2017

Integrating Behavioral Trigger Messages into a mHealth System Design for Chronic Disease Management

Scott Sittig

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Integrating Behavioral Trigger Messages into a mHealth System Design for Chronic Disease Management

By

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Integrating Behavioral Trigger Messages into a mHealth System Design for Chronic Disease Management

A Dissertation

Presented to the Faculty of
The University of Texas
Health Science Center at Houston
School of Biomedical Informatics
in Partial Fulfilment of the Requirements for the Degree of
Doctor of Philosophy

By
Scott Sittig, MHI, RHIA

University of Texas Health Science Center at Houston
2017

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Dedication

This dissertation is dedicated to my wife Danielle who encouraged me to continue with my studies and supported me during this remarkable journey. She sacrificed countless hours of her own time in an effort to provide me with opportunities to conduct my research. In addition, I would like to dedicate this dissertation to my parents Ray and Wanda who constantly encouraged me to complete my degree and never failed to mention how proud of me they were. Finally, I would like to dedicate this dissertation to my three children: Kennedy, Andrew and Alex. I hope they can reflect on my journey one day and know that they too can accomplish their dream goal(s).
Acknowledgements

Through this dissertation process I have grown intellectually and have gained a new appreciation for the dedication and skillset needed to conduct research in the biomedical informatics arena.

First of all, I would like to thank my advisor Amy Franklin, for her remarkable guidance and support during this process. She was always there for me whether I needed research design assistance or simply a positive counselling session to continue pushing forward. I would also like to thank my committee members: Sriram Iyengar, Sahiti Myneni and Jing Wang for their guidance and notable assistance. In addition, I would like to thank all of the faculty at the UTHSC School of Biomedical Informatics who provided me with an incredible education and shaped my ideology of biomedical informatics.

I would also like to thank the University of Louisiana at Lafayette for supporting me and allowing me complete my dissertation work while being employed full-time. In particular, I would like to thank Melinda Oberleitner for her continued support and mentorship throughout my journey.

I would like to thank all of the participants who took part in the study. Without them, my research does not exist. In addition, I would like to thank Lafayette General Health for allowing me to conduct research under their umbrella.

Finally, I would like to thank my many friends and family members who have supported me throughout the course of this dissertation process. I would like to specifically mention, Susan Fenton, Oscar Pinzon, Lisa Delhomme, Lisa Broussard, and Helen Hurst.
Abstract

Recent changes in health information technology have dramatically altered the face, delivery, and management of healthcare particularly as it relates to mHealth. With increases in smart phone ownership, mHealth potentially has the ability to provide far-reaching transformation of chronic disease management particularly when aligned with behavioral change theories and persuasive technology. MHealth applications have an advantage over computers and various print communications as the consumer can engage with the application at any time and at any location. The Interactive Health Communication Application (IHCA) states that by combining support mechanisms such as behavior change theories into electronic devices as a method to transmit or receive health information can potentially lead to changes in knowledge, motivation and self-efficacy. Adding constructs of the Fogg Behavior Model, Social Cognitive Theory and Persuasive Technology to the IHCA framework can create an engaged persuasive system leading to improvements in self-efficacy, self-management and knowledge. The hypotheses for our study are 1) participants will demonstrate improved scores on self-efficacy, knowledge and self-management following the intervention period, 2) participants will be more engaged in the usage of capABILITY following behavioral triggers, and 3) participants who receive spark triggers involving motivation will engage in the utilization of capABILITY faster than those who receive facilitator triggers.

The results of this study provide important findings for 1) mHealth system design utilizing IHCA with new constructs for chronic disease management, 2) design and develop of persuasive spark and facilitator trigger messages, and 3) understanding of user
engagement when behavioral (spark and facilitator) trigger messages are utilized. The findings of the study revealed that self-efficacy, self-management, and knowledge did improve post intervention. In addition, the study showed that spark triggers continually cued participants to engage with capABILITY quicker than facilitator triggers.
Vita

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Field of Study

Health Informatics
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Chapter 1: Introduction

The implementation of the Medicare Access and CHIP Reauthorization Act (MACRA) in 2017 has changed the landscape of healthcare. MACRA replaces the Physician Quality Reporting System and Meaningful Use mandates. Under MACRA, medical providers will have to rely more heavily on health IT to meet new quality, clinical practice initiatives and meaningful use of certified electronic health record systems criteria (Clough & McClellan, 2016). These changes bring forth critical areas that must be improved through the use of health informatics such as: the need to utilize advanced analytics and data mining including self-management systems, promoting mHealth use to spurn mobile service innovations for chronic disease conditions and creating mHealth modules that incorporate behavior change theory (Burner, Menchine, Kubicek, Robles, & Arora, 2014; El-Gayar, Timsina, Nawar, & Eid, 2013; Pal et al., 2013; Rai, Chen, Pye, & Baird, 2013).

There is an increasing use of mobile health (mHealth), sensing technology, registries using data repositories to electronic health record systems and claims databases for patients with chronic disease. Patients are now being asked to take an active role in the management of their chronic disease processes. With a shift in reimbursement tied to quality outcomes versus the traditional volume of patients being seen, models of how healthcare is managed are changing. By leveraging the diffuse permeation of smartphones we can create theoretically driven mHealth solutions. These solutions would engage patients in their chronic disease management while ultimately targeting sustainable behavior change in an effort to ease the burden of chronic disease
management.

Understanding how to engage patients (consumers) in their own behavior and health management, particularly as it relates to self-management for chronic conditions, is a daunting task. However, through the use of mHealth we are able to design new techniques to promote patient engagement which includes combining theoretical principles from behavior change and persuasive technology into existing mHealth design architectures (Jepson, Harris, Platt, & Tannahill, 2010; Murray, Burns, See, Lai, & Nazareth, 2005; Yu et al., 2012). Utilizing persuasive technology in which the patient interacts with an mHealth application while receiving relevant feedback can promote user engagement, improve motivation and can bolster patient’s belief in their own ability to manage (self-efficacy) their complex chronic health condition. (Chatterjee & Price, 2009; Mohr, Schueller, Montague, Burns, & Rashidi, 2014). Self-efficacy refers to a person’s belief that he/she can accomplish a task to produce a given outcome and has been shown to lead to positive behavior change and improved clinical outcomes particularly in patients with chronic illnesses (i.e. diabetes mellitus) (Ahola & Groop, 2013; Gao, Wang, Zhu, & Yu, 2013; Trief, Teresi, Eimicke, Shea, & Weinstock, 2009).

By virtue of its connectivity and portability, mHealth has the ability to keep patients engaged in the management of their chronic disease(s) in-between clinical visits, particularly, when focused on improving their belief that they can self-manage their disease. This is due to the ability to easily distribute mhealth interventions that patients need/want and display desired information in an easily understandable manner (El-Gayar et al., 2013; Pal et al., 2013). Mhealth solutions that focus on chronic disease can be
integrated into larger healthcare environments such as hospital systems and managed care organizations for easy distribution to improve self-efficacy in these particular patients.

There is a growing need to integrate mHealth within hospital infrastructures and to identify mHealth solutions based on perceived health conditions. Targeting receptive consumers/patients via perceived health conditions such as diabetes within a health IT system can potentially encourage broadly implemented interventions (El-Gayar et al., 2013; Rai et al., 2013). Hospital systems and managed care organizations have a magnitude of health data residing in their health IT systems, which can be used to target consumers based on perceived health conditions and create mHealth applications that increase a sense of personalization based on these perceived health conditions. Although systems such as medical claims databases have historically been utilized for administrative functions such as predicting hospital readmissions, these data sets can aid in the development of mHealth tools to create mHealth applications which can improve self-care within a population such as individuals with chronic disease (He, Mathews, Kalloo, & Hutfless, 2014). We believe that incorporating persuasive techniques such as tunneling and trigger messages in combination with behavior change theories in a mHealth application will enhance the consumers’ sense of personalization and utilization of mHealth. In addition, the inclusion of both persuasive technology and behavior change theories into a mHealth application can potentially improve the adoption and overall wide-spread use of these applications (El-Gayar et al., 2013).

Previous published work on mHealth for chronic disease has shown promise in the areas of improving self-efficacy and self-management however these were studies of
short duration and did not included persuasive triggers messages but rather just simple reminder messages (i.e. text messages) (Arora, Peters, Agy, & Menchine, 2012; Faridi et al., 2008; Lawrence Fisher & Dickinson, 2011). In addition, integration of behavior change theories into mHealth applications has proven effective in the design and outcomes of recent studies (Kelders, Kok, Ossebaard, & Gemert-Pijnen, 2012; McMahon, Vankipuram, Hekler, & Fleury, 2014; Tufano & Karras, 2005). Utilization of IHCA frameworks have shown to be effective for chronic (i.e. type II diabetes) disease management as it relates to knowledge and self-efficacy (Murray et al., 2005; Weymann, Dirmaier, Wolff, Kriston, & Härter, 2015; Weymann, Härter, Petrak, & Dirmaier, 2013). Even with these critical breakthroughs in mHealth there are still gaps as it relates mHealth for chronic disease management. These gaps include: designing theoretically grounded mHealth application utilizing a user-centered design for chronic disease self-management, embedding multiple theoretical constructs such as persuasive technology and behavior change theories into a mHealth system design, and utilization of behavioral trigger messages instead of simple reminder messages for cueing specific behavioral tasks.

For this study, we focused on integrating theories of behavior change (Social Cognitive Theory), Fogg Behavior Model and persuasive technology into an IHCA framework focused mHealth application called capABILITY. In addition, we developed two sets of behavioral triggers messages called sparks and facilitators which focused on highlighting motivation and ability (Fogg, 2009). We focused on a population of individuals with type 2 diabetes as an example of a group with chronic disease that could
potentially benefit from such an application. We designed capABILITY through a user-centered approach in order to improve self-efficacy, knowledge and self-care in individuals with type II diabetes. It is important to note that only the educational content is related to type II diabetes so capABILITY has the potential to be replicated in other chronic disease cases by simply changing out the educational content.

I believe that by incorporating Social Cognitive Theory, Fogg Behavior Model and persuasive technology into the IHCA construct for mHealth design that we can improve self-efficacy, self-management and knowledge for individuals with chronic disease. I also believe that behavioral triggers hold the key to cueing specific behavioral tasks and engagement within a mHealth application. To answer these questions we need to understand the impact of capABILITY and the impact of different types of triggers on behavior. To that end, we will explore the following hypotheses: 1) We hypothesize that after the capABILITY intervention, participants will demonstrate improved scores on self-efficacy, knowledge and self-management, 2) We hypothesize that following the persuasive technology framework, participants will be more engaged in the usage of capABILITY following a behavioral trigger and 3) We hypothesize that following the persuasive technology framework, participants who receive spark triggers involving motivation will engage in the utilization of capABILITY faster than those who receive facilitator triggers.
Chapter 2: Literature Review – Theoretical and guiding support for a persuasive mHealth application for chronic disease management

Utilization of mHealth as a mechanism to engage consumers in their healthcare particularly that of chronic disease management continues to gain momentum. Theoretical and guiding support for the design of a mHealth application to improve self-efficacy, knowledge and self-care measures in chronic disease falls within three domains: 1) mHealth and persuasive technology, 2) behavior change theory and self-efficacy, and 3) chronic disease management (focus on type II diabetes).

mHealth and persuasive technology

Interest in mHealth technology and usage is growing rapidly due to the increase in ownership of mobile devices. As of September 2015, 165,000 healthcare related mobile applications were available for download (“How many health apps actually matter?,” 2015). The volume of these programs reflects the hope and interest in the ability of mHealth to transform healthcare (Andrew, Borriello, & Fogarty, 2007; Connelly, Faber, Rogers, Siek, & Toscos, 2006; Fogg, BJ, 2002; Iyengar, Florez-Arango, & Garcia, 2009; Revere & Dunbar, 2001). Due to this widespread smart phone dissemination, mHealth potentially has the ability to provide far-reaching transformation of healthcare particularly when aligned with behavior change theories and persuasive technology (Andrew et al., 2007; Blanson Henkemans et al., 2009; Connelly et al., 2006; Fogg, BJ, 2002; Iyengar et al., 2009).

Definitions of mHealth may vary, however, generally it is defined as the utilization of mobile phones and other mobile devices to provide public health or medical
interventions (Arora et al., 2012). These devices can include mobile phones, tablets, blue-tooth medical devices, personal digital assistants or any other type of wireless device. These technologies have the ability to support health monitoring at the individual and population level in regards to supporting chronic disease self-management, promote behavior change, and provide personalized ready for access interventions that have not been recently possible (Kumar et al., 2013). This is particularly due to an individual being able to access their mHealth intervention at any given point since most individuals have constant access to their smartphone.

mHealth applications have been shown to be effective in advancing self-management for chronic disease such as diabetes (Arora et al., 2012; Lawrence Fisher & Dickinson, 2011; Kumar et al., 2013; Vodopivec-Jamsek, de Jongh, Gurol-Urganci, Atun, & Car, 2012). For example, in Faridi et al’s study providing type 2 diabetics with daily text messages helped to improve their self-care behavior including improved self efficacy and trends towards better HbA1c levels (Faridi et al., 2008).

MHealth applications have an advantage over computers and various print communications because they are available at any time and any place (Revere & Dunbar, 2001). These systems can engage with users without requiring initiation of action by the patient. The push of messages to consumers can assist in behavior change modification. However, the inclusion of theory is often overlooked in the overall design (van Vugt, de Wit, Cleijne, & Snoek, 2013) of such system. When included, behavior change theories, such as Social Cognitive Theory (focus on self-efficacy) and Health Belief Model, are effective in the user engagement of mHealth applications (McMahon et al., 2014; Tufano
Persuasive technology (Fogg, 2009; Kelders et al., 2012) provides a framework of including behavioral trigger messages and tunneling designs in such systems. A successful development of behavior change theories into mHealth through the use of persuasive technology which creates behavior change techniques will hopefully lead to: reinforcement of behavior, change in attitude/belief and ultimately a change in behavior (Oinas-Kukkonen & Harjumaa, 2008).

We evaluated the Interactive Health Communication Applications (IHCA) Framework to determine if the incorporation of Social Cognitive Theory, Fogg Behavior Model and Persuasive Technology into a single mHealth application (See Figure 1) was plausible. We feel that this particular combination of theoretical constructs will lead to improvements in self-efficacy, knowledge and self-management.

Figure 1. IHCA Construct
The Interactive Health Communications Application (IHCA) Framework focuses on “the interaction between a consumer (patient) with an electronic device/communication device (mHealth) to access/transmit health information or receive guidance and support on a health-related issue” (Murray et al., 2005). Interactive Health Communication Applications combine health information with at least one additional service such as decision support, behavior change or peer support. Such applications have been shown to be effective particularly in increasing self-efficacy (Murray et al., 2005). This delivery mechanism also supports personalization and fosters self-management competencies (Murray et al., 2005; Weymann, Härter, & Dirmaier, 2013).

Creating behavioral change techniques through persuasive design can take on many forms. The persuasive system design by Oinas-Kukkonen and Harjumaa is categorized into the following features: primary task support, dialogue support, credibility support and social support (Lehto & Oinas-Kukkonen, 2011; Oinas-Kukkonen & Harjumaa, 2008). Following these types of persuasive design features is important as individuals often know that a particular behavior is good for them to adhere to but actually sustaining this beneficial behavior is difficult. Many individuals face similar road blocks in their attempt to sustain a healthy behavior such as: lack of motivation, lack of ability and inability to be reminded to perform a specific behavior (Fogg, 2009; Koldijk, Kraaij, & Neerincx, 2016).

Persuasive technology can assist in delivering these behavioral change techniques by triggering behaviors through explicit messages such as: “deliver messages at the right time”, provide “reminders” and use “badges as incentives for goal(s) accomplishment”
(Chatterjee & Price, 2009). These triggers can be comprised of text messages, alarms, notifications, etc. Triggers facilitate the performance of specific behavior or can be used to alter behaviors (Fogg, 2009). Delivering triggers is a process and not as a single act (Kelders et al., 2012; Torning & Oinas-Kukkonen, 2009) or a basic reminder (Burner et al., 2014). Well-designed trigger messages help individuals accomplish smaller behavioral tasks. Their impact is how triggers facilitate the development of self-efficacy through success on small tasks which leads to support in accomplishing the larger tasks needed in chronic disease management (Mohr et al., 2014).

