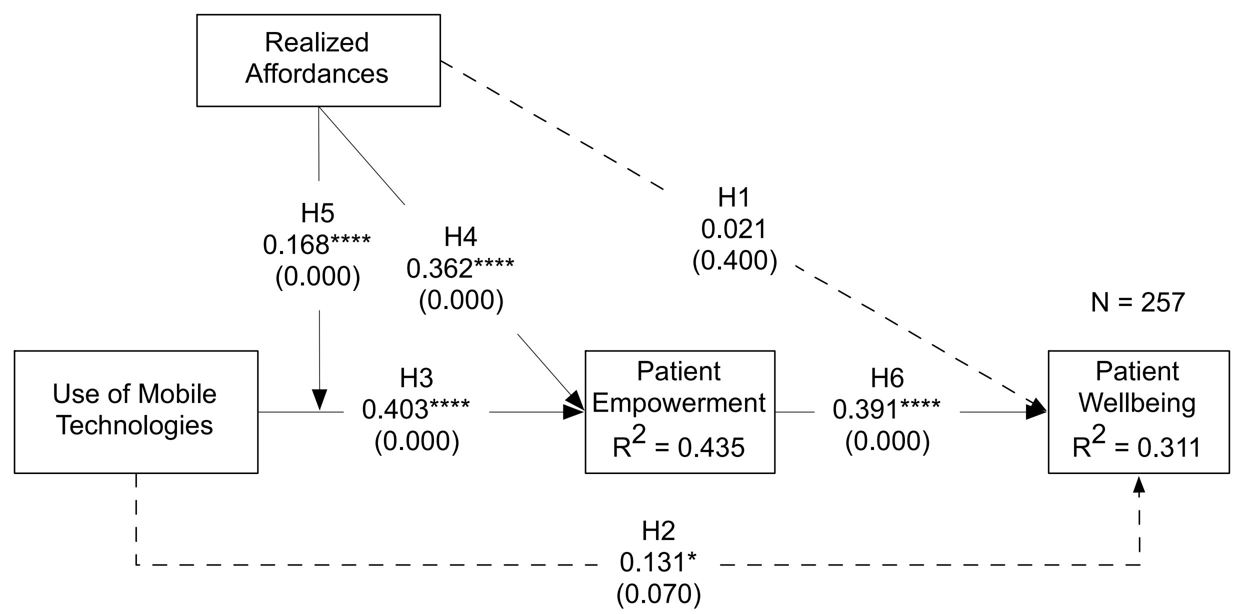
To further expand our understanding of the effect of affordances and use of technology on patient well-being, we added the empowerment aspect to the structural model and re-ran the data (see Figure 3.4). Results clearly show that empowerment mediates the relation between the use of mobile technologies and the subjective well-being of patients. Empowerment explains 23.2 percent of variance in the respondent's well-being. The direct relation between realized affordances and use of technology to a patient's subjective well-being have become insignificant (p=0.907 & p=0.227). The path coefficient between use of technology and empowerment was significant with a value of 0.287 (p=0.000) and between realized affordances and patient empowerment was 0.394 (p=0.000). Thus hypotheses 3 and 4 are supported. To mitigate the concerns of selection bias, we collected data from over 200 patients who don't use any technology for managing their diabetes. We performed univariate and multivariate analysis of variance and compared empowerment levels between users and non-users of mobile technology for diabetes management. In the process, we used all the demographic variables as covariates. Results indicate that the empowerment of diabetes patients who don't use any technology is significantly different and lower than those who use the technology.




One-Tailed; ****p < 0.001, ***p < 0.01, **p < 0.05, *p < 0.10

Figure 3.4. Structural Model with Patient Empowerment as Mediator

To further see the moderation effect of affordances on the relation between the use of mobile technologies and empowerment, we re-ran the model (see Figure 3.5) and found that the moderating effect is significant (path coefficient = 0.173, p = 0.002) and explanatory power of technology use on empowerment increased from 39.7 percent to 42.2 percent. Therefore hypothesis 5 is supported. Further, the effect size between use of technology and patient empowerment also increased from 0.284 to 0.394. Finally, path coefficient between patient empowerment and patient well-being was 0.431 (p=0.000) indicating that hypothesis 6 is also supported. Table 3.6 provides a summary of the results of hypotheses testing.




One-Tailed; ****p < 0.001, ***p < 0.01, **p < 0.05, *p < 0.10

**Figure 3.5. Structural Model with Realized Affordance as Moderator**

**Table 3.6. Hypotheses Testing Summary**

| # | Hypothesis | Support | Comment |
|---|---|---|---|
| H1 | Realized Affordances → Patient Well-being | P.S. | Full mediation through empowerment |
| H2 | Use of Technology → Patient Well-Being | Yes | Full mediation through empowerment |
| H3 | Use of Technology → Patient Empowerment | Yes | Yes |
| H4 | Realized Affordances → Patient Empowerment | Yes | Yes |
| H5 | Realized Affordances x Use of Technology → Patient Empowerment | Yes | Yes |
| H6 | Patient Empowerment → Patient Well-being | Yes | Yes |

## 3.8 Limitations

Before getting into the discussion and implications of our research, we recognize that as with any study, our research also has a few limitations. We do not claim that our results are generalizable to all chronic illness patients, but one of the key questions is whether the findings can be generalized to a wider population of diabetes patients. Two key aspects that influence generalizability of the research findings are survey participants and the study context (Cook and Campbell, 1979). In more general terms, external validity is the extent to which the findings and conclusions of the study would hold across other individuals in other places and at other times. Our research involved diabetes patients over 18 years of age who currently use mobile technologies for diabetes management. Now, whether the results of the study can be extended to the entire population of diabetes patients depends on how close the sample matches the population. There are certain aspects that can help mitigate the external validity concerns. The unit of analysis in our study is an individual and it examines their use of mobile technologies for managing diabetes. The study also consists of a decent sample size, 257 diabetes patients who use technology on a daily basis. The phenomenon of the level of usage of technology and its impact on patient well-being is expected to be noticeable in the wider diabetes patient population. Every chronic disease has its own uniqueness, so we do not claim that the results of this study can be extended to other chronic illness types. We believe that technology affordances positively influence patient empowerment across all chronic illnesses. However, this generalizability of the findings across other illness types can be best understood by conducting research in those contexts. Insights and the knowledge gained from this study would be useful in applying this research to other contexts. Extending the results of this study across all age groups is another possible threat to external validity. While age is not a continuous variable in our study, over 90% of the study participants fall between 25 and 64 years of age. So, age doesn't seem to pose a real threat to generalizability of study results.

Another possible threat to external validity is interpreting results across ethnic groups. Close to 75% of our survey respondents are caucasian. Underrepresentation of diabetes patients from other ethnic groups could be due to lack of education, low income levels to afford technology for managing diabetes, or could be lack of awareness. In analyzing our study results, we have controlled for all demographic variables. However, it would be interesting to study whether any of the demographic variables moderate hypothesized relationships.

Generalizing the results of the study across technologies is another concern that might pop up. Analysis of results and conclusions are not drawn based on data collected from one single technology. Thus, generalizing results across technologies should be a major concern. Potential for common method variance exists because measures for all constructs in the model were collected at the same point in time. However, as the data is collected from a cross-sectional study of diabetes patients, causality cannot be inferred from the results.

## 3.9 Discussion and Conclusion

The goal of this study was to understand how mobile technologies influence the subjective well-being of diabetes patients through patient empowerment. Using technology affordances as theoretical foundation, we conceptualized and empirically validated how the affordances of mobile technologies contribute to patient empowerment, which in turn influence a patient's subjective well-being. Findings provide strong support for the proposed hypotheses and explain significant variance in the dependent and mediating variables. Results indicate that realized affordances and the level of use of mobile technologies positively influence patients' subjective well-being by empowering them. Reflecting on the analysis of the results and findings from the study leads to some observations. Evaluation of antecedents of our model reveals mutual importance of mobile technology use and affordances in patient empowerment. The patient empowerment appears to depend, in part, on how well mobile technologies for diabetes management provide affordances, potential for self-management activities, and the level at which patients use those technologies. We provide contributions of our study and then discuss implications for theory and research.

### *3.9.1 Contribution*

The study contributes to the literature by showing how technology affordances influence diabetic patients' well-being via empowerment. Further, this study introduces the concept of realized affordances of mobile technologies and illustrates its important role, together with the use of technology. Empowerment has already been shown in the literature to influence patient well-being. However, our study adds value to the literature by showing that technology affordances, a very crucial aspect of technology, influences patient empowerment. Both technology use and the affordances of mobile technologies positively influence subjective assessments of patients' well-being by empowering them in their process of diabetes self-management. In addition to this, technology affordances reinforce the effect of technology use on patient empowerment.

### *3.9.2 Implications for Theory*

Perception and realization of technology affordances may differ based on the patient characteristics such as their knowledge and understanding about mobile technologies, computer literacy, and to some extent on their healthcare literacy. One of the implications for theory would be to see how perception and the realization of affordances of a particular technology vary based on patient characteristics. This would be an interesting study because realization of technology affordances can be improved by educating patients in various aspects.

Further research needs to be conducted to determine the types of applications and components of those applications that are of most use in the self-management of diabetes. The data collected by the authors showed a multitude of applications in use across the survey respondents. Many had similar foci regarding accomplishing self-care behaviors in diabetes management, but we don't yet know which application is best in helping patients with self-management. Further research on the capabilities of these mobile apps and a comparative study of design aspects across various applications would be required to get an understanding of which application would be better in accomplishing self-care behaviors. Further, additional research would be required to understand the suitability of applications for patients based on their health condition.

Value can be added in this line of research by studying differential effects of different affordances rather than one single construct in the self-management of diabetes. Every affordance may have its own importance and different affordances may have varying effects on empowerment. It would be interesting to study the influence of affordances separately. This can probably address mixed or inconsistent results currently found in the literature on the impact of using IT for diabetes self-management.

In this study, we collected data by surveying two groups of diabetes patients, viz., those who use and those who do not use mobile technologies for diabetes management. To alleviate the concerns of selection bias, we have compared the empowerment levels between the two groups and found them to be significantly different and also that the empowerment is lower among non-users compared to users. It would be interesting to perform a longitudinal study of same group of diabetes patients to assess the impact of technology on empowerment. Future research can select a large group of diabetes patients who do not current use any technology, and provide them access to mobile technologies for managing their illness. This group can be observed over a period of time and researchers can compare a before and after picture of the same set of patients. This can help isolate any confounding effects of other factors on empowerment and give a clear picture of the influence of technology on patient empowerment in the process of diabetes self-management.

### *3.9.3 Implications for Practice*

Given the strong influence of Level of Technology Use on Patient Empowerment and the moderating effect of Realized Affordances, it is important to focus and understand these affordances when designing mobile technologies for diabetes self-management. When patients believe that technology can really afford them functions and action possibilities which can make their self-management activities more effective, and in turn improve their health and well-being, they are very likely to adopt and use those technologies in their daily lives. This will have long standing effect on health of the society and cost of healthcare.

The importance of technology affordances in contributing toward patient empowerment should be recognized. Patients with chronic illnesses need a regular assessment of their clinical, behavioral, and psychological needs. Some of these needs can be fulfilled through proper self-management. If mobile technologies when designed and developed keep these needs in view, they can positively contribute to a patents quality of life and well-being to a great extent.

Apart from studying the influence of various technology functions on empowerment and well-being, future research can include specific types of mobile technologies and study their influence on well-being. Comparing the effect of different types of technologies such as wearable devices, handheld devices, and home-based consumer health information technologies by a group of patients and across chronic illnesses would be an interesting extension of this study. Further, study of how the usage of the same technology delivers a different level of effect across chronic illness would be of great value to the practice.

### *3.9.4 Conclusion*

Within the United States, incidents of diabetes are on the rise. Diabetes, one of the deadly chronic illnesses, if not managed well and timely, can cause serious anguish to the patient, their family members, and to society in general. Diabetes self-management, while unable to cure diabetes, can help patients experience a better quality of life and can eventually lead to positive impacts on their well-being. Mobile technologies can play a critical role in accomplishing this. Drawing from affordance literature, this study developed a theoretical model of patient empowerment in diabetes self-management. The model explicates how mobile technology affordances influence patient well-being through their empowerment. Empirical analyses reveal that higher levels of realized affordances and mobile technology usage positively associated with patient empowerment, which in turn positively influences patient’s well-being. An interesting finding of the study is that realized affordances moderate the relationship between technology use and empowerment indicating that higher realized affordances enhance patient empowerment for a given level of technology usage. These insights not only provide researchers with a better understanding of how technology affordances influence patient empowerment in the context of diabetes self-management, but also assist technology designers and developers to better understand and adjust their strategies to increase mobile technology adoption in diabetes self-management.

## Overall Conclusion

Diabetes is a serious illness and its occurrence has been consistently rising for the past several decades. It poses a heavy burden on the society in terms of healthcare cost and if not properly managed at the right time, it adversely impacts patient's quality of life and well-being. Information technology in general, and mobile technologies in particular, has the potential to help diabetes patients in managing their illness. However, the effect of these technologies in diabetes self-management is relatively unknown. The overarching objective of this dissertation, comprised of three essays, was to understand the role of mobile technologies in diabetes self-management. Drawing primarily from technology affordance theory, self-regulation model of illness representation, and diabetes self-care behaviors advocated by the American Association of Diabetes Educators (AADE7), we developed an instrument to measure the affordances of mobile technologies in diabetes self-management. In the first paper, we validated the instrument using a nomological network. In the second essay, we developed and validated a model in which patient's illness perceptions were conceptualized to influence his or her intentions of mobile technology adoption and continued use. In our third essay, we elucidated the influence of realized affordances and mobile technology use on patient empowerment. Models in our research were validated using data collected from over 450 diabetes patients. Findings from the first essay suggest that technology affordances positively influence patient's beliefs about usefulness and ease of using technology. Second essay illustrates that patients' perceptions of their health status and health control have differential influence on non-users' and users' beliefs on technology adoption and continued use. The third essay demonstrates that use of technology and what it affords significantly influence patient's empowerment. Overall, insights from our research reveal that technology affordances do play a significant role in diabetes self-management. We firmly believe that our research makes an important contribution for theory development and practice and will inspire others to investigate and advance technology affordance research in other chronic illness areas.