The Fogg Behavior Model (FBM) provides a framework of behavior change through persuasive technology. The FBM states that the prerequisites for a behavior include 1) sufficient motivation, 2) ability to perform the behavior, and 3) reminders to perform the behavior (Fogg, 2009). Fogg proposes that triggers at each of these stages can support behaviour change. While the FBM model specifies the need for these triggers, little is known about the variability and interaction across trigger types.

In Fogg’s Behavior Model he identifies three prerequisites as well as three specific types of triggers called: sparks, facilitators and signals (Fogg, 2009). A spark trigger is designed for individuals who lack motivation, a facilitator trigger is designed for individuals who lack ability and a signal is simply a reminder message to perform a specific behavior (Fogg, 2009). Research has shown that individuals usually identify with behavioural triggers messages such as motivational cues when they are delivered (Burner et al., 2014). In many cases, reminder messages have been added to existing or developed behavior change interventions to serve as cues but don’t necessarily have behavioural
constructs embedded in them (Lee, Koopmeiners, Rhee, Raveis, & Ahluwalia, 2014; Steinberg, Levine, Askew, Foley, & Bennett, 2013; Tabak, op den Akker, & Hermens, 2014). Many individuals want to make a distinct lifestyle change (i.e. patient with chronic disease) however they may lack the motivation to consistently stick with the new behavior (Dennison, Morrison, Conway, & Yardley, 2013). Developing triggers through a framework like the FBM can help individuals achieve the type of motivation or increase in ability that they need to accomplish a specific behavior.

**Timing of messages**

Trigger messages are often delivered with 3 – 5 messages per week however this frequency varies by the type of mHealth study (Abroms, Whittaker, Free, Mendel Van Alstyne, & Schindler-Ruwisch, 2015; Heffernan et al., 2016). Frequency and timing are dependent on the type of mHealth study and should be mindful of message fatigue (Abroms et al., 2015; Fogg, 2009.) For example, it would not be recommended to send a spark trigger to motivate eating a healthy meal at every mealtime. In addition, a thorough understanding of the study population receiving these triggers should be examined. For instance, if everyone worked at night you would not want to send trigger messages during the day while they are sleeping.

**Personalization**

In addition, persuasive technology can support mHealth applications by increasing personalization attributes (Heffernan et al., 2016)(Burner et al., 2014). In a recent systematic review of adherence to web-based interventions it was discovered that primary task support elements within persuasive technology such as personalization was employed
in interventions aimed at chronic conditions which ultimately improved adherence to the intervention (Kelders et al., 2012). This is an important finding as keeping individuals engaged in an mHealth intervention is key to being able to evaluate its effectiveness. As the use of mHealth tools attempts to reach broader audiences with less direct personalization, it will become necessary to better understand the parameters of how this target works. For instance, utilizing PGHD can create a sense of personalization while also building on improving self-efficacy.

**Patient Generated Health Data**

One current method of personalization is to allow individuals to enter their own data. This includes the ability to key in patient-generated health data (PGHD) such as: weight, blood glucose, caloric intake, exercise logs, etc. This PGHD can then be used to provide feedback to users in graphs, tables and other goal-based displays (Choe, Lee, Munson, Pratt, & Kientz, 2013; Hartzler et al., 2014). The input of PGHD must be easy and free of barriers in order to support use (Heffernan et al., 2016). This is where a user-centered design approach could be implemented to further understand how the users would like to visualize the input characteristics to insure accurate data logging while improving simplicity.

Currently, there are very few mHealth applications that incorporate behavior change theory and persuasive technology into one mHealth application. The mHealth application that we developed incorporate aspects from Social Cognitive Theory, Fogg Behavior Model and Persuasive Technology. We utilized PGHD, spark triggers and facilitator triggers as a guided persuasive feedback framework. This allowed the participants to feel
connected to the mHealth tool which we feel will lead to a greater capacity of persuasion to improve self-efficacy, knowledge and self-care measures. The incorporation of behavior change theory and persuasive technology into a single mHealth application is not without its challenges.

**Behavior change theory and self-efficacy**

Utilization of PGHD, persuasive technology and trigger messages within a mHealth tool adds a promising new informatics component to engaging the patient. However, in order to get to the root-cause of poor chronic disease management, we must also address behavior change.

In life we are challenged with individualized obstacles that require us to overcome and persevere. People with chronic disease have the additional burden of self-managing their disease processes every day. In order to succeed in overcoming these obstacles, individuals must believe that they are capable of successfully executing certain tasks.

Alfred Bandura defined self-efficacy as, “the beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments.” This belief in self is a critical component to behavior change (Bandura, 1977, 2001; Bandura, A, 1997).

Managing our health behaviors is a key component to reducing preventable disease and death particularly as it relates to chronic disease (Glanz, K., and Viswanath, K., 2008). The demand for those in health education and health behavior to facilitate behavior change continues to rise with a growing number of traditional and mHealth interventions to choose from (Glanz, K., and Viswanath, K., 2008). This, in itself presents several problems: determining which intervention to use, which behavior change
models would work best, is there evidence-based medicine to support its usage. Review of literature by preventative measure and chronic disease showcases a plethora of behavioral change models to choose from. There are a number of health behavior change models such as The Health Belief Model (HBM) and Social Cognitive Theory (SCT) that focus on increasing self-efficacy to change behavior (Glanz, K., and Viswanath, K., 2008). Both of these models work well in terms of helping individuals manage/control chronic diseases as they both consider self-efficacy a key concept in overall behavior change (Glanz, K., and Viswanath, K., 2008).

Social Cognitive Theory considers the unique way in which individuals acquire and maintain behavior through interaction with their social environment (Bandura, 1977, 2001). This is important in terms of managing a chronic disease such as type II diabetes as an individual must have the belief (self-efficacy) that have the ability to manage their disease to produce a desired outcome(s). Research has shown that the performance of many behaviors is determined by self-efficacy, especially those behaviors that are complex or difficult in nature (Bandura, A, 1997).

**Self-efficacy**

This ties into Bandura’s aforementioned belief that managing a complex process (i.e. chronic disease management) is associated with self-efficacy. Perceived self-efficacy is essentially a person’s belief that he/she can accomplish a task(s) to produce a given outcome. Self-efficacy beliefs can be developed in four ways according to Bandura: (1) mastery experience, (2) social modeling, (3) improving physical and emotional states, and (4) verbal persuasion (Bandura, A, 1997; Glanz, K., and Viswanath, K., 2008).
Mastery experience focuses on providing goals that are staggered in an increasingly challenging format, which allows for personal mastery of each goal (Bandura, 1977; Glanz, K., and Viswanath, K., 2008). Social modeling is used in an effort to show people that others like themselves are able to complete tasks that they need to accomplish without adverse consequences. Improving physical and emotional states refers to the effort of ensuring that people are relaxed and in a de-stressed environment prior to attempting a new behavior change (Bandura, 1977; Glanz, K., and Viswanath, K., 2008). Verbal persuasion is used in an attempt to influence behavior by telling a person that they can be successful (encouraging communication).

Self-efficacy has been targeted to promote behavior change in students, athletic functioning, phobias and career development however it is also used to change behavior in healthcare particularly that of individuals that have chronic diseases. Higher baseline self-efficacy scores have also been linked improvements in diabetes self-management task such as: diet, exercise and medication management (Al-Khawaldeh, Al-Hassan, & Froelicher, 2012; L. Fisher, Hessler, Maharani, & Strycker, 2014; Hurley & Shea, 1992; Tan, Magarey, Chee, Lee, & Tan, 2011; Wu et al., 2011).

Combining IHCA, FBM, and Social Cognitive Theory
Research has shown that interventions benefit from the incorporation of behavior change theory (Koldijk et al., 2016; McMahon et al., 2014). This includes provision of motivation which has been found to increase adherence as compared to interventions focused on knowledge and education (Minet, Møller, Vach, Wagner, & Henriksen, 2010; Webb, Joseph, Yardley, & Michie, 2010). The IHCA framework provides an
opportunity to merge FBM and SCT while utilizing persuasive technology to deliver behavioral trigger messages (See Figure 2). We feel that the aforementioned additions to the IHCA framework will allow for the creation of mHealth applications that focus on improving the complex management of chronic disease (i.e. type II diabetes).

![Interactive Health Communication Applications Framework](image)

Figure 2. IHCA with SCT, Fogg Behavior Model and Persuasive Technology
Chronic disease management (type II diabetes focus)

With chronic disease prevalence rates increasing more and more patients are being asked to take an active role in the management of their chronic disease(s). Creating mHealth solutions targeting specific chronic diseases such as type II diabetes can assist these individuals with their complex day-to-day management. As of 2012, almost half of the adult population in the United States (117 million people) has one or more chronic health conditions/diseases (Ward, Schiller, & Goodman, 2014). In addition, five out of the top ten causes of death in 2010 were attributed to chronic diseases of which diabetes was ranked seventh ("FastStats," n.d.).

Unlike with acute disease, individuals with chronic disease(s) must accept the fact that they play a significant role in the overall management of their disease process (Brady et al., 2013; Kroon et al., 2014). This process is part of the overall chronic disease management (CDM) that takes place between patients and clinicians. CDM has become an important instrument for improving not only individual patient outcomes but population level patient outcomes (Horswell et al., 2008). Even though research has shown that self-management tasks as part of the overall CDM is key to improving outcomes of chronic disease, medical care often fails to include intervention components that transition to a more effective self-management by the patient (Wagner, Austin, & Von Korff, 1996).

Diabetes

The two main types of diabetes mellitus are type 1 and 2. Type 1 diabetes is an autoimmune disease for which the immune system attacks and destroys insulin-producing
beta cells in the pancreas. Type 2 diabetes is the most common type of diabetes accounting for 90 to 95 percent of people who have diabetes. The total cost of diagnosed diabetes in the United States for 2012 was $245 billion and diabetes contributed to 69,701 direct deaths (“Diabetes | NIDDK,” n.d.).

Table 1

Diagnosed and undiagnosed diabetes among people aged 20 years or older, US, 2012

<table>
<thead>
<tr>
<th></th>
<th>Number with Diabetes (millions)</th>
<th>Percentage with Diabetes (unadjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 years or older</td>
<td>28.9</td>
<td>12.3</td>
</tr>
<tr>
<td>By Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 – 44</td>
<td>4.3</td>
<td>4.1</td>
</tr>
<tr>
<td>45 – 64</td>
<td>13.4</td>
<td>16.2</td>
</tr>
<tr>
<td>65 years or older</td>
<td>11.2</td>
<td>25.9</td>
</tr>
<tr>
<td>By Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15.5</td>
<td>13.6</td>
</tr>
<tr>
<td>Female</td>
<td>13.4</td>
<td>11.2</td>
</tr>
</tbody>
</table>

The number of newly diagnosed patients with type II diabetes mellitus is on the rise. Although there are continuing advances in the management of diabetes, suboptimal controls is still common (Clark, 2008). A key component of care is diabetes self-management education (DSME) (Funnell et al., 2010). A traditional DSME program includes clinical visits, diabetes group education sessions, individualized meetings with
dietitians, access to diabetes brochures and paper documentation logs for glycemic measurement, diet, exercise and medication intake (Chan, Wong, & Chan, 2012; Quinn et al., 2009). This approach presents significant challenges such as patient access to clinicians, sustainability, lack of knowledge, low perceived self-efficacy and ultimately sub-optimal long-term participation (Tang, Funnell, & Oh, 2012). With the evolution of mHealth we are able to breakdown these traditional barriers to provide DSME components via mHealth and engage the patient/consumer through a user centered approach that allows continuous access to materials (Bu et al., 2007; Dyer, 2013; Keselman, Logan, Smith, Leroy, & Zeng-Treitler, 2008; Tatar, Arsand, Skrøvseth, & Hartvigsen, 2013; Yu et al., 2012).

Although education is an important component in supporting management of chronic disease, self-efficacy also plays a strong role. Individuals with self-efficacy regarding their own self-care also have higher self-management scores (Dutton et al., 2009; Esden & Nichols, 2013; van der Heijden, Pouwer, Romeijnders, & Pop, 2012). Improving self-efficacy is vital to engaging individuals with chronic disease and improving their self-care management however very few research studies have been conducted to target a promotion in perceived self-efficacy (King et al., 2010; Ludman et al., 2013; Mann, Ponieman, Leventhal, & Halm, 2009; Nelson, McFarland, & Reiber, 2007; Wu et al., 2007). In order to improve the management of chronic disease such as type II diabetes mellitus, innovative solutions for wide spread self-efficacy enhancement and self-care management are needed (Piette, 2007).
Going beyond the individual

Leveraging health IT systems to create novel approaches to assist in creating chronic disease management strategies is necessary. Hospital systems and managed care organizations (MCO) have a robust amount of clinical and behavioral health data within their health IT systems and medical claims databases. Unfortunately, many of the existing health IT systems were not designed to manage population health and fully support chronic disease management (Joshua R. Vest et al., 2016). For instance, medical claims databases have routinely been utilized for surveillance of diseases rather than a tool to stimulate patient-centered care that engages the patient to take ownership of their chronic disease (Jones, Coulter, & Conner, 2013; Joshua R. Vest et al., 2016; Segal & DuGoff, 2014). With the implementation of the Affordable Care Act came provisions to utilize the Medicare system to implement Accountable Care Organizations (ACO) (Berwick, Nolan, & Whittington, 2008). For ACOs to control costs, they must improve patient experiences by managing healthcare at a population level. Health information technology can help facilitate identification of specific types of patients, create dashboards to support data mining and provide insight into adherence of existing programs (DeSalvo et al., 2014; Dixon, Jabour, Phillips, & Marrero, 2014; McAdam-Marx et al., 2014). Additionally, such programs can be used to support healthcare coordination and disease management with a focus on chronic disease management (Barnes, Unruh, Chukmaitev, & van Ginneken, 2014). The Medicare Access and CHIP Reauthorization Act (MACRA) focuses on population health-based clinical practice improvements and overall accountability beyond the individual patient encounter (Joshua
R. Vest et al., 2016). Essentially, we are moving from an individual care delivery model to a model that focuses on population health. New healthcare policies should provide a health IT highway to developing new chronic disease management mHealth applications that can automate some of the resource-heavy processes that individuals with chronic disease(s) must manage on a daily basis (Oreskovic, Huang, & Moon, 2015). Hopefully this will also lead hospital systems, ACOs, and MCOs to create initiatives to collect more data on health behaviors and social determinants rather than just treatment (chronic or acute) data. This new data could be utilized to created persuasive and behaviorally enhanced mHealth solutions targeted toward chronic disease management. In addition, these new mHealth solutions could help account for the range of relevant behaviors in a population such type II diabetes through the collection of appropriate behavioral and social determinants data. Finally, incorporating data from a health IT system to build a mHealth tool creates the first stage in integrating a chronic disease self-management system within an existing healthcare infrastructure.

In summary, it is challenging to design mHealth applications that embed behavior changes theories which is one of the reasons we see so few mHealth applications grounded in behavior change theories. We feel that by adding to the IHCA framework we can design a new mHealth design model that allows for the embedding of behavior change theories with the additional delivery of behavioral trigger messages (persuasive technology). The behavioral trigger messages will allow us to hone in on self-efficacy and cue the participants to complete specific behavioral tasks. We feel that it will take the combination of the IHCA framework with Social Cognitive Theory, Fogg Behavioral
Model and Persuasive Technology to design an mHealth system for improving chronic disease management (increasing self-efficacy, knowledge and self-management).
Chapter 3: Designing mHealth Persuasive Triggers

Methods

The Fogg Behavior Model states that in order for a person to perform a specific task he/she must be motivated, have the ability to perform the behavior and essentially be triggered to perform that behavior (Fogg, 2009). In the existing model different triggers are hypothesized to serve different purposes but have not been evaluated for (comparative) effectiveness. We hypothesize that there may exist differences between these triggers. In order to test this hypothesis, we must first develop distinct triggers.