Appendix A

Instrument for Measuring Affordances of Mobile Technologies

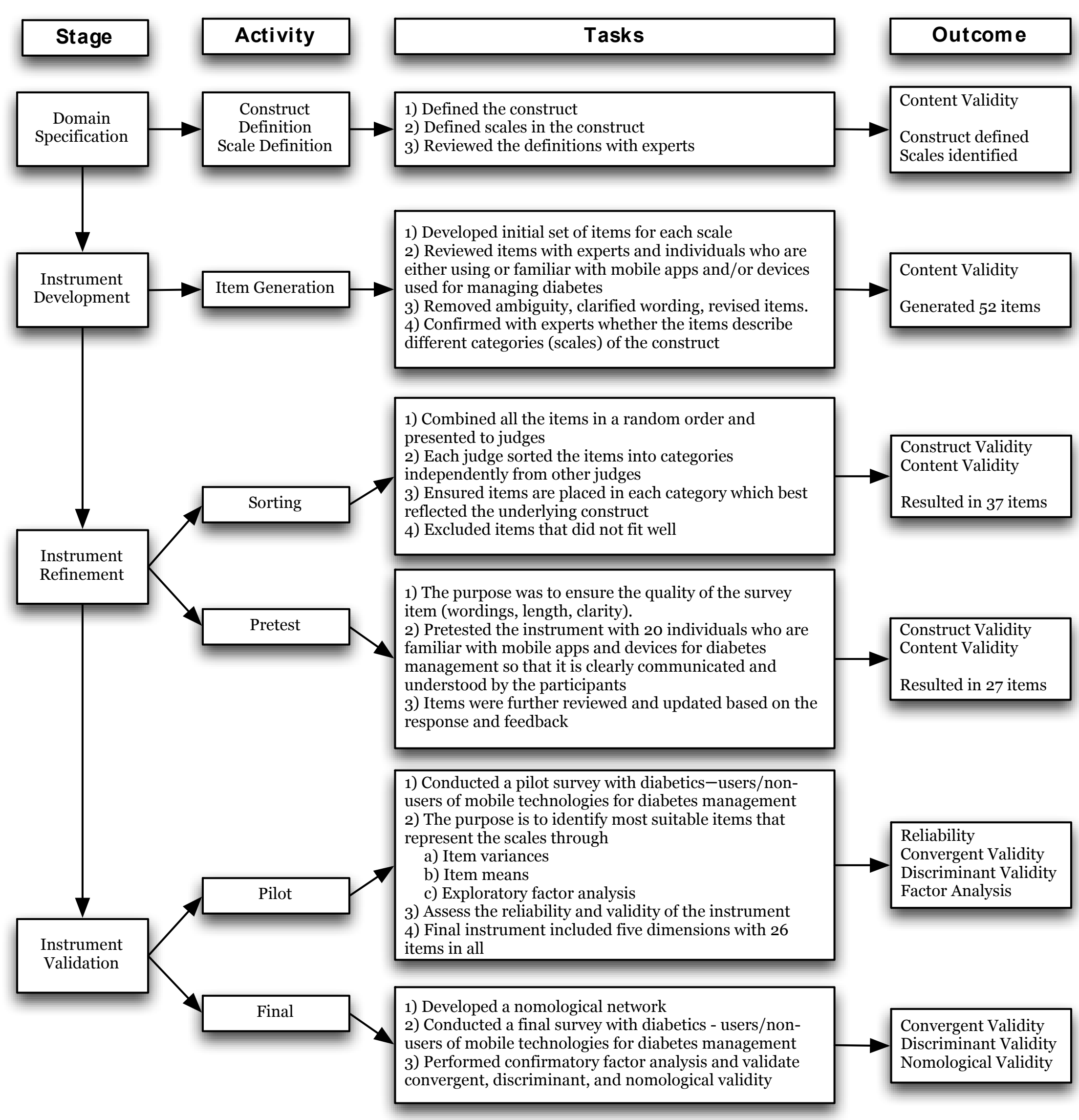
for Diabetes Management

## Instrument Development Process

There are several techniques suggested in the literature regarding instrument development. For example, Churchill (1979) suggested a paradigm consisting of an eight-step procedure for developing measures in the marketing research. Similarly, a framework, consisting of ten steps, for developing measures was proposed for MIS researchers (MacKenzie et al., 2011). DeVellis (2012) provided specific guidelines in eight steps for developing measurement scales. Following these guidelines and recommendations from the literature, and adapting the methodology adopted by other researchers (Moore and Benbasat, 1991; Chu and Chau, 2014), we took a four-step approach for developing the instrument. Figure A.1 describes the details of the steps and the work carried out through these steps.

Step one involves defining the boundaries of the phenomenon. Using the literature on technology affordances and diabetes self-care behaviors, we performed a content analysis to draw boundaries for the instrument. We specified the domain and defined the overall construct and its sub-dimensions in this step. Items for each scale were developed in step 2 by primarily discussing with experts in the field and through literature review. In step 3, items were refined following a meticulous sorting procedure and pretesting process. Finally, the instrument was validated in step 4, in which we performed pilot surveys of two groups of diabetes patients who are users and non-users of mobile technologies for diabetes management to validate the instrument. To further ensure the validity of the survey instrument, we conducted a final survey with two groups of diabetes patients–users and non-users of mobile technologies –to test the nomological network.

**Figure A.1. Stages of Instrument Development Process**




### *A.1 Use of Technology in Self-Management*

Studies on the use of technology in diabetes self-management explored how various types of technology influence patient self-management behavior. Simple text messages using short message services (SMS) via mobile phones (Jones et al., 2014; Mulvaney et al., 2012) have been shown to be effective in improving self-management aspects such as taking medication, reducing risks, problem solving, adherence to appointments and treatments, blood glucose measurement, and treatment compliance. Social media has been effective in improving patient well-being through self-management. Merolli et al., (2013) performed a literature review on health outcomes and related effects of using social media concluded that technology had a positive impact on patients' psychological health through information-sharing and peer-support.

A literature review on the effect of Web2.0 on self-management by older adults (Stellefson et al., 2013) found that technology helps in enhancing self-efficacy of the patients in managing their conditions. Authors found that technology helps in aspects such as mediation adherence, social support, and communication with healthcare providers, which can help in self-care activities of taking medication, reducing risks, and healthy coping. Wearable sensors and tracking devices can be very effective in monitoring illness conditions and improving physician-patient relationships. Applebloom et al., (2014), in their literature review, found that these mobile technologies have potential for monitoring cardiovascular activity, blood glucose, and neurological functioning. These technologies can potentially influence healthy coping of the patients through improving relationships with their physicians, increasing patient autonomy, and improving patient engagement in their care process.

One of the key aspects of self-management is adhering to medical treatment. Failure to do so can lead to patients' death and increased healthcare costs. Heinrich and Kuiper (2012) found that handheld devices helped 89.4% of the patients adhere to medication through reminders and feedback mechanism. However, the study did not measure adherence rate prior to the study, making it difficult to measure the improvement in treatment adherence. Or and Tao (2014) performed a meta-analysis of 62 studies involving randomized control trials and concluded that technology can improve self-monitoring, physical activities, regular health checkups, and patients' eating habits. However, consistency across the studies was lacking. El-Gayar et al., (2013), in their systematic review of 104 studies related to IT use for diabetes self-management, found that technologies such as smartphones, Internet, and decision support systems can assist in diabetes self-management. However, several studies did not demonstrate the desired levels of glucose management, adoption, and patient satisfaction.

**Table A.1: Summary of Literature Review on Diabetes Self-Management**

| # | Technology used | Key Self-management Aspects | Methodology | Key findings | Technology Affordance | Source |
|---|---|---|---|---|---|---|
| 1. | Wearable body sensors | • Self tracking and monitoring symptoms such as glucose levels, heart and respiration rate, and blood pressure<br>• Measure physical activity | Literature review | Wearable sensors are effective and reliable in monitoring conditions chronic illnesses. They also have potential to improve physician-patient relationships and increase patient autonomy in managing their health. | • Monitoring<br>• Being active<br>• Reducing risk | Appelboom et al., 2014 |
| 2. | Internet, Phone, Decision Support, Telemedicine | • Measuring and transmitting measurable markers such as glucose readings<br>• Sharing data with health care providers<br>• Real-time feedback based on data entered | Literature review | IT has potential for positive impacts on self-management of chronic illnesses.<br>Some studies did not show positive effect of IT on self-management, adoption, and patient satisfaction. Further research is needed. | • Monitoring<br>• Healthy coping | El-Gayar et al., 2013 |
| 3. | Handheld devices | • Medication adherence<br>• Medication reminders | Experiment | Most study participants adhered to medication regimen because of reminders.<br>The study did not measure medication adherence prior to the handheld device intervention, so it was not clear whether adherence levels improved because of handheld devices | • Taking medication<br>• Reducing risks<br>• Problem solving | Heinrich and Kuiper, 2012 |
| 4. | m-Health, Home telemonitoring, Web-based support, Patient portals, Patient health records | • Adherence to medical treatment | Review of technologies | Technology has potential to help patients with monitoring, adherence to medication, and other self-management aspects and thus provide continuous, cost-effective, and patient-centered care by engaging patients in self-management activities. | • Monitoring<br>• Taking medication<br>• Reducing Risks<br>• Problem Solving | Howren et al., 2013 |
| 5. | Mobile phones and SMS service | • Adherence to treatment plans<br>• Adherence to appointments<br>• Determining health-related goals to pursue | Meta-Review (A review of Systematic Reviews) | SMS through mobile phones have positive impact on the chronic illness self-management tasks and selected clinical and behavioral outcomes. | • Taking medication<br>• Reducing risks<br>• Problem solving | Jones et al., 2014 |
| 6. | Social Media | • Peer support<br>• Information sharing | Literature review | Social media positively influences psychological well-being | • Healthy coping | Merolli et al., 2013 |
| 7. | Mobile phones | • Blood glucose measurement and monitoring<br>• Adherence to blood glucose monitoring and insulin administration | Experimental Study | It is possible to use mobile phones to measure glucose monitoring and insulin administration in adolescents. | • Monitoring<br>• Taking medication<br>• Reducing risks | Mulvaney et al., 2012 |