Designing the triggers

We utilized the Fogg Behavior Model (FMB) in the creation of trigger messages as part of the capABILITY build out to support behavior management of type II diabetes. We chose to utilize spark and facilitator triggers due to their potential impact on behavior change, specifically improving self-efficacy (Fogg, 2009). Sparks and facilitators have been studied only on a limited basis where signals (reminders) are frequently studied and evaluated for their effectiveness (Weymann et al., 2015). This larger effort will ultimately compare the effectiveness of triggers across participants utilizing capABILITY as the mHealth application. As a first step, we describe our procedure to design sparks and facilitators to support a population group rather than attempting to tailor messages to individuals.

Sparks.

According to Fogg, sparks are elements of motivation. These sparks can encompass 1) pleasure or pain, 2) hope or fear, and 3) social acceptance or rejection (Fogg, 2009).
Although each of these motivators includes the potential of motivation of behavior through the avoidance of a negative consequence, we utilized only positive spark triggers in our designs (i.e. forms of pleasure, sense of hope and social acceptance). For example, to foster feelings of social acceptance, we direct individuals to view materials including “people like yourself”. This type of spark is intended to motivate the participant to engage in positively modelled behavior motivated by feelings of similarity. In addition, we continuously utilized words such as empowering, rewarding, and enjoyable to elicit an interpretation of pleasure and sense of hope.

Facilitators.

Like sparks, facilitators are intended to support behaviors that are currently challenging to an individual. Facilitators promote change by helping individuals understand they already possess the needed means to achieve success. Fogg’s notion is that people who lack ability can be persuaded to try through messages that show tasks are accomplishable and that the participants have everything they need at hand to complete a task or behavior (Fogg, 2009). For example, one means of facilitating adherence to diet and nutrition behaviors may be to help participants recognize they possess the means to prepare appropriate meals with readily available items (e.g. “make a delicious dessert with items you have on hand.”). An effective facilitator message must also convey a sense of simplicity and that the target behavior is easy to accomplish. With this in mind we continuously utilized words such as easy, simple, and simple steps to elicit an interpretation of simplicity.
**Trigger Definitions**

**Sparks** - Motivate behavior so that users feel ready to take action. This is accomplished by increasing motivation utilizing one of the following three motivation elements via text, video, graphics etc: 1.) pleasure or pain, 2.) hope or fear and 3.) social acceptance or rejection.

Pleasure or Pain = Motivation to something that is happening in the moment and the result of the motivation statement is immediate.

Hope or Fear = Hope is the anticipation of something good happening. Fear is the anticipation of something bad happening or the anticipation of some type of loss.

Social acceptance or rejection = Social acceptance is motivation through social acceptance. Social rejection is the motivation to avoid being socially rejected.

**Example:**
Other individuals like yourself have managed to control their diabetes while adding healthy snacks/desserts to their diet. Eating these can still be fun and pleasurable. Click the following link to view yummy but healthy snack ideas!

**Facilitators** - Trigger the behavior by making the behavior easier to do/accomplish while not requiring resources that the user does not have at the moment. This is accomplished by increasing the simplicity of accomplishing a specific task through text, video, graphics, etc.

**Example:**
Make a low-carbohydrate dessert with items you have on hand. Click the plate to review the peach crisp recipe (uses canned peaches and other items that you probably already have). No peaches – No problem! Use what you have!

Figure 3. Spark and Facilitator Operational Definitions

**Evaluating the triggers**

Building from the didactic content on type II diabetes from capABILITY, we developed our triggers by embedding motivational messages and notions of easy tasks and goal completion into our messages. Initially, we created 5 spark and 5 facilitator triggers all related to dietary constructs (American Diabetes Association, American Association of...
Diabetes Educators and the Summary of Diabetes Self-Care Activities Measure) without limiting word counts. We developed 20 spark and 20 facilitator messages in total for testing. We felt that this number would provide a strong enough sample size to guide the development of the final trigger messages to be deployed within capABILITY. The spark trigger messages included motivational statements focused on the hope, pleasure and inclusion such as “YOU can still eat your favorite foods and “other people like YOURSELF are able to accomplish this”. For facilitator messages we embedded statements that highlighted the ease of success and ability such as “quick easy solutions” and “this is easy with the items you have on hand”. We eventually limited all triggers (sparks and facilitators) to a word count of 45 or less. This decision was made after further literature review and user testing (Heffernan et al., 2016). We then went through two stages of evaluation and redesign with our expert panel. Finally, we asked a new group of representative users to classify our triggers as either sparks or facilitators. The above Figure 3 provided the definitions in use to our participants. They were asked to individually classify each message according to the meaning conveyed.

**First iteration of evaluation.**

The first iteration of triggers was evaluated by 8 participants that consisted of faculty members at the School of Biomedical Informatics (University of Texas Health Science Center at Houston) and College of Nursing and Allied Health Professions at the University of Louisiana at Lafayette all of whom are familiar with persuasive technology and mHealth applications. The participants classified six messages as being either a spark or a facilitator. All instructions, definitions, and messages were delivered synchronously to participants.
via online survey tool. Participants were not informed regarding the total number of each message type. Following this independent classification, each participant provided feedback to the author regarding their categorization choices through semi-structured interviews. Participants were not provided feedback as to the ‘correctness’ or adherence of their response to the authors’ expected classification system.

Results.

Participant responses were compared to the anticipated trigger type. As seen in Figure 4, at most six out of eight reviewers categorized any message in the same way. Interviews with participants revealed struggles with ambiguity in our proposed language. As participants reported viewing each message as potentially motivating as well as containing kernels of support for facilitating a sense of ability. For example, the message “thinking about your meals ahead of time allows for snack substitutes” lead to conflict in our participants. Reviewers did not feel confident in interpreting this trigger as a spark (its intended meaning.) Some individuals felt that it was focused on ability (here to think and plan). As we did not provide feedback to the participants, respondents were unaware that their interview responses in some instances contradicted to their classification of items on the survey. We believe this lack of consistency/confidence reflects their noted ambiguity in interpretation.
Redesigning triggers.

Using the feedback from the first evaluation, we attempted to simplify the trigger statements to highlight the intent of the message. A common comment in the feedback was confusion of the diabetes management content from the trigger itself. Literature suggests that in other studies on message interpretation that individuals prefer “short and easy to read” messages (Militello, Melnyk, Hekler, Small, & Jacobson, 2016). Figure 5 shows some of the changes to the messages including reduction in overall message length, and limitation of educational content from the message itself.

Figure 4. Trigger Design Results: Iteration 1
Thinking about your meals ahead of time allows for snack substitutes. Swap the regular bread on your sandwich for low-calorie bread and add a couple small cookies (your total carb count remains the same for the meal). Incorporation of snacks can be fun and rewarding!

A properly stacked pantry makes creating healthy snacks easy! Stock your pantry with the following to create great snacks that are 5 grams of carbohydrates or less: 15 almonds, 3 celery sticks + 1 tablespoon of peanut butter, 1 hard-boiled egg, 1 cup sliced cucumbers + 1 tablespoon ranch dressing or 10 gold fish crackers.

You can still have snacks while managing your diabetic diet. Snacks can help curb hunger while adding a nutritious energy boost to your day!

In order to cook quick diabetic friendly meals at home your pantry must be stocked appropriately. Click the menu icon to review an article on how to stock your pantry/kitchen! A quick easy solution!

**Second round evaluations.**

In the second assessment, the same experts evaluated now 10 messages using the redefined triggers. Now that the experts were familiar with the process and the operational definitions we felt we could add more trigger messages for them to review without having to be concerned with interpretation fatigue.

**Results.**

As Figure 6 shows the results from the second iteration of evaluation showed gains over the previous attempt. Two facilitator triggers now achieved consistent classification across reviewers with the lowest level of agreement now 6 out of 8. (Previously this was the highest level of consistent classification across messages). Interviews with experts revealed easier identification of facilitator triggers due to consistent content about “making a task easier to accomplish” and “having all resources on hand to accomplish
that task”. The participants also mentioned that spark triggers lack this “consistency” of key words. Essentially the experts were picking up on key words that signalled to them that this message was a spark or a facilitator. We only used a couple key words such as simple and easy with our facilitator messages but used 5 – 6 key words with our spark messages. The experts did mention that statements focusing on social acceptance and “that others like yourself have been able to accomplish this” let them to more easily recognize this as a spark message. The other spark messages for which we thought promoted motivation were less transparent to our experts.

![Trigger Design Results: Iteration 2 compared to Iteration 1](image)

**Figure 6.** Trigger Design Results: Iteration 2 compared to Iteration 1

**Redesigning triggers.**

Using the feedback from the second evaluation, we designed all the facilitator triggers to include terminology indicative of: “making a task easier to accomplish” and/or “having
all resources on hand to accomplish that task”. For spark triggers we attempted to capitalize key motivational words in all messages in an effort to prominently indicate its intent and to focus on hope and pleasure. In addition, we limited our key motivational words to: empowering, rewarding and enjoyable. Figure 7 shows some of the changes to the messages.

<table>
<thead>
<tr>
<th>Iteration 2 - Spark Trigger</th>
<th>Iteration 3 - Spark Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>You can still eat carbohydrate-containing snacks while consuming a diabetic friendly diet! View your plate icon for snack ideas.</td>
<td>YOU can still consume proteins with your diabetic diet. YOU can even eat some of your FAVORITES such as: fish and seafood, chicken and other poultry, along with cheese and eggs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Iteration 2 - Facilitator Trigger</th>
<th>Iteration 3 - Facilitator Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>In order to cook quick diabetic friendly meals at home your pantry must be stocked appropriately. Click the menu icon to review an article on how to stock your pantry/kitchen! A quick easy solution!</td>
<td>Portion control and food size determination can be a breeze with these simple tips! Click on the plate icon to read 5 tips for estimating your portion size. You can do it at home or on the go!</td>
</tr>
</tbody>
</table>

Figure 7. Spark and Facilitator Triggers third Iteration Design Process.

**Final evaluation.**

The final iteration of triggers was evaluated by 10 participants’ naïve to the study and unfamiliar with persuasive technology. The procedure followed the survey process described above for 10 triggers. In the third evaluation, average agreement between participant classification and intended categorization was 94% compared to just 73% for iteration 1. Agreement ranged from 88-100%.
Discussion

Our evaluation process indicates that although it is possible to achieve a high degree of consensus regarding the intent of a trigger (i.e. to motivate or to support recognition of ability), careful crafting of the message is required. The reflections from our participants highlighted their dependence on key terms such as ‘easy’, ‘simple’, and ‘simple steps’ to indicate facilitators. Key term identification was also important for spark identification such as “empowering” and “rewarding.

Conclusion

MHealth applications are beginning to utilize trigger messages or cues to action along with behavioral constructs (i.e. Social Cognitive Theory) to enhance behavior change (Nundy, Dick, Solomon, & Peek, 2013; Payne, Lister, West, & Bernhardt, 2015). Our findings suggest that trigger messages require evaluation of their reliable interpretation prior to deployment in mHealth design. The challenge is understanding how your intended audience will interpret these messages, operationalizing the common definition and following the structured methodology when generating instances. Our results indicate this might include, breaking triggers into two parts: 1) behavior change/perform action now and 2) the prompting with terms specific to each trigger type to ensure proper interpretation.

This study has demonstrated that user-testing of persuasive triggers messages is needed to ensure reliable participant interpretation of the message intent. Developing behavioural triggers such as sparks and facilitators are much more complex and simply sending a reminder message as a cue to action. Appropriately designed and evaluated
triggers may improve the outcomes of their mHealth applications. In addition, this formal evaluation process may help to eliminate common pitfalls with health communication such as cultural interpretation, cognitive beliefs, perceptions and behavioral ideology (Hall & Johnson-Turbes, 2015).
Chapter 4: Creation of capABILITY

The purpose of this pilot study was to develop a theoretically grounded IHCA mHealth application utilizing persuasive technology and behavior change theory to further its impact on a chronic disease population and to test its feasibility. Specifically, we wanted to answer the question:

- Do the additions of persuasive behavioral triggers have an impact on mHealth utilization and does the engagement lead to improved gains in self-efficacy, knowledge and self-care management for chronic disease?

capABILITY was iteratively developed utilizing user-centered design methods. The system was then designed based on the IHCA framework to meet the needs of individuals with chronic disease with a primary focus on type II diabetes. A needs assessment was conducted using focus groups.

Focus Group Sessions: Participants and Clinical Experts

The design of mHealth applications often lacks appropriate user needs assessment (Casey et al., 2014). According to Burke et al, in order to improve patient centered outcomes we must actively engage both clinicians and patients in the creation of mHealth applications that enable patients to become more effective self-managers of their chronic disease(s) (Burke, Sherr, & Lipman, 2014). With this in mind, we conducted focus groups with individuals with type II diabetes and with clinical experts who provide their care. We believe that engaging users in the design of the IHCA and its constructs is vital to the proper design of how the behavior changes theories should be embedded.
Focus Groups

Two focus groups (participants with type II diabetes and clinical experts) were independently conducted. Our goal in developing an mHealth application required their input on understanding their beliefs regarding the impact self-efficacy on diabetes self-care management, capturing the type of information clinicians would want to provide to patients with capABILITY, understanding how participants would want to engage with capABILITY, and what would the patients like to see designed within capABILITY itself.

Each focus group session was conducted for a period of 1.5 hours. The clinical expert focus group consisted of: one endocrinologist, one nurse practitioner, two registered nurses and three registered dieticians. Of the seven experts two of them were also certified diabetes educators. Nine participants with type II diabetes mellitus participated in the participant focus group session.

In both focus group discussions, participants were provided with an introduction statement on letterhead along with a standard definition of self-efficacy. In addition, they completed a social demographic survey and consent forms. We utilized a semi-structured focus group question model to stimulate open discussions based on the questions that were selected (Wang & Matthews, 2010; Wang & Siminerio, 2013). Examples of the types of questions asked in the focus group sessions can be seen in Table 2. The focus group session was audio recorded and transcribed to determine common themes.
Table 2

Sample questions utilized for the focus group sessions

<table>
<thead>
<tr>
<th>Focus Group Questions (sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What type of tasks do you give your patients to manage their diabetes at home?</td>
</tr>
<tr>
<td>2. What is your biggest challenge in managing your day-to-day diabetic self-management?</td>
</tr>
<tr>
<td>3. What is needed to create positive behavior change in individuals with diabetes?</td>
</tr>
<tr>
<td>4. Which self-management task are hardest to adhere to and why?</td>
</tr>
<tr>
<td>5. What types of information should be delivered via a mobile health?</td>
</tr>
<tr>
<td>6. Does the length of time between clinic visits play a role in your ability to manage your diabetes?</td>
</tr>
<tr>
<td>7. What would keep users engaged in the mobile health application?</td>
</tr>
<tr>
<td>8. Do you feel timing is important as it relates to when reminders are sent?</td>
</tr>
<tr>
<td>9. How often should users engage/access the mobile health application?</td>
</tr>
<tr>
<td>10. Would having access to your information (HbA1c) provided to you via mobile health on a day-to-day basis help you manage your diabetes more effectively? Why?</td>
</tr>
</tbody>
</table>

Once the audio files were transcribed we utilized NVivo software to identify key concepts, themes and gaps (critical gaps and shared beliefs). We evaluated each focus group session separately as well as a within groups evaluation.

**Focus groups results.**

Themes were extracted from the focus groups. These themes were classified as either a critical gap or shared belief. The critical gaps represent information that was iterated several times and deemed important by the clinicians but not the patients or vice versa. The shared beliefs represent important concepts that were addressed and deemed necessary by both groups. Table 3 shows the themes identified across both focus groups.
The participants identified three critical gaps in their type II diabetes management: health knowledge, self-management and the financial impact of managing their disease. This was important to understand and to include in the design of our mHealth application.

The remaining eight themes were shared beliefs between both groups and included items such as: low self-efficacy, diet struggles and low motivation. These results mirrored information found in the literature and produced some new information, which may be indicative of the culture in South Louisiana (Rai et al., 2013).

In addition, focus group participants voiced a strong desire to receive short videos such as cooking tips and exercise tips in an effort to promote this new behavior change. They felt that this would allow them to better understand the material presented plus keep them engaged in using the mHealth application. Literature also supports this belief to promote engagement with new technology (Bell, Fonda, Walker, Schmidt, & Vigersky, 2012).

Table 3

Focus group theme classifications, definitions and examples.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Classification</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Knowledge</td>
<td>Critical Gap</td>
<td>Diabetic patients feel overwhelmed by all of the self-management information provided. A step-wise approach is crucial.</td>
<td>“Not having a clear understanding of what affects my blood sugar.”</td>
</tr>
<tr>
<td>Self-Management</td>
<td>Critical Gap</td>
<td>Diabetic patients don’t have a clear understanding of what self-management is and how to manage it</td>
<td>“I only focus on my diet.”</td>
</tr>
<tr>
<td>Financial Impact</td>
<td>Critical Gap</td>
<td>How to manage diabetes on a budget.</td>
<td>“My medication went from $60 to $1,000 a month so I had to...”</td>
</tr>
<tr>
<td>Shared Belief</td>
<td>Perceived inability to accomplish a task.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet Struggles</td>
<td>Inability to consistently manage dietary intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attend Appointment</td>
<td>Attend all scheduled medical appointments.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire for Motivation</td>
<td>Receive motivation and positive reinforcement on a regular basis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeling Accountable</td>
<td>The desire to feel all of your hard work is appreciated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Influences</td>
<td>The influence of outside factors and environment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reminders</td>
<td>Short reminder messages such as: did you have protein with your snack today?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact of Stress</td>
<td>Stress plays a role in the diabetes management.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The evaluation of the social demographic surveys also produced information that correlated with the reviewed literature and provided additional details about our population group. All of the experts agreed that self-efficacy plays a role in the ability for an individual with diabetes to manage their disease process. This was an important
finding as our experts agreed with the published literature that improving self-efficacy is one of the keys to helping individuals major their type II diabetes. In addition, 86% of the experts stated that they have suggested a mobile device application for one of their patients. This was an interesting finding as we thought mHealth applications were not as pervasive in the local healthcare community.

Table 4
Sample data, Expert Social Demographic Survey.

<table>
<thead>
<tr>
<th>Provider Type</th>
<th>Number of years providing diabetic care</th>
<th>Have you ever suggested a mobile application to one of your patients?</th>
<th>Do your diabetic patients regularly keep their appointments?</th>
<th>Do you feel perceived self-efficacy plays a role in a diabetic’s patient’s ability to manage their diabetes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse Practitioner</td>
<td>14</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Registered Nurse</td>
<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Registered Dietician</td>
<td>3</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Endocrinologist</td>
<td>15</td>
<td>No</td>
<td>N/A</td>
<td>Yes</td>
</tr>
<tr>
<td>Registered Nurse</td>
<td>3</td>
<td>Yes</td>
<td>N/A</td>
<td>Yes</td>
</tr>
<tr>
<td>Registered Dietician</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Registered Dietician</td>
<td>7</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In regards to the participants, only 55% of them stated they monitor their blood sugar as suggested by their medical provider. In addition, very few of them follow diet instructions and only 33% of communicate with a diabetic educator. These were
important findings that concurred with the literature in regards to the struggles of managing diabetes. After compiling the data seen in table 5 we knew that these would be components of our mHealth design and wanted to ensure that these would be addressed.

Table 5

Participant social demographic survey sample data

<table>
<thead>
<tr>
<th>Age</th>
<th>Length of type II diabetes diagnosis (years)</th>
<th>How often do you see your medical provider for your diabetes?</th>
<th>Do you monitor your blood glucose as recommended?</th>
<th>Do you follow your Diet instructions?</th>
<th>Do you communicate with diabetic educator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>7 Yearly</td>
<td>Yes</td>
<td>No</td>
<td>Completely</td>
<td>Never</td>
</tr>
<tr>
<td>58</td>
<td>4 Quarterly</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>50</td>
<td>10 Bi-annually</td>
<td>No</td>
<td>Sometimes</td>
<td>Never</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>20 Quarterly</td>
<td>Yes</td>
<td>Sometimes</td>
<td>Quarterly</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>3 Yearly</td>
<td>No</td>
<td>Sometimes</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>20 Quarterly</td>
<td>Yes</td>
<td>Sometimes</td>
<td>Never</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>17 Quarterly</td>
<td>Yes</td>
<td>Completely</td>
<td>Never</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>7 Quarterly</td>
<td>Yes</td>
<td>Sometimes</td>
<td>Quarterly</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>10 Quarterly</td>
<td>Yes</td>
<td>Sometimes</td>
<td>Never</td>
<td></td>
</tr>
</tbody>
</table>

We utilized the information gained from the focus group sessions to include the critical gaps and shared beliefs in the design of capABILITY. We wanted to ensure that our design is reflective of the input we received from both key stakeholders. We feel that the incorporation of both key stakeholders (clinical experts and participants) in the user-
centered design process makes capABILITY a unique mHealth tool that integrates clinical and user perspectives.

**System Design: capABILITY**

The challenge in developing capABILITY was to find a theoretical framework that would allow for the additions of persuasive technology and behavior change theories within a mHealth construct. In addition, this theoretical framework needed to focus on improving knowledge attainment and self-efficacy for chronic disease while providing the flexibility to incorporate our user-centered design.

We ultimately decided to utilize the Interactive Health Communication Applications (IHCA) Framework to design capABILITY. The IHCA framework allows for the delivery of health information via mHealth in combination with other theories such as behavior change or decision support (Murray et al., 2005). Previous research has shown that IHCAAs delivered through web-based applications provide a promising way to engage users in their diabetes knowledge and self-management activities (Weymann, Härter, & Dirmaier, 2013; Weymann, Härter, Petrak, et al., 2013). Building on previous IHCA frameworks and the focus group sessions we embedded PGHD and theoretical constructs from: Social Cognitive Theory (focus on self-efficacy), Fogg Behavioral Model and Persuasive Technology. Persuasive Technology, Fogg Behavioral Model and PGHD are new constructs to the IHCA framework for which we have not identified through previous works. We feel that these are vital components to create an engaged mHealth application focused on behavioral change to improve self-efficacy, knowledge and self-management for individuals with chronic disease (i.e. type II diabetes). In particular, we
wanted to evaluate the two types of trigger messages (sparks and facilitators) within the Fogg Behavioral Model to determine their effectiveness to deliver behavioral content within our mHealth application. We created this combination of constructs within the IHCA framework delivered through mHealth to improve self-efficacy, knowledge and self-care management.

The next stage in the system design of capABILITY was to identify a mHealth authoring product that would allow us to incorporate our new IHCA design into the mHealth development. We ultimately decided to utilize a product called guideVUE. (Iyengar et al., 2009). guideVUE is an authoring application that gives you the ability to develop mHealth applications with a strong focus on knowledge transfer. Through the use of guideVUE’s authoring tool we were able to develop capABILITY within our IHCA construct.

In addition, guideVUE provided us the ability to embed our IHCA framework within a module (core educational content) design. We wanted to develop capABILITY with a static IHCA framework and create three distinct educational modules focusing on diet, exercise and self-management. This would allow our design to be replicated in other chronic disease processes by simply interchanging the educational content.

**Content development: capABILITY**

The clinical expert and participant focus groups highlighted the following three areas in terms of needed education and perceived low self-efficacy: diet, exercise and self-management. These three content areas became the core educational modules of
capABILITY and were labelled as: Module 1 (diet), Module 2 (exercise) and Module 3 (self-management).

**Educational**

The development of material for each module was driven by information gathered from the focus group sessions, clinician and individual interviews, and information from the American Diabetes Association, and the Summary of Diabetes Self-Care Activities Measures, Perceived Diabetes Self-Management Scale (PDSMS) and the University of Michigan Diabetes Research and Training Center’s Diabetes Knowledge Test (Årsand et al., 2012; El-Gayar et al., 2013; Fitzgerald et al., 2016; Lorig et al., 2010; Toobert, Hampson, & Glasgow, 2000; Wallston, Rothman, & Cherrington, 2007). The majority of the educational content was retrieved from the American Diabetes Association which was transformed into media and text within capABILITY. The media files consisted of short (2 – 3 minute) videos of myself highlighting key educational content areas such as key strategies for carbohydrate counting and providing weekly content overview videos. In addition, we ensured that the videos could be paused, rewound and fast-forwarded so the participants could have full control of how and when they wanted to watch the videos. The text files consisted of condensed educational content from American Diabetes Association for which we also created hyperlinks in case the participants wanted to read the complete documents. This was particularly useful when we provided health recipes for them to utilize.
Each module within capABILITY consists of three weeks of unique educational material related to that particular core education module. Each week new information is introduced in regards to that particular module (See Table 6).

Table 6

capABILITY module and week classification

<table>
<thead>
<tr>
<th>Module 1: Diet</th>
<th>Module 2: Exercise</th>
<th>Module 3: Self-Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1: Carbohydrate</td>
<td>Week 1: Types of exercises</td>
<td>Week 1: Diabetes facts</td>
</tr>
<tr>
<td>counting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2: Snacks and</td>
<td>Week 2: Overcoming exercise barriers</td>
<td>Week 2: Blood glucose</td>
</tr>
<tr>
<td>Desserts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 3: Diabetes</td>
<td>Week 3: Keeping active during the week</td>
<td>Week 3: Medication management</td>
</tr>
<tr>
<td>superfoods</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The educational information gathered from the American Diabetes Association was first broken down by module and then ultimately by week. The weekly educational topics under each specific module was developed based on the information obtained from the expert and participant focus groups. To begin the classification of educational material we would use in capABILITY we created paper folders (printed from the American Diabetes Association) listed by module then subfolders by week. We then labeled the printouts in order of how we wanted the information displayed in capABILITY. This was a tedious process as we wanted to focus on the Social Cognitive Theory construct of mastery (Bandura, 2001; Bandura, A, 1997). Essentially, this meant that the information would be provided via capABILITY in a staggered format to
promote the ideology of mastery. For instance, Module 1, Week 1 focused on carbohydrate counting and the American Diabetes Association has a great text document discussing three strategies for better carbohydrate counting. We wanted to create an educational video discussing these three strategies while also listing a summary of text information below the video. The first goal question in capABILITY is “How many day(s) will you record your daily carbohydrate consumption?” In addition, participants utilizing capABILITY will record their carbohydrate intake throughout the 9 week study so we felt providing educational material focused carbohydrate counting in the first week of the study would help promote mastery of this particular task. On the paper mock-up of the carbohydrate counting strategies we labeled them as: Module 1, Week 1 educational resources video/text. All of the educational content that would eventually be created within capABILITY was labeled utilizing this same methodology. Prior to transforming the paper mock-ups into the actual educational content within capABILITY an endocrinologist and NP who focuses on type II diabetes reviewed the educational content in the folders to ensure content quality and appropriate label classification. They were both in agreement with the material we provided in the mock-up and the label classification knowing the duration of the capABILITY study (9 weeks).

Self-efficacy

The development of material for each module was centered on self-efficacy and in particular we utilized mastery experience, social modeling and verbal persuasion. For example, we created knowledge questions that became increasingly more challenging as the participants gained mastery experience in a particular module such as exercise. This
technique from Social Cognitive Theory has the strongest impact on self-efficacy belief (Glanz, K., and Viswanath, K., 2008). The educational videos that were developed to show how to manage specific segments of diabetes always included statements such as: “others like yourself have been successful in managing their type II diabetes”. These reinforced social modeling statements were intended to show the participants that people just like themselves have been able to manage their chronic disease. Finally, we embedded verbal persuasion statements in some of our trigger messages such as: “Bringing HEALTHY snacks to work or on the go can help curb hunger while adding a nutritious energy boost to your day! You CAN successfully manage your diet!” The development of these verbal persuasion statements were intended to increase confidence and hopefully begin to induce behavior change. We felt that adding these components of self-efficacy to our educational model would increase self-efficacy which would then lead to increases in knowledge and ultimately improvements in self-management.

**capABILITY development**

We utilized guideVUE to develop each module within capABILITY. Essentially, we developed capABILITY as weekly files as this allowed us to keep all the buttons, layout and location of material within capABILITY static throughout each week. This was very important as previous research has shown that reducing barriers such as changes in layout is essential in trying to persuade new behaviors (Heffernan et al., 2016). The only items that changed each week was the actual education content related to that week’s material. This allowed the users to quickly become comfortable utilizing capABILITY and hopefully feel very comfortable utilizing the mHealth application. The
premise of this design was based on the principle of “tunneling” which is a form of persuasive technology. Through this tunneling design we wanted to ensure that all of the users had the same experience and were exposed to specific information that they might not have seen otherwise. Fogg, describes tunneling as one of the seven types of persuasive tools which can make a desired behavior easier to achieve (Fogg, BJ, 2002).

In addition, tunneling designs have been used to reduce cognitive load which is important in more complex or information heavy mHealth applications such as capABILITY (Fogg, BJ, 2002; Heffernan et al., 2016).

Utilizing the guideVUE Author we developed and designed Module 1, Week 1 which would be the replicating design structure for the following 8 weeks of educational material to be delivered via capABILITY (See Figure 8).
The guideVUE Author allows you to create a mHealth application through a flow map design infrastructure. Essentially, each step that you create will produce a new screen in your mHealth application. Within each step you are able to embed video, audio, text, and images to fully customize the layout of your mHealth application. This allowed us to ultimately design capABILITY using a tunneling approach insuring that each participant had access and followed a predetermined set of screens. When capABILITY is first launched the first screen the user sees is the welcome screen. This screen explains what capABILITY is and includes a capABILITY logo that the users see.
on most screens. At the bottom of this screen is an ID button. When the ID button is pressed it opens a new screen for which each user can select their unique identification number from a drop down menu. At the bottom of the ID screen is a welcome video button that leads the participant to a welcome video screen. This welcome video portrays me as the moderator as I explain what will be covered during this week’s material in capABILITY. It is important to remember that only the content changes week to week so the process in which the user matriculates from screen to screen remains the same. After the user views the welcome video he/she is able to click on the goal button at the bottom of the welcome video screen which then leads them to a new goal’s screen. At this point, the participant can then select an answer to a preformatted goal question. For example, “how many day(s) will you record your daily carbohydrate consumption”? Each week provides a new preformatted goal question for the user to answer. At the bottom of the goal screen is a resources button which leads the user to the educational resources menu (See Figure 9). This menu contains all of the educational material for the week as well as a PGHD option which we call the tracker button. This is the main screen for which the users will spend most of their time. They are able to launch various educational, PGHD and weekly question screens from the educational resource screen. Once the participant clicks on one of the educational resources buttons a new screen appears with that related content. In addition, some educational resources buttons contain multiple screens due to the educational content to be covered (See Figure 9).
After reviewing the educational content the user is able to key in their PGHD by total carbohydrate consumption (Module 1: Diet) by pressing the daily carb tracker button. The user is then able to select the day of the week for which they want to key in their PGHD for carbohydrate consumption. Once they make the day selection a new screen appears and they are able to key in their daily carbohydrate consumption by: breakfast, lunch and dinner. The user does not have to key in all the information at once. They are able to access these screens and key in PGHD at any point which makes it easy for them to key in PGHD when it is actually being calculated. The PGHD fields were initially created to only accept quantitative data but in the earlier focus group sessions it
became quite apparent that individuals with type II diabetes do not always know how to count their carbohydrates. We fixed the quantitative field to allow for qualitative data entry such as: “I consumed two boiled eggs and 1 slice of wheat toast for breakfast”. It was our intention that the users that recorded free text qualitative data would change overtime to quantitative data as their self-efficacy and knowledge improved through the utilization of capABILITY.