| Table A.1: Summary of Literature Review on Diabetes Self-Management (Continued) | | | | | | |
|---|---|---|---|---|---|---|
| **#** | **Technology used** | **Key Self-management Aspects** | **Methodology** | **Key findings** | **Technology Affordance** | **Source** |
| 8. | Consumer Health Information Technologies (CHIT) | • Self-monitoring of blood glucose<br>• Insulin and medication management<br>• Education and personalized feedback<br>• Physical activity<br>• Alerts/reminders<br>• Blood pressure monitoring<br>• Weight management<br>• Psychosocial care | Meta Analysis | Based on a meta-analysis of randomized control trials, the article concludes that CHITs show promise and have potential. However, studies show mixed results on the effectiveness. The benefits of CHIT are not consistent across the studies. | • Monitoring<br>• Taking medication<br>• Reducing risks<br>• Being active<br>• Eating healthy<br>• Healthy coping | Or & Tao, 2014 |
| 9. | Web 2.0 | • Medication adherence<br>• Healthcare utilization<br>• Social support<br>• Communication with healthcare providers | Literature review | Technology helps in improving self-efficacy for managing the illness. Patients benefited from progress-tracking features, receiving feedback from healthcare providers, and receiving social support. | • Taking medication<br>• Reducing risks<br>• Healthy coping | Stellefson et al., 2013 |

In summary, the underlying message of these and several other studies is that technologies can facilitate in self-management leading to the well-being of patients. Our brief literature review on the use of technology for self-management focused on how technology influences AADE7 diabetes self-care behaviors: healthy eating, being active, taking medication, monitoring, healthy coping, problem solving, and reducing risks. In order for the technology to be effective and motivate individuals to adopt and use, they must provide action possibilities to accomplish the above mentioned diabetes self-care behaviors.

*A.2 Domain Specification and Construct Definition*

Specifying the boundaries of the phenomenon is the first and foremost step in the instrument development process. It helps in clearly defining the content of the scale and developing relevant items for each scale so as to ensure content validity. The domain in our case is the affordances of mobile technologies for managing diabetes. Volkoff and Strong (2013) define affordances as “the potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artifact) and a goal-oriented actor or actors." The key elements that are included in our domain are: (i) potential for action–what is offered by mobile technologies (ii) actor–the patient; and (iii) the goal or objective–accomplishing AADE-recommended self-care behaviors. For diabetics it is important to know those actions that are necessary for keeping diabetes under control. Since realizing AADE7 self-care behavioral objectives promote diabetes management, these behavioral objectives form the basis for defining the dimensions of our instrument and guide us in developing scale items.

### A.2.1 Dimensions of the Measure AMTDS

Following the definition from Volkoff and Strong (2013), we defined affordances of mobile technologies for diabetes self-management (AMTDS) as "the potential for action required by the individual for accomplishing AADE recommended diabetes self-care behaviors." Three key elements can be observed here–first, what is being offered by the technology (action potential); second, to whom this action potential is for (the actor); and third, why this action potential is required (the goal). This can be translated into the domain of diabetes self-management as all the activities (action possibilities) that are required for the diabetes patients (the actor) to accomplish AADE-recommended self-care behaviors (goal). Diabetics must aim to accomplish the AADE-recommended behaviors in order to keep their illness under control. We define these dimensions as "the extent to which mobile technologies help diabetics realize these self-care behavioral goals." Table A.2 lists these self-care behaviors and their definition, which provide the basis for generating the items.

When we closely observe these self-care behaviors, healthy eating and being active are closely related to each other. Similarly, problem solving and reducing risks are closely connected. Hence, we conceptualized our construct as consisting of five dimensions.

**Table A.2. Dimensions of Affordances of Mobile Technologies in Diabetes Management**

| Construct/ Dimension | Definition/ Concept/ Idea |
|---|---|
| Affordances of Mobile Technologies in Diabetes Self-Management | "The potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artifact) and a goal-oriented actor or actors" (Volkoff and Strong, 2013, p. 823)<br><br>"The potential for action required by the individual for accomplishing AADE-recommended diabetes self-care behaviors." |
| Healthy Eating | The extent to which mobile apps and devices help diabetics develop healthy eating habits. |
| Being Active | The extent to which mobile apps and devices help diabetics maintain an active life style. |
| Monitoring | The extent to which mobile apps and devices help diabetics monitor their blood sugar level and other vitals. |
| Taking Medication | The extent to which mobile apps and devices help diabetics adhere to the recommended treatment regimen. |
| Problem Solving | The extent to which mobile apps and devices help diabetics solve daily problems or stressors caused by the disease. |
| Reducing Risks | The extent to which mobile apps and devices help diabetics reduce the risk of developing other complications. |
| Healthy Coping | The extent to which mobile apps and devices help diabetics positively cope with their illness. |

*A.3 Item Generation*

The second step of the instrument development process involved generation of appropriate items under each scale (self-care behavior). We conducted a review of the literature, and particularly the systematic review on seven self-care behaviors (see Boren, 2007), for the observable activities within each self-care behavior. However, we could not find many examples from the extant literature. We then performed extensive discussions with people involved in healthcare practice of diabetes management, experts in the College of Nursing in a major university, and with those who actually are using mobile technologies in managing their diabetes. These discussions provided useful guidance and a basis for developing items for the instrument.  Table A.3 provides key points that arose from discussions with experts and a literature search. These points guided us in developing the items.

A pool of typical items under each of the self-care behavior category (e.g., healthy eating) was generated. We explained about the overall construct and its dimensions to experts and gave them its definition, descriptions for various scales/dimensions, and asked to describe the actions that mobile technologies can/should afford to patients in order for them to accomplish the self-care objectives. This resulted in an initial list of 52 items after rewording, rephrasing, and simplifying the descriptions. Content validity is concerned with the extent to which the items adequately represent the content domain or the construct (DeVellis, 2012). Content validity can be achieved by consulting domain experts where they can offer insights into whether or not the items cover significant aspects of the construct being measured (Howitt & Cramer, 2011; DeVellis, 2012). To ensure content validity, six judges with expertise and/or experience in diabetes management reviewed this initial list of items to assess if they accurately described various affordances offered by mobile technologies and the items are representative of the domain in question.