Once the user reaches either Saturday or Sunday via the PGHD tracker they are then prompted to open a new survey screen. At this point a new survey screen appears for which the participant can answer 4 questions in total related to: self-efficacy, knowledge, self-care and goal (See Figure 10) attainment. The only question that remains constant throughout each week is the self-efficacy question which is: “I’m generally able to accomplish my goals with respect to managing my diabetes”. The participants are able to answer the question via the following Likert Scale: strongly disagree, disagree, neutral, agree and strongly agree. The question is generated from the list of eight self-efficacy questions from the Perceived Diabetes Self-Management Scale (Wallston et al., 2007) The knowledge and self-care questions change each week and are related to the educational content represented that week. The knowledge questions are derived from the University of Michigan Diabetes Research and Training Center’s Diabetes Knowledge Test and are multiple choice in nature. The self-care questions are derived from the Summary of Diabetes Self-Care Activities Measures and are generally listed as an answer of 1 through 7 days (Toobert et al., 2000). The goal question is simply a question asking the participants if they met their goal for the week (the goals is also
provided) with the following answer choices: yes, no or I’m not sure. After answering these survey questions the participants have completed their material for the week. Each week is designed the exact same way with the exception of the PGHD content. For Module 1 (Diet), the participants are able to key in their PHGD for carbohydrate consumption by meal per each day of the week. For Module 2 (Exercise), the participants are able to key in their PHGD for carbohydrate consumption by meal per day of the week and by total exercise (in minutes) per day of the week. For Module 3 (Self-Management), the participants are able to key in their PGHD for carbohydrate consumption by meal per day of the week, total exercise (in minutes) per day of the week and their blood glucose per day of the week. For blood glucose PGHD the participant can enter the blood glucose reading, per or post meal and the time the blood glucose checked. The staggering of PGHD implementation was designed in this manner to correlate to the educational content being delivered. We wanted to incorporate the PGHD tracking when the educational material was introduced per Module (see figure 10). Once it was introduced we kept the previous PGHD tracking components as well which again is why we felt creating a tunneling design would help with the cognitive load on the users at they matriculated through capABILITY.
Triggers

In addition to the capABILITY development, we also developed spark and facilitator trigger messages to coincide with the use of capABILITY (refer to chapter 3 for details on the content development). We created three unique spark and facilitator trigger messages for each week of content within capABILITY. Essentially, we developed 27 spark triggers and facilitator triggers that would be sent to the participants. We utilized a mobile group messaging application called GroupMe which is owned by Microsoft. This application allowed us to send triggers messages to our participants via SMS messaging. Through GroupMe we created two mobile messaging groups called: Sparks and Facilitators. This allowed us to place the participants into specific groups which then
allowed us to send either a spark or facilitator trigger message to a specific group (See Figure 11). The participants were listed by their research ID number instead of their name or other identifying information. This design ensured that all the participants in a specific group received the exact same message and also received it at the exact same time.

<table>
<thead>
<tr>
<th>Spark Triggers (delivered via GroupMe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tuesday 10:00 am</td>
</tr>
<tr>
<td>• Thursday 10:00 am</td>
</tr>
<tr>
<td>• Saturday 10:00 am</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facilitator Triggers (delivered via GroupMe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tuesday 10:00 am</td>
</tr>
<tr>
<td>• Thursday 10:00 am</td>
</tr>
<tr>
<td>• Saturday 10:00 am</td>
</tr>
</tbody>
</table>

Figure 11. capABILITY and Trigger Layout

capABILITY data capture.
capABILITY was designed to capture very specific data points that would be utilized for analysis as well as user viewing (See Table 7).
Table 7
capABILITY data capture

<table>
<thead>
<tr>
<th>Description</th>
<th>Data Type</th>
<th>Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant ID</td>
<td>Quantitative</td>
<td>Each log-in</td>
</tr>
<tr>
<td>Goal statement</td>
<td>Quantitative and</td>
<td>Once per week</td>
</tr>
<tr>
<td>PGHD (carbohydrates, exercise and blood glucose)</td>
<td>Qualitative</td>
<td></td>
</tr>
<tr>
<td>Survey questions (self-efficacy, knowledge, self-care and goals)</td>
<td>Quantitative and Qualitative</td>
<td>Once per week</td>
</tr>
</tbody>
</table>

Once a user accesses a new week of material the first screen they encounter is the goal statement screen. The goal statement changes each week and is targeted to each week’s content. Goals become more challenging over the weeks as mastery develops (Glanz, K., and Viswanath, K., 2008). Participants both set their goal and report whether or not they met this milestone (answer choices were = yes, no, or I’m not sure).

Additionally, patient generated health data (PGHD) components supported users in capturing key points such as their carbohydrate consumption, exercise, and blood glucose levels (See Figure 12).
The PGHD components coincided with the module delivery through capABILITY (see above figure). Participants were able to key in quantitative data and qualitative data into the PGHD fields.

The four survey questions at the end of each week was designed to measure and evaluate behavioral and knowledge changes throughout the utilization of capABILITY. Prior to utilizing capABILITY the participants completed a full self-efficacy, knowledge and self-care measures survey. These participants would eventually complete this survey again upon completion of the capABILITY study. At the conclusion of each week capABILITY was designed so that the user could answer the following questions related to: self-efficacy, knowledge, self-care and goal assessment (See Table 8).
## Table 8

### Module 1, weekly survey questions

<table>
<thead>
<tr>
<th>Module 1: Diet</th>
<th>Goal (1 per week)</th>
<th>Knowledge question (1 per week)</th>
<th>Self-efficacy question (1 per week)</th>
<th>Self-care question (1 per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1: Carbohydrate counting</td>
<td>How many day(s) will you record your daily carbohydrate consumption?</td>
<td>Which of the following is highest in carbohydrates?</td>
<td>I’m generally able to accomplish my goals with respect to managing my diabetes</td>
<td>On how many of the last SEVEN DAYS did you space carbohydrates evenly through the day?</td>
</tr>
<tr>
<td>Week 2: Snacks and deserts</td>
<td>How many day(s) will you prepare a healthy snack?</td>
<td>What effect does unsweetened fruit juice have on blood glucose?</td>
<td>I’m generally able to accomplish my goals with respect to managing my diabetes</td>
<td>On how many of the last SEVEN DAYS did you eat five or more servings of fruits and vegetables?</td>
</tr>
<tr>
<td>Week 3: Diabetes superfoods</td>
<td>How many different types of diabetes superfood will you try?</td>
<td>The diabetes diet is?</td>
<td>I’m generally able to accomplish my goals with respect to managing my diabetes</td>
<td>How many of the last SEVEN DAYS have you followed a healthful eating plan?</td>
</tr>
</tbody>
</table>
All of the weekly questions are derived from the list of pre/post survey questions. The self-efficacy (SE) survey question as seen in Table 2 is the only question that remains static throughout the study. The SE answers to the SE question were designed as a radio button layout with the following answer choices: strongly disagree, disagree, neutral, agree and strongly agree. The knowledge answers to the knowledge questions were designed with a radio layout as well in a multiple choice format. The self-care answers were to the self-care questions were designed with a radio button layout as well with the following choices (number of days): 1, 2, 3, 4, 5, 6, 7. Finally, the goal assessment was simply a reiteration of the weekly goal statement and asking did you meet your goal (yes, no, I’m not sure). Collecting the weekly survey data in this format was critical as it would allow us to compare a research participant’s pre-test and post-test data to how they were actually interacting with capABILITY weekly. This data also allows us to determine if specific types of trigger messages have an impact on self-efficacy, knowledge and self-care.

**capABILITY data logs.**

In addition to the information entered by the participant, interactions with the system were also logged. The data files were extracted from the guideVUE website as XLS files which we then evaluated and analyzed (See Table 9).
Table 9

capABILITY data log

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log ID</td>
<td>Unique identifier per log-in</td>
</tr>
<tr>
<td>Latitude</td>
<td>Geographic position at log-in</td>
</tr>
<tr>
<td>Longitude</td>
<td>Geographic position at log-in</td>
</tr>
<tr>
<td>Address</td>
<td>Physical location at log-in</td>
</tr>
<tr>
<td>Time stamp</td>
<td>Log-in date and time</td>
</tr>
<tr>
<td>Duration</td>
<td>Time spent viewing a step (screen in capABILITY) in seconds</td>
</tr>
<tr>
<td>Step</td>
<td>Name of each screen viewed</td>
</tr>
<tr>
<td>ID number</td>
<td>Unique participant ID number</td>
</tr>
<tr>
<td>Goal</td>
<td>Answer to goal question</td>
</tr>
<tr>
<td>PGHD</td>
<td>Carbohydrate, exercise and blood glucose data</td>
</tr>
<tr>
<td>Survey Questions</td>
<td>Self-efficacy, knowledge, self-care and goal assessment</td>
</tr>
</tbody>
</table>

Using this data we could evaluate for example, how long a particular research participant viewed a specific video in Module 1, Week 1. We can analyze the total duration of capABILITY usage by participant, module, day or even morning vs. evening. In addition, we can evaluate the timing of our trigger messages to utilization of capABILITY (See Figure 13).
Heuristics Evaluation and User Testing

Heuristics evaluation

A heuristic evaluation was conducted by expert reviewers familiar with the process. A heuristic evaluation involves the evaluation of a system for adherence to principles of good design such as the screen colors, screen layout and formatting seen below (Nielsen & Molich, 1990; Zhang, Johnson, Patel, Paige, & Kubose, 2003).

Table 10

Heuristic Evaluation Guidelines

<table>
<thead>
<tr>
<th>14 Guidelines &amp; Principles</th>
<th>5 Level Severity Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. [Consistency] Consistency and standards in design.</td>
<td>Scale of 1 to 4</td>
</tr>
<tr>
<td>2. [Visibility] Visibility of system state.</td>
<td>0 = No issue/Not applicable</td>
</tr>
<tr>
<td>3. [Match] Match between system and world.</td>
<td>1 = Cosmetic – Potential for lower quality of clinical care due to decreased efficiency, increased frustration, or increased documentation burden or workload burden</td>
</tr>
<tr>
<td>4. [Minimalist] Minimalist design.</td>
<td>2 = Minor – Potential for workarounds that create patient safety risks</td>
</tr>
<tr>
<td>5. [Memory] Minimize memory load.</td>
<td>3 = Major – Potential for patient morbidity</td>
</tr>
<tr>
<td>6. [Feedback] Informative feedback.</td>
<td>4 = Catastrophic – Potential for patient mortality</td>
</tr>
<tr>
<td>7. [Flexibility] Flexibility and customizability.</td>
<td></td>
</tr>
<tr>
<td>10. [Closure] Clear closure.</td>
<td></td>
</tr>
<tr>
<td>12. [Language] Use users’ language.</td>
<td></td>
</tr>
<tr>
<td>13. [Control] Users are in control.</td>
<td></td>
</tr>
</tbody>
</table>

In total there were 8 violations and all were at level 1 on the severity scale. The system was redesigned following this input.
Pilot Review

Two clinical experts (an endocrinologist and family nurse practitioner) and two individuals with type II diabetes were provided access to the first week of capability. Participants were asked to review the content and functionality. As all weeks followed the same physical structure, this limited review was believed to capture all functional issues with the system. These participants provided feedback and participated in a semi-structured debriefing session (SEE APENDIX). There were specific questions for the clinical experts and the individuals with type II diabetes. Below is a sample of questions that were utilized during the interview process.

- “Do you recommend making any changes to the clinical content? If so, what changes do you recommend (clinical experts)”?
- “Do you feel confident that individuals diagnosed with type II diabetes will understand the content delivered through capABILITY (clinical experts)”?
- “Did you have any problems utilizing capABILITY or have any trouble navigating through the screens”?
- “Do you recommend making any changes to capABILITY? If so, what would they be”?

The two clinical experts were in agreement with the answers they provided via the semi-structured question format. Overall, they felt very confident that capABILITY was providing clinically correct information about type II diabetes. They were both in agreement that utilizing information from the American Diabetes Association as the backbone of the educational content was the best methodology. In addition, they felt
strongly that allowing the user to key in PGHD data would keep them engaged and hopefully lead to them taking more responsibility in the care of their type II diabetes. Most of the recommendations they provided were minor or cosmetic such as: change the words medication adherence to medication management and add hyperlinks to critical educational resources such as carbohydrate counting strategies. We made both of these changes to include other cosmetic improvements as well.

The two individuals with type II diabetes were also in agreement. They felt that they were able to navigate easily through capABILITY and the content that was provided would help them manage their type II diabetes. They also stated that it was easy to key in PGHD, answer the goal question and the weekly educational questions. Their suggested improvements included creating a button to see what content has already been viewed and to include more videos. This feedback was similarly incorporated into the design.

After completing the design process, heuristic evaluation and user testing we felt capABILITY was ready to pilot test among a group of individuals with type II diabetes.
Chapter 5: A mHealth Pilot Study

Based on focus groups, trigger message development, heuristics evaluation and user-testing the final capABILITY mHealth product was created. At this point we were ready to evaluate the effectiveness of capABILITY amongst individuals with type II diabetes. Our main research goal was to determine the impact of trigger messages on self-efficacy, knowledge, self-care and overall capABILITY usage. In order to answer the below hypotheses we conducted a randomized controlled trial utilizing employees (diagnosed with type II diabetes) at Lafayette General Health.

Study Hypotheses

Hypothesis 1: We hypothesize that after the capABILITY intervention, participants will demonstrate improved scores on self-efficacy, knowledge and self-management.

Hypothesis 2: We hypothesize that participants will be more engaged in the usage of capABILITY following a behavioral trigger.

Hypothesis 3: We hypothesize that participants who receive spark triggers involving motivation will engage in the utilization of capABILITY faster than those who receive facilitator triggers.

Methods

Institutional Review Board (IRB) approval

The research study was approved by the University of Texas health Science Center at Houston IRB and the University of Louisiana at Lafayette IRB. Both IRB approvals were provided to Lafayette General Health System for which the research participants resided.
Setting

The study was conducted through the Lafayette General Health (LGH) System. LGH consists of seven hospitals and other various ancillary facilities (i.e. cancer center, physician clinics and surgical plaza) in the greater Acadiana area in South Louisiana. Participants of the research study were an employee or spouse of an employee at LGH and represented various hospitals, ancillary facilities and clinics within the system.

Study population

The study population consisted of 20 participants who had a current diagnosis of type II diabetes. The diagnosis was confirmed through ICD-10 codes within the LGH medical claims database as well as the LGH Nurse Navigator. LGH marketing and communication department sent an email and physical flyer to all employees within their system inviting them to participate in the study. Within the email and flyer, participants were instructed to contact the Nurse Navigator if they were interested in participating in the study. At this time the participants self-disclosed to the nurse navigator if they had type II diabetes (as confirmation) and wanted to participate in the study.

Study Design

capABILITY was designed to cover three main diabetes content areas which we call modules: diet, exercise and self-management (i.e. medication adherence, glucose monitoring). The length of the study was 9 weeks in duration with three weeks of content per module. Within each module new material was delivered each week through capABILITY. Essentially, every Monday started a new week’s worth of educational material that was intended to last until Sunday. In addition, A 3 Cross Factor Design
methodology was utilized. Each participant was randomly assigned to either the control group (no triggers), spark trigger group or facilitator trigger group. At the beginning of each module the participants would be randomly assigned to one of the three aforementioned classification groups.

We utilized the Perceived Diabetes Self-Efficacy Scale adapted by Wallston, Rothmans and Cherrington, Diabetes Knowledge Test developed by Michigan University, and the Summary of Diabetes Self-Care Activities Measures scale (SDSCA) (Fitzgerald et al., 2016; Toobert et al., 2000; Wallston et al., 2007). All the participants completed the perceived diabetes self-efficacy scale along with the knowledge test and SDSCA Pre/Post intervention. In addition, the participants answered one self-efficacy, knowledge, self-care and goal question at the conclusion of each week within capABILITY.

**Diabetes self-efficacy**

The Perceived Diabetes Self-Efficacy Scale is a reliable and valid instrument utilized in numerous studies (Wallston et al., 2007). It consists of eight diabetes specific self-efficacy questions score on a range from 1 = “Strongly Disagree” to 5 = “Strongly Agree” (Wallston et al., 2007). Four of the questions (#s 1, 2, 6, and 7) are worded so that the higher the agreement the lower the self-efficacy. According to the scale parameters these four questions were reverse scored. After this was completed the totals were added to the other questions to produce a total self-efficacy score.
**Diabetes knowledge**

The Diabetes Knowledge Test consists of 23 knowledge test items and was developed and validated by the Michigan Diabetes Research Training Center (Fitzgerald et al., 2016). The 23 questions represent an overall test of general diabetes knowledge and can be administered to people regardless if they take insulin or not. The questions are in a multiple choice format with only one plausible correct answer per question.