## Table A.3. Diabetes Self-Care Behaviors: Aspects To Be Considered for Item Generation

| Behavior | Aspect | Details |
|---|---|---|
| Healthy Eating | Importance | Eating healthy food at the right time in right proportions helps patients manage their blood sugar levels |
| | Points to ponder | Making healthy food choices, Eating a balanced diet involving a variety of foods, understand portion sizes, eat at regular intervals |
| Being Active | Importance | Being active helps with weight control, heart condition, and improves energy. Through regular exercise, body can make better use of insulin and food thereby improving blood sugar levels |
| | Points to ponder | Regular physical activity such as walking, biking, swimming, cleaning the house; maintaining active record of exercises; tracking weight, calories burned |
| Monitoring | Importance | Regular monitoring of blood sugar levels and other biomarkers helps in knowing the impact of medication, physical activity, and other stressors on blood sugar levels |
| | Points to ponder | Keeping track of blood sugar levels at regular intervals, sharing data with others, measuring and monitoring biomarkers, monitoring sleep patterns |
| Taking Medication | Importance | Understanding treatment regimen is very important for diabetics because taking regular medication helps maintain their blood sugar levels and reduces other side effects |
| | Points to ponder | Complying with healthcare provider recommendations, keeping reminders or alarms to take medication, keeping track of medication, making adjustments as needed, knowing information about medication and dosages |
| Problem Solving | Importance | Daily problems or stressors can put the body under stress resulting in dramatic fluctuations in blood sugar levels |
| | Points to ponder | Knowing information about problems that can occur, know how others are solving their problems, knowing trends on a daily basis to solve problems, sharing data with healthcare provider |
| Reducing Risks | Importance | Reducing risks of complications from diabetes can help improve quality and quantity of life for people with diabetes |
| | Points to ponder | Tracking sleep patterns, access information about diabetes related risks, communicating with healthcare provider, knowing about preventive care |
| Healthy Coping | Importance | Healthy and positive coping with the emotions associated with diabetes can contribute to better control over one's diabetes |
| | Points to ponder | Seek support from others, understand how others are coping, share information with family and care providers, connecting and interacting with others going through similar problems |

*A.4 Instrument Refinement*

A.4.1 Construct Validity

The survey items were self-developed with the help of diabetes management healthcare practitioners, experts in diabetes practice in the College of Nursing, and individuals familiar with the technology. These items will be subject to survey responses by diabetes patients. To ensure construct validity, it is important that the survey respondents see the same meaning as established by the researcher for each item. Among several methods described in the research methods literature for content assessment, one common method involves respondents or experts to review and categorize or sort items into various groups based on how closely they are connected to definition of the construct and its sub-dimensions. Research suggests that experts familiar with the content in the field must review the instrument repeatedly until some level of consensus is reached (Cronbach, 1971 as cited in Straub, 1989). When new scales are being developed, a technique involving sorting of items into various categories, provides an excellent means of establishing construct validity (Moore and Benbasat 1991). Further, equivocal items and unclear scale definitions might lead to problems in getting proper survey responses. Experts in the field and survey respondents can provide valuable insights that can help avoid these problems (Churchill Jr, 1979). Given the fact that there is no empirical work in this area where affordance concept is applied to construct development, we determined to take a two-step approach–one taking expert opinion for refining the item wordings and two, sorting them into appropriate categories–as a means of ensuring construct validity.

In the first step, six judges comprising of university faculty and individuals who are either using or are familiar with mobile apps and devices for managing their disease reviewed the initial list of 52 items. These judges assessed whether the items, measured on five-point Likert scales (1 = strongly disagree; 5 = strongly agree), describe various affordances offered by mobile technologies. Effort has been made to ensure that the items satisfy three criteria–one, the descriptions are unequivocal; two, the item must be relevant to diabetes self-management;

and three, the item must be consistent with three key aspects of the construct definition–action potential, the actor (patient), and the AADE diabetes self-care objective (the goal).

After four to six weeks of domain development and initial refinement, the items were shuffled and printed separately on a sheet of paper without any details related to the construct or underlying dimensions. This list of items along with construct definition and descriptions of sub-dimensions on a separate paper was given to a panel of experts. A total of nine individuals with experience and/or expertise in diabetes management and related mobile technologies were asked to indicate whether or not each item can be categorized according to how closely they were related to each dimension/scale of the construct. Each individual sorted the items separately according to their availability on different days and this sorting exercise went on for weeks. The experts were encouraged to make note of any errors in descriptions, lack of clarity or mistakes in the wording of scale items. Based on the results of the sort exercise, we removed items that were either ambiguous or if they were categorized into a category different from a priori category. This sorting step resulted in 37 items, with 73% of the items matching with original categorization. To further refine and clean the instrument, we pre-tested these 37 items with other individuals and experts by conducting an online web-based survey. A total of 25 individuals participated in the survey. In addition to filling out the survey, we asked the survey respondents to provide feedback on aspects such as time taken to filling the survey, and whether the items are too lengthy or verbose. The survey instrument was further refined based on this feedback, which resulted in 27 items. Please see appendix for the details of the results.

### *A.5. Instrument Validation*

#### A.5.1 Exploratory Factor Analysis (EFA)

To determine the number of factors underlying the items, we conducted a pilot study to collect data from two groups of diabetes patients–those who currently use mobile technologies and those who currently do not use any mobile technology, but are familiar and knowledgeable about those technologies. The user dataset consisted of 183 completed survey responses and the non-user dataset contained 157 completed survey responses. Data collected from the pilot survey was used to perform exploratory factor analysis and to assess reliability and validity of the instrument.

A.5.2 Data Description

Our population of interest was all of the diabetes patients, familiar with mobile apps and devices used for diabetes self-management. We specifically collected data from both users and non-users of these technologies. Items for the questionnaire were developed in such a way that the non-users provided their perception of what mobile technologies afford (perceived affordances) and the users were asked to provided responses to what these mobile technologies actually afford (realized affordances). We received a total of 157 and 183 completed and useful responses from non-users and users, respectively. Table A.4 provides the distribution of respondents according to gender, age, usage of smartphone apps in general, and usage of mobile technologies for diabetes management. The gender distribution in the user and non-user population is more or less balanced. From the non-user population, about 44% are males and 55% are females. From the user population, males and females represented 55.7% and 43.7%, respectively and two respondents did not provide their gender information. Eighty-four (53.5%) non-users are above 55 years of age and 119 (65%) of users are below 45 years age. There was one user who did not indicate an age group. This shows that the older population does not use mobile technologies in their diabetes management and the majority of users belong to the younger population.

We also collected data about mobile apps usage in general and for diabetes management in particular: 61 percent (96) of non-users and 55 percent (100) of users used some king of mobile app and smartphones for over two years. Regarding mobile technologies meant for diabetes management, we ensured that all the non-users are familiar and knowledgeable about the technologies. From the user population, 142 (77.6%) respondents used mobile technologies for over six months.

**Table A.4. Characteristics of Pilot Data**

| | | Non-Users | Users |
|---|---|---|---|
| Total | | 157 | 183 |
| | | | |
| Gender | Male | 69 | 102 |
| | Female | 86 | 81 |
| | No Response | 2 | |
| | | | |
| Age | 18-24 | 4 | 11 |
| | 25-34 | 20 | 62 |
| | 35-44 | 26 | 46 |
| | 45-54 | 23 | 26 |
| | 55-64 | 52 | 24 |
| | 65-74 | 27 | 12 |
| | >74 | 5 | 1 |
| | No response | | 1 |
| | | | |
| General Smartphone app usage | 0-6 Mos | 16 | 19 |
| | 6-12 Mos | 20 | 27 |
| | 1-2 Yrs | 25 | 37 |
| | 2-5 Yrs | 55 | 51 |
| | > 5 Yrs | 41 | 49 |
| | | | |
| Usage of mobile technologies for managing diabetes | 0-6 Mos | N/A | 41 |
| | 6-12 Mos | N/A | 41 |
| | 1-2 Yrs | N/A | 71 |
| | 2-5 Yrs | N/A | 21 |
| | > 5 Yrs | N/A | 8 |

To assess the dimensionality underlying 27 items, we performed principal component analysis (PCA) on the dataset containing responses from both users and non-users using SPSS. The initial factor analysis suggested four factors with eigenvalues 1.0, Kaiser-Guttman criterion, explaining 68% of variance. However, after examining the total variance explained, we find that the fifth factor accounted for more than 3.5% of the variance. According to the theory, the evidence-based diabetes self-care behavior framework, and considering scree plot, keeping five factors actually was more meaningful.  Hence we decided to include the fifth factor in the factor extraction. In addition, we removed one of the items, HC1, as it cross-loaded on multiple factors. We performed the factor analysis by fixing the number of factors to be extracted to five. Technology affordance construct is a second order reflective construct in which factors are correlated. So, we used oblimin rotation and the solution converged in eleven iterations. The final solution resulted in a 26-item Technology Affordance construct with five subscales, which accounted for 71.6% percent of the total variance. The factor loadings are presented in Table A.5. Based on how items have loaded on to these five factors, we named them as follows: Factor 1, named as “Reducing Risks and Problem Solving (RRPS)” accounts for all those affordances of mobile technologies that enable patients to solve diabetes-related problems and reduce risks involved. Factor 2, entitled “Being Active and Healthy Eating (BAHE),” contains items related to affordances of mobile technologies that help diabetes patients in eating healthy foods and maintaining an active lifestyle. Factor 3, called “Monitoring (MO),” includes all those items that make patients monitor and keep track of their blood glucose levels, and other measurable biomarkers. “Healthy Coping (HC),” the fourth factor, comprises of those items that help patients in coping with their health condition. Finally, the fifth factor, termed as “Taking Medication (TM),” encompasses affordances that assist patients with complying with treatment regimen.

| Table A.5. EFA – Rotated Factor Loadings | | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| RRPS1 | 0.830 | 0.000 | -0.064 | 0.009 | -0.074 |
| RRPS2 | 0.824 | 0.032 | 0.001 | -0.013 | -0.039 |
| RRPS3 | 0.800 | -0.040 | -0.029 | -0.073 | -0.064 |
| RRPS4 | 0.770 | 0.087 | 0.086 | -0.167 | 0.256 |
| RRPS5 | 0.740 | 0.053 | 0.034 | -0.107 | 0.011 |
| RRPS6 | 0.744 | 0.021 | 0.038 | -0.013 | -0.142 |
| RRPS7 | 0.720 | -0.006 | 0.150 | 0.158 | -0.043 |
| RRPS8 | 0.695 | 0.170 | 0.147 | 0.042 | 0.074 |
| BAHE1 | -0.030 | 0.857 | 0.119 | -0.099 | 0.046 |
| BAHE2 | 0.214 | 0.680 | -0.025 | 0.198 | -0.098 |
| BAHE3 | 0.060 | 0.783 | 0.091 | -0.087 | -0.005 |
| BAHE4 | 0.008 | 0.769 | 0.186 | 0.127 | 0.028 |
| BAHE5 | 0.224 | 0.617 | -0.016 | 0.266 | -0.223 |
| BAHE6 | -0.125 | 0.884 | 0.008 | -0.289 | 0.057 |
| BAHE7 | 0.278 | 0.620 | -0.173 | 0.085 | -0.228 |
| BAHE8 | 0.239 | 0.554 | -0.199 | 0.113 | -0.335 |
| MO1 | 0.009 | 0.091 | 0.800 | 0.185 | -0.034 |
| MO2 | 0.094 | 0.015 | 0.728 | 0.011 | -0.138 |
| MO3 | 0.094 | -0.034 | 0.713 | -0.052 | -0.164 |
| MO4 | 0.097 | 0.200 | 0.529 | -0.336 | 0.161 |
| HC2 | 0.397 | 0.010 | 0.066 | -0.511 | -0.227 |
| HC3 | 0.281 | 0.167 | -0.062 | -0.603 | -0.254 |
| HC4 | 0.386 | 0.030 | -0.035 | -0.568 | -0.265 |
| TM1 | 0.134 | -0.007 | 0.355 | -0.129 | -0.515 |
| TM2 | -0.020 | 0.105 | 0.168 | -0.031 | -0.747 |
| TM3 | 0.020 | 0.114 | 0.185 | -0.244 | -0.602 |
| BAHE–Being Active and Healthy Eating; RRPS–Reducing Risks and Problem Solving; HC–Healthy Coping; MO–Monitoring; TM–Taking Medication; | | | | | |

A.5.2 Confirmatory Factor Analysis and Nomological Validity

Validity of a measurement instrument is its ability to measure what it actually intended to measure. Instrument validation, the fourth step in the instrument development process, involves assessment of reliability, convergent validity, discriminant validity, factorial validity, and nomological validity.

Consistency in measurement is referred to as reliability and one of the ways to assess it is by using the test-retest method. Including several similar items in a measure and by using diverse sample of respondents rather than a small group of individuals increases the reliability of the instrument. In a self-reporting survey instrument, having more items to measure the construct will be more reliable than a construct with fewer items. Convergent and discriminant validity of the instrument ensure construct validity (Shaughnessy et al., 2012).

To establish construct validity and nomological validity of technology affordances (Perceived Affordances and Realized Affordances), we used PLS. The details are described under the measurement model section of Paper-1.

Items for Constructs Used in Paper-I

| Table A.6. Affordances of Mobile Technologies in Diabetes Management (Non-Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Reducing Risks and Problem Solving** | | I think mobile apps and/or devices that are available for managing diabetes could… |
| | RRPS1 | provide me information about diabetes related risks |
| | RRPS2 | enable me to get important information about preventive care |
| | RRPS3 | help me understand why I am taking medication and its importance to my health |
| | RRPS4 | help me avoid complications and worsening disease condition |
| | RRPS5 | help me understand how each aspect of my daily routine affects my disease |
| | RRPS6 | help me in understanding my disease and treatment options |
| | RRPS7 | allow me to know that to do when my blood sugar level is low or high |
| | RRPS8 | provide me with information to solve diabetes related problems |
| | | |
| **Being Active and Healthy Eating** | BAHE1 | allow me to track calories burned during exercising |
| | BAHE2 | provide information such as nutrition facts on diabetic-friendly foods (fruits, vegetables, meat, etc.,) and/or meals I consume |
| | BAHE3 | enable me to set and/or track my exercising or activity goals |
| | BAHE4 | enable to track food and nutrition consumption |
| | BAHE5 | enable me to know about portion size of foods and/or meals for healthy diabetic diet |
| | BAHE6 | enable me to track the amount of exercise (e.g., time spent, steps walked, etc.,) |
| | BAHE7 | make recommendations about type of exercises (such as walking, running, bicycling, swimming, etc.,) |
| | BAHE8 | help me know about foods (such as fruits, vegetables, and meat) and/or meals not suitable for my health condition |
| | | |
| **Healthy Coping** | HC1 | provide information to share with other diabetics |
| | HC2 | enable me to seek support from the members of social groups who are experiencing diabetes |
| | HC3 | make it possible to get data to interact with others who are going through similar problems |
| **Monitoring** | MO1 | enable me to share information about measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) with people who care for me (For example., family members, healthcare provider, friends, etc.) |
| | MO2 | allow me to monitor measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) |
| | MO3 | enable me to track changes in measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) |
| | MO4 | allow me to see trends based upon the time of day |
| **Taking Medication** | TM1 | enable me to track the type of drug or medication to take |
| | TM2 | allow me to set reminders for taking medication |
| | TM3 | enable me to comply with healthcare provider’s recommended medicines and dosages |