**Diabetes self-management**

The Summary of Diabetes Self-Care Activities Measure (SDSCA) is a brief self-report measure (25 questions) of diabetes self-management activities covering items such as: general diet, specific diet, exercise, blood-glucose testing, foot care and smoking (Toobert et al., 2000). It has been used in various diabetes research studies and is a reliable and valid tool for measuring diabetes self-management. We utilized the following subscales for our study: General Diet (2 questions), Specific Diet (2 questions), Exercise (2 questions), Blood Glucose (2 questions) and Foot Care (2 questions).

The study was comprised of two cohort groups and we utilized a within-subjects design. Cohort 1 consisted of 17 participants and cohort 2 consisted of 3 participants. Cohort 1 started their study on 10/31/2016 and completed it on 01/01/2017 (see Table 11). Cohort 2 started their study on 11/14/2016 and completed it on 01/15/2017. The participants in each cohort were randomly assigned to one of three groups: capABILITY control, capABILITY with spark triggers and capABILITY with facilitator triggers.
Participants in the spark and facilitator groups received triggers messages on Tuesday, Thursday and Saturday mornings at 10:00 am. These messages were delivered via SMS messaging through an application called GroupMe.

**Study Procedures**

Following recruitment through Lafayette General Health (LGH), all participants were invited to attend various tutorial sessions that were provided at LGH’s main campus. For those participants who could not attend we provided one-on-one sessions. Prior to the start of the tutorial session the participants completed the following documents: study consent, social-demographic survey, self-efficacy survey, knowledge test, self-care measure survey. In addition, we installed capABILITY on their mobile devices prior to the start of the tutorial sessions. This was accomplished through opening
each participant’s app store on their respective mobile device. Upon opening the app store we searched and then downloaded the guideVUE application. At this time capABILITY was then available for the participants to utilize through guideVUE.

Participants were contacted prior to the tutorial session via the nurse navigator at LGH to create a username and password through guideVUE and to bring their mobile devices to the tutorial sessions. We provided a PowerPoint presentation during the tutorial sessions showing the participants how to download capABILITY, explain the functions of the app, reviewed the weekly schedule, reviewed all of the data screens for Module 1 Week 1, demonstrated how to key data into capABILITY, and demonstrated how to answer questions within capABILITY. We explained to them that they would also receive messages via SMS text and not to worry if there was a period of time when they don’t receive the messages. It was necessary to explain this to the participants as all of them at some point would go through a module (three weeks) without receiving trigger messages. The participants were also provided with a copy of the PowerPoint slides for them to reference during the course of the study. Finally, the participants were instructed to contact me if they needed technological support.

**Utilization of capABILITY**

Upon conclusion of capABILITY training the participants were instructed to utilize capABILITY as they desire. capABILITY was designed as weekly content files so the participants were instructed to download each new week’s worth of content each Monday. They were provided a schedule of weekly content information (see figure 12) for which they could refer to if needed. This process ensured that participants could not
jump forward to information that was not in the canned sequence of events (referring to
tunnelling as a methodology of persuasive technology). Once a weekly capABILITY
was downloaded participants could always go back and view older material (weeks) and
were encouraged to do as much. In addition, participants were asked at the beginning of
the study to complete their weekly goal, key in PGHD and answer their weekly survey
questions. This was only asked of them once at the beginning of the study as we did not
want to continually remind or encourage them as this could have produced an
unwarranted motivation stimulation which would confound with the spark and facilitator
trigger messages.

**Statistical Analysis**

In order to determine if there was a statistically significant increase in self-efficacy,
knowledge and self-management post intervention paired sample t test analyses were
performed. In addition, a between subjects one-way ANOVA was performed to
determine if there was a statistically significate difference in the post-test means of self-
efficacy, knowledge and self-management by time classification in capABILITY of high,
mid and low (see Figure 13). Paired sample t test were also performed on Pre/Post: self-
efficacy, knowledge, general diet, specific diet, exercise, blood glucose and foot care. For
hypothesises 2 and 3 we followed our 3 Factor Cross Design and utilized a repeated
measures (RM) ANOVA for analysis. The dependent variables utilized in the Repeated
Measures ANOVA were control (C), spark trigger (S), and facilitator trigger (F). Only
participants who experienced each dependent variable were utilized for analysis (n=12)
(see Table 12).
Table 12

Participants by Trigger Sequence (C = Control, F = Facilitator, S = Spark)

<table>
<thead>
<tr>
<th>Trigger Sequence</th>
<th>Total Participants n=12</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFS</td>
<td>1</td>
</tr>
<tr>
<td>CSF</td>
<td>4</td>
</tr>
<tr>
<td>FCS</td>
<td>3</td>
</tr>
<tr>
<td>FSC</td>
<td>1</td>
</tr>
<tr>
<td>SCF</td>
<td>1</td>
</tr>
<tr>
<td>SFC</td>
<td>2</td>
</tr>
</tbody>
</table>

Results

In total, 20 participants enrolled in the study and were randomly assigned at the beginning of each module into the control, facilitator or spark groups. Pre and post self-
efficacy, knowledge and self-care measures were collected and analysed on all 20 participants. Due to attrition during the course of the study only 12 participants were utilized for analysis of engagement in hypotheses 2 and 3.

Table 13
Participant Demographic and Pre/Post Test Data

<table>
<thead>
<tr>
<th>Category</th>
<th>Classification</th>
<th>Participant Results (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td>Age</td>
<td>30 - 39</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>40 - 49</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>50 - 59</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>60 - 69</td>
<td>8</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>African American</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Caucasian</td>
<td>13</td>
</tr>
<tr>
<td>Duration of Type II Diabetes Mellitus</td>
<td>&lt; 1 year</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1 year</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 - 5 years</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5 - 10 years</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>&gt; 10 years</td>
<td>9</td>
</tr>
<tr>
<td>Type of Medication</td>
<td>Oral Medication</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Insulin</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Oral Medication and Insulin</td>
<td>4</td>
</tr>
<tr>
<td>Diabetes Related Doctor Visits</td>
<td>Every Six Weeks</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Every Quarter</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Once Per Year</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Twice Per Year</td>
<td>2</td>
</tr>
<tr>
<td>Question</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Communicate With a Diabetes Educator</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Number of People in Household</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Person</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2 People</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3 People</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>4 People</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Utilized a Mobile Application Before</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Technical School</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Some College</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Associates Degree</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Bachelors Degree</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Masters Degree</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management (i.e. RIS Manager)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Professional (i.e. Financial Analyst)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Clinical (i.e. RN)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Clerical (i.e. Billing)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Household Annual Income (US Dollars)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20,000 - 29,999</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>30,000 - 39,999</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>40,000 - 49,999</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>50,000 - 74,999</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>75,000 - 99,999</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt; 100,000</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Take Medication as Prescribed</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>Monitor Blood Glucose as Suggested by Doctor</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Follow Diet</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>---------------------</td>
<td>---</td>
<td>----</td>
</tr>
<tr>
<td>Seldom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Self-Efficacy Score; Mean (SD)

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>3.31 (.84)</td>
<td></td>
</tr>
<tr>
<td>Post-Test</td>
<td>3.63 (.83)</td>
<td></td>
</tr>
</tbody>
</table>

Knowledge Score; Mean (SD)

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>79% (.16)</td>
<td></td>
</tr>
<tr>
<td>Post-Test</td>
<td>82% (.14)</td>
<td></td>
</tr>
</tbody>
</table>

Summary of Diabetes Self-Care Activities Measures (SD)

<table>
<thead>
<tr>
<th></th>
<th>General Diet</th>
<th>Specific Diet</th>
<th>Exercise</th>
<th>Blood Glucose</th>
<th>Foot Care</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Test</td>
<td>Post-Test</td>
<td>Pre-Test</td>
<td>Post-Test</td>
<td>Pre-Test</td>
</tr>
<tr>
<td></td>
<td>3.55 (2.25)</td>
<td>4.37 (1.85)</td>
<td>1.63 (2.17)</td>
<td>2.74 (2.06)</td>
<td>3.92 (2.95)</td>
</tr>
</tbody>
</table>

The mean age in years of the participants was 54.7 (SD: 10.4) and the mean number of years diagnosed with type II diabetes was 9 (SD: 7.6). Most of the participants were female and three-quarters of the population was Caucasian (see Table 13).

Table 14 shows that self-efficacy, knowledge, and self-care measures all improved when the post-test scores are compared to that of the pre-test scores.
Hypothesis 1: We hypothesize that after the capABILITY intervention, participants will demonstrate improved scores on self-efficacy, knowledge and self-management.

A paired samples $t$ test was utilized on each outcome to determine the significance level pre and post the capABILITY intervention. Results indicated statistical significance on three of the seven outcomes (general diet, $p = .038$; exercise, $p = .005$; and blood glucose, $p = .024$). Table 14 displays the mean and standard deviation of the pre and post-test scores, including the change score ($\Delta$) from pre to post, and Cohen’s $d$ effect size.

Table 14
Paired Sample $t$ test on Self-Efficacy, Knowledge and Self-Management, $n = 20$

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pre-Test $M(SD)$</th>
<th>Post-Test $M(SD)$</th>
<th>$\Delta$</th>
<th>$t$</th>
<th>$p$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Efficacy</td>
<td>3.31(.836)</td>
<td>3.63(.832)</td>
<td>.32</td>
<td>-1.650</td>
<td>.115</td>
<td>.38</td>
</tr>
<tr>
<td>Knowledge</td>
<td>0.79(.163)</td>
<td>0.82(.137)</td>
<td>.03</td>
<td>-1.434</td>
<td>.68</td>
<td>.20</td>
</tr>
<tr>
<td>General Diet</td>
<td>3.55(2.26)</td>
<td>4.37(1.80)</td>
<td>.82</td>
<td>-2.234</td>
<td>.038*</td>
<td>.40</td>
</tr>
<tr>
<td>Specific Diet</td>
<td>3.13(1.52)</td>
<td>3.68(1.85)</td>
<td>.55</td>
<td>-1.508</td>
<td>.149</td>
<td>.32</td>
</tr>
<tr>
<td>Exercise</td>
<td>1.63(1.96)</td>
<td>2.74(1.75)</td>
<td>1.11</td>
<td>-3.181</td>
<td>.005*</td>
<td>.60</td>
</tr>
<tr>
<td>Blood Glucose</td>
<td>3.39(3.03)</td>
<td>4.37(2.80)</td>
<td>.98</td>
<td>-2.456</td>
<td>.024*</td>
<td>.36</td>
</tr>
<tr>
<td>Foot Care</td>
<td>3.92(2.75)</td>
<td>4.18(2.29)</td>
<td>.26</td>
<td>-0.723</td>
<td>.479</td>
<td>.10</td>
</tr>
</tbody>
</table>

*Note.* $*$ = significant at the .05 level.
If we only analyse the high and mid users ($n = 14$) of capABILITY, we produce a statistically significant difference in: self-efficacy (.008) and exercise (.012). The high users (7 in total) time range in the system was 117 minutes to 71 minutes and the mid users (7 in total) time in the system ranged from 70 minutes to 21 minutes. Table 15 shows the pre/post mean differences and significance values.

Table 15
Paired Samples t test on Self-Efficacy, Knowledge and Self-Management, n=14

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>$\Delta$</th>
<th>$t$</th>
<th>$p$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Efficacy</td>
<td>3.25(.900)</td>
<td>3.86(.751)</td>
<td>.61</td>
<td>-3.134</td>
<td>0.008*</td>
<td>.74</td>
</tr>
<tr>
<td>Knowledge</td>
<td>0.82(.137)</td>
<td>0.85(.112)</td>
<td>.03</td>
<td>-1.247</td>
<td>0.234</td>
<td>.24</td>
</tr>
<tr>
<td>General Diet</td>
<td>3.82(2.38)</td>
<td>4.96(1.37)</td>
<td>1.14</td>
<td>-2.462</td>
<td>0.29</td>
<td>.59</td>
</tr>
<tr>
<td>Specific Diet</td>
<td>3.14(1.51)</td>
<td>3.82(1.20)</td>
<td>.68</td>
<td>-1.663</td>
<td>0.12</td>
<td>.50</td>
</tr>
<tr>
<td>Exercise</td>
<td>1.54(2.14)</td>
<td>2.75(1.86)</td>
<td>1.21</td>
<td>-2.925</td>
<td>0.012*</td>
<td>.60</td>
</tr>
<tr>
<td>Blood Glucose</td>
<td>3.61(3.25)</td>
<td>4.61(2.83)</td>
<td>1.00</td>
<td>-1.880</td>
<td>0.083</td>
<td>.33</td>
</tr>
<tr>
<td>Foot Care</td>
<td>4.22(2.70)</td>
<td>4.54(2.08)</td>
<td>.32</td>
<td>-.671</td>
<td>0.514</td>
<td>.13</td>
</tr>
</tbody>
</table>

*Note. * = significant at the .05 level.

We also performed a one-way ANOVA to analyse the between-group differences (high, mid, low) on each outcome (See Table 16). The one-way ANOVA did not show any
statistically significant differences between groups. This could be in part to the small \( n \) within each group (high, mid and low users).

Table 16

One-way ANOVA between groups (high, mid, low users)

<table>
<thead>
<tr>
<th>Between-subjects Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Efficacy</td>
<td>2</td>
<td>3.259</td>
<td>1.629</td>
<td>2.796</td>
<td>0.089</td>
</tr>
<tr>
<td>Knowledge</td>
<td>2</td>
<td>0.088</td>
<td>0.044</td>
<td>2.752</td>
<td>0.092</td>
</tr>
<tr>
<td>General Diet</td>
<td>2</td>
<td>21.05</td>
<td>10.53</td>
<td>4.447</td>
<td>0.29</td>
</tr>
<tr>
<td>Specific Diet</td>
<td>2</td>
<td>1.162</td>
<td>0.581</td>
<td>0.154</td>
<td>0.859</td>
</tr>
<tr>
<td>Exercise</td>
<td>2</td>
<td>11.17</td>
<td>5.585</td>
<td>2.030</td>
<td>0.164</td>
</tr>
<tr>
<td>Blood Glucose</td>
<td>2</td>
<td>3.478</td>
<td>1.739</td>
<td>0.202</td>
<td>0.819</td>
</tr>
<tr>
<td>Foot Care</td>
<td>2</td>
<td>14.45</td>
<td>7.224</td>
<td>1.442</td>
<td>0.266</td>
</tr>
</tbody>
</table>

Discussion

The results of the study show improvements in self-efficacy, knowledge and self-management however not all of them showed a statistically significant change from pre to post intervention. When we analysed the data with all participants (\( n=20 \)) we produced statistically significant improvements in general diet, specific diet and blood glucose measures. Essentially, the utilization of capABILITY produced the most significant changes in self-management. When we only analyse data from the high and mid users (\( n=14 \)) of capABILITY we produce a statistically significant difference in self-
efficacy and general diet. The self-efficacy significance changed dramatically from the first analysis (n=20) of .115 to the second analysis (n=14) of .008. Therefore, the data hints that there is a difference between groups and that the more time spent utilizing capABILITY the more appreciable improvement in self-efficacy can be expected. Even though there were improvements in knowledge outcome scores, these gains did not produce a statistically significant difference from pre-to-post intervention. This was not surprising as we learned through our earlier focus group sessions and post-intervention debriefing session that knowledge was not directly correlated to self-efficacy. We had participants who scored very high on their knowledge tests but scored really low on their self-efficacy survey. These participants told us that even though they have a high knowledge level they did not feel they could add something else to their already full load as being a provider, spouse and parent. In addition, overall the knowledge scores were fairly high to start so potentially there was not much room for growth. Finally, we determined that there was not a statistically significant difference in post-measure outcomes between the three time classification groups (high, mid, low).

**Hypothesis 2: We hypothesize that following the persuasive technology framework, participants will be more engaged in the usage of capABILITY following a behavioral trigger.**

Engagement was operationalized by duration (i.e., total time in capABILITY). To analyse duration by type of behavioral trigger (spark, facilitator and control), the triggers
were ordered in the form of a 3-factor crossover design. Figure 14 represents the ordering sequence of the participants (n=12).