| Table A.7. Affordances of Mobile Technologies in Diabetes Management (Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Reducing Risks and Problem Solving** | | Mobile apps and/or devices you are currently using or have used in the past… |
| | RRPS1 | provide me information about diabetes related risks |
| | RRPS2 | enable me to get important information about preventive care |
| | RRPS3 | help me understand why I am taking medication and its importance to my health |
| | RRPS4 | help me avoid complications and worsening disease condition |
| | RRPS5 | help me understand how each aspect of my daily routine affects my disease |
| | RRPS6 | help me in understanding my disease and treatment options |
| | RRPS7 | allow me to know that to do when my blood sugar level is low or high |
| | RRPS8 | provide me with information to solve diabetes related problems |
| | | |
| **Being Active and Healthy Eating** | BAHE1 | allow me to track calories burned during exercising |
| | BAHE2 | provide information such as nutrition facts on diabetic-friendly foods (fruits, vegetables, meat, etc.,) and/or meals I consume |
| | BAHE3 | enable me to set and/or track my exercising or activity goals |
| | BAHE4 | enable to track food and nutrition consumption |
| | BAHE5 | enable me to know about portion size of foods and/or meals for healthy diabetic diet |
| | BAHE6 | enable me to track the amount of exercise (e.g., time spent, steps walked, etc.,) |
| | BAHE7 | make recommendations about type of exercises (such as walking, running, bicycling, swimming, etc.,) |
| | BAHE8 | help me know about foods (such as fruits, vegetables, and meat) and/or meals not suitable for my health condition |
| | | |
| **Healthy Coping** | HC1 | provide information to share with other diabetics |
| | HC2 | enable me to seek support from the members of social groups who are experiencing diabetes |
| | HC3 | make it possible to get data to interact with others who are going through similar problems |
| **Monitoring** | MO1 | enable me to share information about measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) with people who care for me (For example., family members, healthcare provider, friends, etc.) |
| | MO2 | allow me to monitor measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) |
| | MO3 | enable me to track changes in measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) |
| | MO4 | allow me to see trends based upon the time of day |
| **Taking Medication** | TM1 | enable me to track the type of drug or medication to take |
| | TM2 | allow me to set reminders for taking medication |
| | TM3 | enable me to comply with healthcare provider's recommended medicines and dosages |

| Table A.8. Items for other constructs (Non-Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Intention to Adopt** | INT1 | I intend to start using mobile apps and/or devices for managing diabetes in the next couple of months |
| | INT2 | I would be interested in using mobile apps and/or devices for managing diabetes in the next couple of months |
| | INT3 | I predict I would adopt and start using mobile apps and/or devices for managing diabetes in the next couple of months |
| | INT4 | I plan to adopt and start using mobile apps and/or devices for managing diabetes in the next couple of months |
| | | |
| **Perceived Usefulness** | PU1 | I believe using diabetes related mobile apps and/or devices improves my diabetes management |
| | PU2 | I think using diabetes related mobile apps and/or devices enhances my effectiveness in managing diabetes |
| | PU3 | I believe diabetes related mobile apps and/or devices are useful in managing diabetes |
| | | |
| **Perceived Ease of Use** | PEU1 | I think interacting with diabetes related mobile apps and/or devices does not require a lot of my mental effort |
| | PEU2 | I believe diabetes related mobile apps and/or devices are easy to use |
| | PEU3 | I believe it is easy to get diabetes related mobile apps and/or devices to do what I want them to do |

| Table A.9. Items for other constructs (Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Intention to Continue to Use** | ICU1 | I intend to continue using mobile apps and/or devices for managing diabetes |
| | ICU2 | I want to continue using mobile apps and/or devices for managing diabetes rather than discontinue |
| | ICU3 | I predict I will continue using mobile apps and/or devices for managing |
| | ICU4 | I plan to continue using mobile apps and/or devices for managing diabetes in future |
| | ICU5* | I don't intend to continue using mobile apps and/or devices for managing diabetes in future |
| | | |
| **Usefulness** | U1 | Using diabetes related mobile apps and/or devices improves my diabetes management |
| | U2 | Using diabetes related mobile apps and/or devices enhances my effectiveness in managing diabetes |
| | U3 | I find diabetes related mobile apps and/or devices are useful in managing diabetes |
| | | |
| **Ease of Use** | EOU1 | Interacting with diabetes related mobile apps and/or devices does not require a lot of my mental effort |
| | EOU2 | I find diabetes related mobile apps and/or devices to be easy to use |
| | EOU3 | I find it is easy to get diabetes related mobile apps and/or devices to do what I want them to do |

* Reverse coded. Later removed because of low factor loading

| Table A.10. Items for Common Constructs (Non-Users and Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Personal Innovativeness** | PI1 | If I hear about a new mobile app and/or device, I would look for ways to experiment with it |
| | PI2 | Among my peers, I am usually the first to try out new mobile apps and/or devices |
| | PI3* | In general, I am hesitant to try out new mobile apps and/or devices |
| | PI4 | I like to play with new mobile apps and/or devices whenever I get an opportunity |
| | | |
| **Illness Representation** | IR1 | How much does your diabetes affect your life? |
| | IR2 | How long do you think your diabetes will continue? |
| | IR3 | How much control do you feel you have over your diabetes? |
| | IR4 | How much do you think your treatment can help your diabetes? |
| | IR5 | How much do you experience symptoms from your diabetes |
| | IR6 | How concerned are you about your diabetes? |
| | IR7 | How well do you feel you understand your diabetes? |
| | IR8 | How much does your diabetes affect you emotionally (e.g., does it make you angry, scared, upset, or depressed)? |

Appendix B

Construct Definitions and Instrument Items Used in Paper-2

| Table B.1. Construct Definitions | |
|---|---|
| **Dimension** | **Definitions/Concepts/Ideas** |
| | |
| **Perceived Ease of Use** | The extent to which an individual (diabetes patient) believes that using mobile technologies for diabetes self-management would be effortless (Davis, 1989; Venkatesh et al., 2003) |
| **Perceived Usefulness** | The degree to which an individual (diabetes patient) believes that using mobile technologies would improve his or her diabetes self-management (Davis, 1989; Venkatesh et al., 2003) |
| **Intention to Use** | The extent to which an individual (diabetes patient) intends to adopt mobile technologies for managing his or her diabetes (Venkatesh and Davis, 2000; Venkatesh et al., 2003) |
| **Ease of Use** | The extent to which using mobile technologies for diabetes management is free of effort based on actual experience of an individual (diabetes patient) (Venkatesh and Davis, 2000; Venkatesh et al., 2003) |
| **Usefulness** | The extent to which mobile technologies are useful in managing diabetes (Venkatesh and Davis, 2000; Venkatesh et al., 2003) |
| **Intention to Continue to Use** | The extent to which an individual (diabetes patient) intends to continue to use mobile technologies for managing diabetes (Bhattacherjee, 2001; Venkatesh and Goyal, 2010) |
| **Perceived Health Status** | The extent to which an individual (diabetes patient) perceives his or her health status in terms of symptoms, timeline, consequence, severity, and emotional impact (adapted from Broadbent et al., 2006) |
| **Perceived Health Control** | The extent to which an individual (diabetes patient) perceives that he or she is in control their health (adapted from Broadbent et al., 2006) |

| Table B.2. Instruments Items (Non-Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Intention to Adopt** | INT1 | I intend to start using mobile apps and/or devices for managing diabetes in the next couple of months |
| | INT2 | I would be interested in using mobile apps and/or devices for managing diabetes in the next couple of months |
| | INT3 | I predict I would adopt and start using mobile apps and/or devices for managing diabetes in the next couple of months |
| | INT4 | I plan to adopt and start using mobile apps and/or devices for managing diabetes in the next couple of months |
| **Perceived Usefulness** | PU1 | I believe using diabetes related mobile apps and/or devices improves my diabetes management |
| | PU2 | I think using diabetes related mobile apps and/or devices enhances my effectiveness in managing diabetes |
| | PU3 | I believe diabetes related mobile apps and/or devices are useful in managing diabetes |
| **Perceived Ease of Use** | PEU1 | I think interacting with diabetes related mobile apps and/or devices does not require a lot of my mental effort |
| | PEU2 | I believe diabetes related mobile apps and/or devices are easy to use |
| | PEU3 | I believe it is easy to get diabetes related mobile apps and/or devices to do what I want them to do |

| Table B.3. Instrument Items (Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Intention to Continue to Use** | ICU1 | I intend to continue using mobile apps and/or devices for managing diabetes in future |
| | ICU2 | I want to continue using mobile apps and/or devices for managing diabetes in future rather than discontinue |
| | ICU3 | I predict I will continue using mobile apps and/or devices for managing diabetes in future |
| | ICU4 | I plan to continue using mobile apps and/or devices for managing diabetes in future |
| | ICU5* | I don't intend to continue using mobile apps and/or devices for managing diabetes in future |
| **Usefulness** | U1 | Using diabetes related mobile apps and/or devices improves my diabetes management |
| | U2 | Using diabetes related mobile apps and/or devices enhances my effectiveness in managing diabetes |
| | U3 | I find diabetes related mobile apps and/or devices are useful in managing diabetes |
| **Ease of Use** | EOU1 | Interacting with diabetes related mobile apps and/or devices does not require a lot of my mental effort |
| | EOU2 | I find diabetes related mobile apps and/or devices to be easy to use |
| | EOU3 | I find it is easy to get diabetes related mobile apps and/or devices to do what I want them to do |

* Reverse coded. Later removed because of low factor loading

| Table B.4. Items for Common Constructs (Non-Users and Users) | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| | | |
| **Perceived Health Control** | IR3 | How much control do you feel you have over your diabetes? |
| | IR4 | How much do you think your treatment can help your diabetes? |
| | IR7 | How well do you feel you understand your diabetes? |
| **Perceived Health Status** | IR1 | How much does your diabetes affect your life? |
| | IR2 | How long do you think your diabetes will continue? |
| | IR5 | How much do you experience symptoms from your diabetes |
| | IR6 | How concerned are you about your diabetes? |
| | IR8 | How much does your diabetes affect you emotionally (e.g., does it make you angry, scared, upset, or depressed)? |

# Appendix C

## Construct Definitions and Instrument Items Used in Paper-3

| Table C.1. Construct Definitions | |
|---|---|
| **Dimension** | **Definitions/Concepts/Ideas** |
| **Affordances of Mobile Technologies in Diabetes Self-Management** | |
| | "The potential for action required by the individual for accomplishing AADE recommended diabetes self-care behaviors." (Volkoff and Strong, 2013) |
| **Problem Solving and Reducing Risks** | Definition for each of the sub-dimension of the construct<br>The extent to which mobile apps and devices afford diabetics<br>1) the opportunity to solve daily problems or stressors caused by the disease and reduce the risk of developing other complications.<br>2) develop healthy eating habits and maintain an active lifestyle<br>3) positively cope with their illness<br>4) the opportunity to monitor their biomarkers (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, A1C)<br>5) the opportunity to adhere to the recommended treatment regimen |
| **Autonomy Support** | |
| | The extent to which the performance benefits of mobile apps and devices are realized is largely reflected in the level at which the individual has incorporated the technology within his or her life. (Adapted from Sundaram et al., 2007) |
| **Frequency** | The degree to which the person uses the mobile technologies for managing his/her diabetes |
| **Routinization** | The degree to which the person adapts to mobile technologies usage or incorporates it into his or her daily routine. |
| **Infusion** | The degree to which the person maximizes the potential of the mobile technologies for managing his/her diabetes |
| **Patient Empowerment** | |
| | The degree to which patients are enabled to actively engage in the self-management of diabetes (Anderson and Funnell, 2000; 2010). |
| **Subjective Well-being** | |
| | Patients' subjective assessment of their overall quality of life at emotional and physical level. |

| Table C.2. Instrument Items | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| **Affordances of Mobile Technologies in Diabetes Self-Management** | | |
| **Reducing Risks and Problem Solving** | | Mobile apps and/or devices you are currently using or have used in the past… |
| | RRPS1 | provide me information about diabetes related risks |
| | RRPS2 | enable me to get important information about preventive care |
| | RRPS3 | help me understand why I am taking medication and its importance to my health |
| | RRPS4 | help me avoid complications and worsening disease condition |
| | RRPS5 | help me understand how each aspect of my daily routine affects my disease |
| | RRPS6 | help me in understanding my disease and treatment options |
| | RRPS7 | allow me to know that to do when my blood sugar level is low or high |
| | RRPS8 | provide me with information to solve diabetes related problems |
| | | |
| **Being Active and Healthy Eating** | BAHE1 | allow me to track calories burned during exercising |
| | BAHE2 | provide information such as nutrition facts on diabetic-friendly foods (fruits, vegetables, meat, etc.,) and/or meals I consume |
| | BAHE3 | enable me to set and/or track my exercising or activity goals |
| | BAHE4 | enable to track food and nutrition consumption |
| | BAHE5 | enable me to know about portion size of foods and/or meals for healthy diabetic diet |
| | BAHE6 | enable me to track the amount of exercise (e.g., time spent, steps walked, etc.,) |
| | BAHE7 | make recommendations about type of exercises (such as walking, running, bicycling, swimming, etc.,) |
| | BAHE8 | help me know about foods (such as fruits, vegetables, and meat) and/or meals not suitable for my health condition |
| | | |
| **Healthy Coping** | HC1 | provide information to share with other diabetics |
| | HC2 | enable me to seek support from the members of social groups who are experiencing diabetes |
| | HC3 | make it possible to get data to interact with others who are going through similar problems |
| **Monitoring** | MO1 | enable me to share information about measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) with people who care for me (For example., family members, healthcare provider, friends, etc.) |
| | MO2 | allow me to monitor measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) |
| | MO3 | enable me to track changes in measurable indicators (such as blood glucose, weight, blood pressure, BMI, Waist Circumference, etc.,) |
| | MO4 | allow me to see trends based upon the time of day |
| **Taking Medication** | TM1 | enable me to track the type of drug or medication to take |
| | TM2 | allow me to set reminders for taking medication |
| | TM3 | enable me to comply with healthcare provider’s recommended medicines and dosages |

| Table C.3. Items for Level of Use | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| **Level of Use** | | |
| **Frequency** | FREQ1 | On average, how many times have you been using mobile apps and/or devices in managing diabetes<br>□□Once a month □□Once a week □□A few times a week □ Once a day □ Several times a day |
| | FREQ2 | How frequently have you been using mobile aps and/or devices in managing diabetes<br>□□Never □□Rarely □□Sometimes □ Very Often □ Always |
| | | |
| **Routinization** | ROUT1 | My use of mobile apps and/or devices has been incorporated into my regular daily diabetes management schedule |
| | ROUT2 | My use of mobile apps and/or devices is pretty much integrated as part of my normal routine of diabetes management |
| | ROUT3 | My use of mobile apps and/or devices is a normal part of my daily life |
| | | |
| **Infusion** | INFU1 | I am using mobile apps and/or devices to their fullest potential for supporting my diabetes management activities |
| | INFU2 | I am using all capabilities of mobile apps and/or devices in the best fashion to help me manage diabetes |
| | INFU3 | I doubt that there are any better ways for me to use mobile apps and/or devices to support my diabetes management activities |
| | INFU4 | My use of mobile apps and/or devices has been integrated and incorporated at the highest possible level |

| Table C.4. Items for Subjective Well-Being | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| **Subjective Well-Being** | | |
| **Emotional Well-Being** | | Please indicate how you have been feeling over the last two weeks |
| | ESWB1 | I've been feeling cheerful and optimistic about the future |
| | ESWB2 | I've not been feeling useful |
| | ESWB3 | I've been able to make up my mind about things |
| | ESWB4 | I've not been dealing with problems well |
| | | |
| **Physical Well-Being** | PSWB1 | I don't feel active or vigorous |
| | PSWB2 | I feel full of energy |
| | PSWB3 | I feel exhausted and tired |
| | PSWB4 | I have been well rested and relaxed |

| Table C.5. Items for Diabetes Empowerment | | |
|---|---|---|
| **Scale** | **Item** | **Question** |
| **Diabetes Empowerment** | | In general, I believe that I: |
| | DEMP1** | …know what part(s) of taking care of my diabetes that I am dissatisfied with |
| | DEMP2 | … am able to turn my diabetes goals into a workable plan |
| | DEMP3 | … can try out different ways of overcoming barriers to my diabetes goals |
| | DEMP4 | … can find ways to feel better about having diabetes |
| | DEMP5 | … know the positive ways I cope with diabetes-related stress |
| | DEMP6 | … can ask for support for having and caring for my diabetes when I need it |
| | DEMP7 | … know what helps me stay motivated to care for diabetes |
| | DEMP8 | … know enough about myself as a person to make diabetes care choices that are right for me |
| ** Removed due to low factor loading | | |

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