A Repeated Measures ANOVA was run to examine the differences between three different triggers (spark, facilitation and control) and duration. Preliminary analysis revealed that the sphericity assumption was not upheld (Mauchly’s Test = .411, \( p = .012 \)). The within-subject analysis revealed that there was not a significant effect, \( F(1, 2) = .677, \ p = .518 \)

<table>
<thead>
<tr>
<th>Participant(s)</th>
<th>Trigger</th>
<th>Test</th>
<th>Trigger</th>
<th>Test</th>
<th>Trigger</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
</tr>
<tr>
<td>2</td>
<td>Spark</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
<td>Control</td>
<td>Duration</td>
</tr>
<tr>
<td>3</td>
<td>Facilitator</td>
<td>Duration</td>
<td>Control</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
</tr>
<tr>
<td>4</td>
<td>Control</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
</tr>
<tr>
<td>5</td>
<td>Facilitator</td>
<td>Duration</td>
<td>Control</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
</tr>
<tr>
<td>6</td>
<td>Facilitator</td>
<td>Duration</td>
<td>Control</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
</tr>
<tr>
<td>7</td>
<td>Control</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
</tr>
<tr>
<td>8</td>
<td>Facilitator</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
<td>Control</td>
<td>Duration</td>
</tr>
<tr>
<td>9</td>
<td>Spark</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
<td>Control</td>
<td>Duration</td>
</tr>
<tr>
<td>10</td>
<td>Spark</td>
<td>Duration</td>
<td>Control</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
</tr>
<tr>
<td>11</td>
<td>Control</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
</tr>
<tr>
<td>12</td>
<td>Control</td>
<td>Duration</td>
<td>Spark</td>
<td>Duration</td>
<td>Facilitator</td>
<td>Duration</td>
</tr>
</tbody>
</table>

Figure 14. Engagement 3-factor Crossover Design
In addition, descriptive statistics showed the weekly mean duration (in seconds) of time per participant in the control group (621) to be greater than spark (537) and facilitator (500). Table 17 shows the engagement (duration in seconds) by module and also by trigger type.

Table 17

Engagement (time duration) by Trigger Type within each Module

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Module 1</th>
<th></th>
<th>Module 2</th>
<th></th>
<th>Module 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Duration (seconds)</td>
<td>Percentage</td>
<td>Duration (seconds)</td>
<td>Percentage</td>
<td>Duration (seconds)</td>
<td>Percentage</td>
</tr>
<tr>
<td>Control</td>
<td>11,949</td>
<td>48%</td>
<td>5,122</td>
<td>32%</td>
<td>5,289</td>
<td>28%</td>
</tr>
<tr>
<td>Facilitator</td>
<td>7,898</td>
<td>32%</td>
<td>3,660</td>
<td>22%</td>
<td>6,475</td>
<td>35%</td>
</tr>
<tr>
<td>Spark</td>
<td>5,023</td>
<td>20%</td>
<td>7,419</td>
<td>46%</td>
<td>6,902</td>
<td>37%</td>
</tr>
<tr>
<td></td>
<td>24,870</td>
<td>100%</td>
<td>16,201</td>
<td>100%</td>
<td>18,666</td>
<td>100%</td>
</tr>
</tbody>
</table>

Behavioral tasks were also evaluated as participant activity within capABILITY.

Behavioral tasks that participants could take part in included: set a weekly goal, acknowledgement of meeting the goal at the end of the week, weekly PGHD input, answer weekly self-efficacy question, answer weekly knowledge question and answer weekly self-management question. Figure 15 represents behavioral task participation by trigger type and figure 16 shows the overall behavior adherence ratios by trigger type.
Discussion

The parameters for hypothesis 2 was that a participant must be active in capABILITY and receive all three types of triggers (control, spark, facilitator). This parameter reduced our sample size to 12 due to attrition throughout the course of the study. In addition, we operationalized engagement as duration of time spent utilizing
capABILITY. We also used descriptive data from behavioral task within capABILITY such as: set a weekly goal, acknowledgement of meeting the goal at the end of the week, weekly PGHD input, answer weekly self-efficacy question, answer weekly knowledge question and answer weekly self-management question.

The Repeated Measures ANOVA showed that there was not a significant within-subject effect between the trigger types and duration. The results also showed that when participants were in the control group they engaged (duration) with capABILITY more than when they were in the spark or facilitator trigger group. Overall, participants when in the control group utilized capABILITY for 22,360 seconds as compared to 18,033 seconds for participants in the facilitator group and 19,344 for participants in the spark. As seen in figure 14 the participants were randomly assigned each module to a particular trigger group. Every three weeks (start of new module) the participants were randomized into one of the three trigger groupings. At the start of the study (module 1) there were 5 participants in the control group, 4 in the facilitator group and 3 in the spark group. Since we ended up with 12 participants for this analysis the start of the randomized grouping order may have impacted engagement as a whole. As seen in Table 18 duration time in Module 1 far exceeded duration time in Module 2 and 3. This is common at the beginning of a study however there were 5 participants in the control to start the study compared to only 3 in the spark group. In Modules 2 and 3 the participants in the spark group outperformed (more duration time in capABILITY) those in the control and facilitator groups. It is plausible that if the randomized trigger groupings started out with the same number of participants in the spark group as the control group that we would see
the spark group with the largest overall duration time. Even though it would not be statistically significant it would be an important descriptive data finding.

In addition to the engagement (duration) analysis a descriptive analysis was conducted on behavioral tasks within capABILITY. The control group completed the most behavioral tasks (148) followed by the spark group (133) then the facilitator group (116). As stated above this could be linked to more participants starting Module 1 in the control group. Even though the control group completed the most behavioral tasks the spark group had the highest adherence percentage to completing the behavioral tasks as seen in Figure 16.

Hypothesis 3: We hypothesize that following the persuasive technology framework, participants who receive spark triggers involving motivation will engage in the utilization of capABILITY faster than those who receive facilitator triggers.

Engagement was operationalized by average time from trigger delivery to capABILITY login. To analyse average time from trigger to capABILITY login by type of behavioral trigger (spark, facilitator and control), the triggers were ordered in the form of a 3-factor crossover design. Figure 17 represents the ordering sequence of the participants (n=12). A RM ANOVA was run to examine the differences between three different triggers (spark, facilitator and control) and average time to login capABILITY post trigger delivery. Preliminary analysis revealed that the sphericity assumption was not upheld
(Mauchly’s Test = .293, $p = .002$). The within-subject analysis revealed that there was not a significant effect, $F(1, 2) = .945, p = .404$.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Trigger</th>
<th>Test</th>
<th>Trigger</th>
<th>Test</th>
<th>Trigger</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control</td>
<td>Avg. Trigger to</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
</tr>
<tr>
<td>2</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
<td>Control</td>
<td>Avg. Trigger to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
</tr>
<tr>
<td>3</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
<td>Control</td>
<td>Avg. Trigger to</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
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<tr>
<td></td>
<td></td>
<td>Login Time</td>
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<td>Login Time</td>
<td></td>
<td>Login Time</td>
</tr>
<tr>
<td>4</td>
<td>Control</td>
<td>Avg. Trigger to</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
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<tr>
<td></td>
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<td>Login Time</td>
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<td>Login Time</td>
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</tr>
<tr>
<td>5</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
<td>Control</td>
<td>Avg. Trigger to</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
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<tr>
<td></td>
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<td>Login Time</td>
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<td>Login Time</td>
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</tr>
<tr>
<td>6</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
<td>Control</td>
<td>Avg. Trigger to</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
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<td>Login Time</td>
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<td>Login Time</td>
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<td>Login Time</td>
</tr>
<tr>
<td>7</td>
<td>Control</td>
<td>Avg. Trigger to</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
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<tr>
<td></td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
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<td>Login Time</td>
</tr>
<tr>
<td>8</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
<td>Control</td>
<td>Avg. Trigger to</td>
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<tr>
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<td>Login Time</td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
</tr>
<tr>
<td>9</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
<td>Control</td>
<td>Avg. Trigger to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
</tr>
<tr>
<td>10</td>
<td>Spark</td>
<td>Avg. Trigger to</td>
<td>Control</td>
<td>Avg. Trigger to</td>
<td>Facilitator</td>
<td>Avg. Trigger to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
<td></td>
<td>Login Time</td>
</tr>
</tbody>
</table>
In addition, descriptive statistics showed that participants in the spark group logged into capABILITY quicker than those in the control and facilitator group based on the timing of trigger delivery. Figure 18 shows the weekly mean trigger to login time (seconds) by trigger grouping. In this particular figure the smaller the average trigger to login time the better the outcome. Essentially, this figure is showing how quickly a trigger message cues a participant to log into capABILITY to execute a task. Table 18 shows the module mean trigger to login time (seconds) by trigger grouping.
Table 19

Mean Weekly Trigger to Login Time by Module

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Module 1 Trigger to Login (seconds)</th>
<th>Module 2 Trigger to Login (seconds)</th>
<th>Module 3 Trigger to Login (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>370,374</td>
<td>216,949</td>
<td>259,015</td>
</tr>
<tr>
<td>Facilitator</td>
<td>220,370</td>
<td>243,373</td>
<td>205,604</td>
</tr>
<tr>
<td>Spark</td>
<td>188,711</td>
<td>194,637</td>
<td>162,676</td>
</tr>
</tbody>
</table>

As seen in the table above the spark triggers consistently outperformed the control and facilitator triggers in terms of cueing the participants to engage with capABILITY more quickly post receipt of a trigger. The spark trigger group produced the quickest trigger to login response for each module.

**Discussion**

The parameters for hypothesis 3 are the same as in hypothesis 2. For hypothesis 3 we operationalized engagement as the duration of time between trigger delivery to participant login of capABILITY.

The Repeated Measures ANOVA showed that there was not a significant within-subject effect between the trigger types and the duration of time between trigger delivery to participant login of capABILITY. As seen in figure 17 the participants were randomly assigned each module to a particular trigger group. Every three weeks (start of new module) the participants were randomized into one of the three trigger groupings. Even though the results were not statistically significant the spark triggers did produce the fastest response from trigger to capABILITY login. Overall, participants when in the
The spark group had a weekly mean response trigger to capABILITY login time of 182,502 seconds. This time is significantly quicker than the facilitator trigger time of 220,001 seconds and the control of 291,392 seconds. As seen in table 19 the spark triggers also produced the fastest mean response trigger to capABILITY in each module as well. The fact that the spark triggers brought the participants to capABILITY at a much quicker response time is a very important finding. The Fogg Behavior Model states that in order for a person to accomplish a specific behavioral task the following must occur: be motivated, have the ability/capacity to perform the behavior and to be triggered to perform the behavior (Fogg, 2009). Spark triggers could be the missing link in the attempt to cue individuals to perform a specific behavior within a given amount of time. It is interesting to note that both the spark and facilitator triggers outperformed the control group in bringing the participants to capABILITY quicker however individuals in the control group actually spent more time using capABILITY. We feel this confirms that the triggers (in particular the spark) cue an individual to accomplish a task but does not necessarily improve their engagement as time spent within a system. This is evidenced in a study by Weymann et al. where a tailored IHCA designed for individuals with chronic diseases showed that the participants spent significant more time in the system compared to the control group however it did not lead to more knowledge or patient empowerment (Weymann et al., 2015). It should be noted that trigger messages were not utilized in this study. Combining a tailored IHCA mHealth application with spark triggers could potentially improve both engagement in the system as well as behavioral outcomes.
Participant Debriefing

A post intervention debriefing session was conducted utilizing a semi-structured question format (16 questions in total). In total, 8 out of the 20 participants volunteered to participate in the debriefing session which lasted for 2 hours. The debriefing session was conducted at Lafayette General Health System in a private conference room. The main goal of the debriefing session was to find out more information on: what did the participants learn, how did capABILITY help them manage their diabetes, what aspects of capABILITY did they learn the most from, when were they most compelled to utilize capABILITY what was their interpretation of the trigger messages, how could capABILITY be improved and would they continue using capABILITY post intervention.

Question one focused on what did the participants learn through capABILITY. In total, 7 out of the 8 participants responded to the open ended question.

In total, the debriefing participants provided 97 answers for the 16 questions asked during the session. Figure 19 depicts a sample of the questions provided and the participants’ responses.

<table>
<thead>
<tr>
<th>Sample Questions</th>
<th>Sample Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did you find surprising about using capABILITY?</td>
<td>&quot;Helped me be aware of taking my medication.&quot; &quot;Ease of use, ability to access at all times.&quot;</td>
</tr>
<tr>
<td>How did it help you with managing your type II diabetes?</td>
<td>&quot;Setting weekly goals helped me build self-care around work commitments.&quot; &quot;It reminded me to do daily CBGs and motivated me to stay on diet and to do exercises.&quot;</td>
</tr>
</tbody>
</table>
How have you changed in regards to managing your diabetes from before the study to now?  
"Increased priorities, now identifying methods to place emphasis on self-care activities."
"More serious about diet, exercise, health in general and foot care."

What did you best learn from? Video, text, links, goals, keying of carbs, exercise or blood glucose? 
"Documenting my own information."
"Videos"
"Text, links, goal setting which provides a structure."

Did you use the tracking mechanism (i.e. keying of carbs)? If so, how? 
"Used the carb tracker and exercise more than I did the blood glucose."
"It did make me more conscientious about things like walking and getting in steps."

What did you think of the messages you received? 
"They were instructive and encouraging."
"The messages were informative and engaging. Much more pleasant than reading and also more engaging."

When did you feel the most compelled to use capABILITY? 
"In the evenings after I ate."
"First thing in the morning."
"As time progressed I was more compelled to use capABILITY. It was becoming a good habit. I used it at night after my daily activities and eating."

What was your overall experience with using capABILITY? 
"I lost 7 pounds during the program."
"Although I knew most of the information presented. It made me more aware of what I was doing wrong in trying to manage my diabetes."
"Positive and educational. Provided me with insight regarding my personal barriers to compliance."

How was your engagement with capABILITY? 
"Engagement was very good and improved each time I used it. "I was engaged - very. I feel less controlled since the study ended. With capABILITY I was able to manage my habits more reliably."

---

Study Summary

The results of the study show improvements in self-efficacy, knowledge and self-management. Between groups analysis did not reveal statistically significant differences but the data does hint that the more time spent utilizing capABILITY the more appreciable improvement in self-efficacy can be expected.
In addition, a Repeated Measures ANOVA showed that there was not a significant within-subject effect between the trigger types and total capABILITY duration usage. A descriptive analysis of completed behavioral tasks within capABILITY showed that the control group completed the most behavioral tasks (148) followed by the spark group (133) and the facilitator group (116). Even though the control group participants completed the most behavioral tasks the spark group had the highest adherence completion percentage rate (See Figure 15).

A Repeated Measures ANOVA was also performed on trigger types and the duration of time between trigger delivery to participant login of capABILITY which showed no significant within-subject effect. Descriptive analysis showed that participants when in the spark group had a weekly mean response trigger to capABILITY login time of 182,502 seconds. This time is significantly quicker than the facilitator trigger time of 220,001 seconds and the control of 291,392 seconds. The fact that the spark triggers brought the participants to capABILITY at a much quicker response time is a very important finding. We feel this confirms that spark triggers can cue an individual to accomplish a behavioral task quicker than facilitator messages or simply no message at all.

Participants utilization of capABILITY varied with some users spending little time in the system while others utilized capABILITY almost daily. This is seen in hypothesis one as we looked for differences between groups by high, mid and low users of capABILITY. We felt it was important to showcase a super user of capABILITY in order to better understand what more time spent utilizing capABILITY means.
Case Study: Super User

For the sake of confidentiality we will refer to the super user as “Jane” throughout this case study. Jane recorded the highest capABILITY usage time in 4 out of the 9 intervention weeks. She outperformed the study population as a whole in most of the behavioral task and engagement characteristics. Jane was diagnosed 15 years ago and takes oral medication to manage her diabetes. She completed technical school and works as a nurse with an average work hour week of 45 hours. “Jane” meets with her endocrinologist every quarter and has never communicated with a Certified Diabetes Educator. According to “Jane”, she sometimes follows her diet, does not monitor her blood glucose as suggested by her physician and has not presented to the emergency room within the last year for a diabetes related medical problem. “Jane” falls within the 60 – 69 years of age range and lives at home with a significant other. In addition, “Jane” provided the following commentary during the participant debriefing session:

- “capABILITY helped me choose the right foods to eat and motivated me to keep up my exercises.”
- “capABILITY showed me the importance of logging down my diet and exercise which helped keep my blood sugar stable.”
- “I looked forward to each Monday to download the new module and see what it was.”
- “I lost 7 pounds during the program.”

The following figures shows “Jane’s” user characteristics and how she compared to all participants in the study. The figures focus on usage duration and AM/PM usage,
engagement characteristics, and self-efficacy, knowledge and self-management outcomes.

Figure 20. “Jane” Weekly capABILITY Usage (seconds)

Like many of the participants Jane’s highest usage of capABILITY came in week 1. This graphical (See Figure 20) depiction of the time slopes was also common among the participants who utilized capABILITY throughout the intervention (Jane’s weekly numbers are just higher). As seen in Figure 21, Jane frequently outperformed the rest of the study population group in terms of capABILITY usage characteristics. She was very active in terms of entering data in capABILITY as her PGHD weekly data entry average was two days greater than the study population group average. In addition, Jane’s data showed that she met her goal in 6 out of the possible 9 weeks compared to the study group population average of 4. As seen in figure 22, Jane utilized capABILITY more in
the evening than in the morning hours. This was also a common theme amongst all the participants.

Figure 21. “Jane” capABILITY Usage Characteristics compared to All Participants (averages)
Figure 22. “Jane” Login Times

Figure 23. SE, Knowledge and Self-Management Pre-Post Scores

All of Jane’s post-test analyses increased as compared to that of her pre-test scores.

In addition, she scored higher than the study group population post-test averages in: self-
efficacy, knowledge, and self-management (general diet, specific diet, exercise, blood glucose and foot care).

Jane’s usage of capABILITY shines a light into “what could be” with more time spent utilizing capABILITY. It does appear through Jane’s usage story that the more one uses capABILITY the greater the return in self-efficacy, knowledge and self-management.
Chapter 6: Limitations, Future Direction and Conclusions

As patients are being asked to take on a more active role in the management of their chronic disease processes it is imperative that we leverage mHealth to create solutions to ease this burden. Our study has shown that an IHCA designed mHealth solution which embeds theories from Social Cognitive Theory, Fogg Behavior Model and Persuasive Technology can improve self-efficacy, knowledge and self-management for individuals with type II diabetes. In addition, our study showed that spark trigger messages have the ability to cue an individual to action quicker than a facilitator trigger.

Limitations

The primary limitation of this study was the small sample size which did not produce a large enough statistical power for us to detect statistically significant changes in the engagement of behavioral triggers. Even though we had a sample population of 200 plus individuals with type II diabetes we were only able to recruit 20 to participant in the 9 week mHealth study. Second, all of the participants in the study were employed full-time with benefits which may not fully represent a typical chronic disease population. Third, the study duration of 9 weeks intersected with three holidays (Thanksgiving, Christmas and New Year’s) and it is unclear whether or not this had an effect on the participants or outcomes. The study suggests that spark triggers outperformed facilitator triggers in response time to capABILITY utilization. Being that spark triggers focus on motivation a limitation of the study is that we did not get a baseline motivation score on the participants nor did we measure their motivation.
Future Direction

In this research we have proposed adding Persuasive Tech, Social Cognitive Theory and Fogg Behavior Model to the Interactive Health Communication Applications Framework (IHCA) to create a mHealth application targeted at improving self-efficacy, knowledge, and self-management within a chronic disease population. Our study focused on a population of individuals with type II diabetes and future work should attempt to validate the improvements in self-efficacy, knowledge and self-management within a similar or different chronic disease population.

This research added to the existing IHCA framework to embed specific Persuasive Technology components such as tunnelling and the use of the Fogg Behavior Model (focus on spark and facilitator triggers). The type II diabetes education material utilized to build capABILITY from the American Diabetes Association, American Association of Diabetes Educators and our experts should be perceived as an interchangeable patient education segment within the framework. Future research should focus on utilizing the framework that we added while exchanging the educational material for another chronic disease population in an attempt to replicate our results in the areas of: self-efficacy, knowledge and self-management.

More work needs to done in deciphering the appropriate mechanics to writing spark and facilitator trigger messages. Although the concept of writing messages to motivate individuals to perform a specific behavior (spark) or to trigger a behavior while acknowledging to the individual the behavior is easy (facilitator) seems easy on the
surface it is complicated by human interpretation. This is especially true when you add the intricacies of healthcare language to the spark and facilitator triggers.

Little is known about how participants react to spark and facilitator triggers as many past studies simply focused on reminder triggers (signals). Our study showed that participants who received spark triggers engaged in the utilization capABILITY more quickly than those who received facilitator triggers. This important finding may potentially mean that triggers that focus on motivation impel individuals to perform a behavior now more than triggers that try to show how easy a behavior is to accomplish. Future research should seek to validate these results in other participant populations. If these studies validate our results then it may be possible to develop triggers (particularly sparks) which can be delivered to large population groups without the need for tailoring detailed messages.

Though our study showed that participants who received spark triggers engaged in the utilization of capABILITY more quickly it did not necessarily keep them engaged in usage of capABILITY. Even though the data was not statistically significant participants in the control group (no triggers) spent more time utilizing capABILITY than those in the spark and facilitator trigger groups. This finding along with participant feedback shows that tailoring is still important in the design of persuasive mHealth or computer systems. Previous research has shown that tailoring helps engage users (spending more time in the system) in the utilization of mhealth and computer systems but does not always lead to desired improvements in behavioral outcomes (Smith et al., 2016; Weymann et al., 2015). Future research should focus on giving the participants the ability to tailor the
mHealth solution to their needs while delivering spark triggers in an effort to produce the desired/target behavior.

**Conclusions**

The results of this study are important to the fields of biomedical informatics, consumer informatics and persuasive technology. In this study we have shown how to add additional theoretical constructs to the existing IHCA framework such as Social Cognitive Theory, Fogg Behavior Model and Persuasive Technology to create a mHealth application (capABILITY) focused on improving self-efficacy, knowledge and self-management for individuals with chronic disease. We utilized a user-centered design process which incorporated individuals with type II diabetes and clinical experts. Persuasive spark and facilitator triggers were designed and validated through three iterations of development and testing. Our work suggests that self-efficacy, knowledge and self-management can be improved through utilization of theory-driven mHealth applications.

In addition, our work implies that spark triggers have the ability to cue specific individual actions quicker than facilitator triggers or simply no triggers at all. This is an important discovery in the area of consumer informatics as we may be able to design triggers through a targeted population based approach instead of individualized tailored triggers. Creation of population based spark triggers by chronic disease could be an effective approach to cueing positive behavioral tasks for large populations at a time through mHealth. This could become a powerful tool that could be utilized in Accountable Care Organizations (ACO), Managed Care Organizations (MCO), large
healthcare systems or population health management at any level. It is to be noted that our research findings in the area of spark triggers differs from the idea in the Fogg Behavior Model that individuals may be more tolerant of facilitators or reminders over the course of time (Fogg, 2009). Our nine week study showed that spark triggers continually cued participants to engage with capABILITY at the beginning and at the conclusion of the study. From these finding we feel confident that trigger messages which contain motivation (sparks) in the form of pleasure, hope and social acceptance cue actions quicker than facilitator messages or simple reminders.

Our findings also contribute to the field of biomedical informatics by leveraging theories from the social, behavioral and informational sciences by suggesting a new integrated IHCA approach for mHealth system design targeting a chronic disease population. This new IHCA mHealth system design integrates Social Cognitive Theory, Fogg Behavior Model and Persuasive Technology into a chronic disease management model. The education section of this new model can be interchanged depending on which chronic disease the mHealth solution is targeting.

This study has laid the foundation for future research into theoretical driven mHealth applications designed for chronic disease populations while utilizing specific persuasive triggers (i.e. sparks) to cue a target behavior. The results of our study suggest that a defined chronic disease population such as type II diabetes can see appreciable increases in self-efficacy, knowledge and self-management.
References


https://doi.org/10.3233/THC-2009-0545


https://doi.org/10.5888/pcd10.120112


for people with chronic disease. Retrieved February 17, 2017, from
https://www.dovepress.com/computer-based-interactive-health-communications-for-people-with-chron-peer-reviewed-article-SHTT


Dennison, L., Morrison, L., Conway, G., & Yardley, L. (2013). Opportunities and challenges for smartphone applications in supporting health behavior change:
qualitative study. *Journal of Medical Internet Research, 15*(4), e86.

https://doi.org/10.2196/jmir.2583


Diabetes | NIDDK. (n.d.). Retrieved February 20, 2017, from

https://www.niddk.nih.gov/health-information/diabetes


https://doi.org/10.1007/s10865-009-9200-0


104


https://doi.org/10.2196/jmir.2104


https://doi.org/10.1002/14651858.CD008963.pub2


https://doi.org/10.18553/jmcp.2014.20.7.691


**Systematic Reviews, 12, CD007457.**

https://doi.org/10.1002/14651858.CD007457.pub2


116


Author, A. A. (Year of publication). *Title of work: Capital letter also for subtitle.* Location: Publisher.


Author, A. A., & Author, B. B. (Date of publication). Title of article. *Title of Journal, volume number*, page range. doi:00000000/00000000/00000000/0000 or http://dx.doi.org/10.0000/0000

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http://owl.english.purdue.edu/owl/resource/560/01/
Appendix A: Participant Focus Group Questions

1. Describe self-efficacy
   a. I will then provide a generic definition of self-efficacy
2. Do you feel you are unable to accomplish and or maintain self-management tasks (i.e. diet, exercise)? Why do you feel you are unable to accomplish or maintain these tasks?
   a. Specific examples?
3. What is your biggest challenge in managing your day-to-day diabetic self-management?
   a. Do you think improving your self-efficacy would help?
4. What is the average length of time between clinician-patient communication? In person, telephone or email?
   a. Do you feel the length of time between these communications/interactions play a role in your ability to manage your diabetes?
   b. Would accessing information through a smart phone/mobile device help your day-to-day management in between clinical visits?
5. Have you ever been invited to attend diabetic education sessions?
   a. If yes, how often?
   b. If you stopped attending, why?
6. Have you ever attended a diabetic education session?
   a. If so, what did you think of them?
   b. If not, why?
7. Out of the following four self-management components which are the hardest to accomplish and maintain?
   a. Also, which ones do you feel your perceived self-efficacy is the lowest?
   b. What do you think contributes to your low self-efficacy?
   c. diet, exercise, glucose monitoring and medication adherence
8. How do you feel about using a smart phone/mobile device application which would provide modules to help you with you diabetic self-management?
   a. What are some positives to using a smart phone/mobile device application?
   b. What are some negatives to using a smart phone/mobile device application?
c. Do you feel you would need training to utilize the smart phone/mobile device application?

9. Would the design of the application play a role in your usage of the application?
   a. Color
   b. Layout
   c. Material

10. Do you currently use other types of smart phone/mobile applications (they don’t have to be healthcare related)?
    a. What do you like about them from a usage standpoint?
    b. What don’t you like about them from a usage standpoint?
    c. What keeps you going back to access the application?

11. What type of media would you like to interact with via the application?
    a. Video, audio, text, combination?

12. Would receiving tailored messaging from a clinician play a role in your continued usage of the application? I will provide an example of a tailored message.

13. What would you like to see be delivered in a mobile application that targets self-efficacy in diabetic patients?
    a. What would keep you engaged in using the application
    b. How often do you feel you would use the application?
Appendix B: Clinical Expert Focus Group Questions

1. Describe self-efficacy
2. Do your diabetic patients often mention that they feel they can’t accomplish self-management tasks? What do you think leads to patients not accomplishing these tasks?
   a. Specific examples?
3. Do you try to improve perceived self-efficacy in your diabetic patient population?
   a. If so, what techniques?
4. What is your biggest challenge in managing diabetic patient care?
   a. Do you think targeting self-efficacy would help?
5. Why do you feel it is so hard to improve self-efficacy in diabetic patients?
   a. What is the biggest obstacle?
   b. What responses do patients provide in regards to low self-efficacy?
6. What components of self-management do you feel can be improved through improving perceived self-efficacy?
   a. Mention these if they don’t come up: diet, exercise, glucose monitoring and medication adherence
7. Which self-management component(s) do you feel is more adaptable to change positively if self-efficacy is improved: diet, exercise, glucose monitoring and medication adherence?
8. Would you consider letting your patients use smart phone applications that target and try to improve perceived self-efficacy?
   a. Positive attributes to this approach?
   b. Negative attributes to this approach?
9. How would your patients respond to using a mobile application?
10. From a clinical perspective what needs to be included in a smart phone application that targets and tries to improve self-efficacy?
    a. Should self-efficacy be targeted by a specific self-management component (i.e. Diet)?
    b. Should the app design follow standards such as the Summary of Diabetes Self-Care Activities Measure?
c. From a self-efficacy standpoint what would you try to accomplish in the design?
   i. Examples of how to include self-efficacy information.

11. What type of media do you think your patients would respond to best via smartphone app?
   a. Mention these if they don’t come up: Video, audio, text, combination?
   b. Do your patients respond better to a particular type of media?

12. From your perspective what would keep patients engaged in using a smartphone application targeted toward self-efficacy?
   a. How often do you feel they should access the application?

13. Do you feel tailored messaging from a clinical provider could improve self-efficacy if delivered via a mobile phone application?
   a. How would you perceive this tailored message being delivered?
Appendix C: Sample Trigger Messages

Spark Triggers

1. Counting and tracking your carbohydrates can be FUN and REWARDING!
2. Many individuals like YOURSELF are already trying some of the diabetic superfoods. Give one of them a try this week!
3. Staying active is FUN and REWARDING! Refer to your staying active tab to learn about ENJOYABLE staying active tips at work and home!
4. You don't need a gym membership to make exercising FUN and REWARDING! Refer to your no gym tab for ENJOYABLE exercises!
5. Taking your medication as prescribed will help keep your diabetes under control! YOU can manage your diabetes and live a better life!

Facilitator Triggers

1. Creating healthy snacks can be EASY with snack to carbohydrate ratio lists! View your snacks tab for SIMPLE and healthy snack ideas.
2. Adding some of the diabetes superfoods to your health diet is EASY! View your superfoods information tab for SIMPLE and EASY recipes.
3. Staying active can be EASY when you have SIMPLE tips for staying active at work, home or on the go!
4. Creating healthy exercise plans can be EASY utilizing capABILITY! View your educational resources tabs for SIMPLE and EASY exercise plans!
5. Managing your diabetes can be more EASILY ACCOMPLISHED by understanding why your blood glucose rises and falls. Review your factors tab in educational resources and follow the SIMPLE STEPS!
Appendix D: The Summary of Diabetes Self-Care Activities

The questions below ask you about your diabetes self-care activities during the past 7 days. If you were sick during the past 7 days, think back to the last 7 days you were not sick.

1. How many of the last SEVEN DAYS have you followed a healthful eating plan?

   0   1   2   3   4   5   6   7

2. On average, over the past month, how many DAYS PER WEEK have you followed your eating plan?

   0   1   2   3   4   5   6   7

3. On how many of the last SEVEN DAYS did you eat five or more servings of fruits and vegetables?

   0   1   2   3   4   5   6   7

4. On how many of the last SEVEN DAYS did you eat high fat foods such as red meat or full-fat dairy products?

   0   1   2   3   4   5   6   7

5. On how many of the last SEVEN DAYS did you participate in at least 30 minutes of physical activity? (Total minutes of continuous activity, including walking).

   0   1   2   3   4   5   6   7

6. On how many of the last SEVEN DAYS did you participate in a specific exercise session (such as swimming, walking, biking) other than what you do around the house or as part of your work?

   0   1   2   3   4   5   6   7

7. On how many of the last SEVEN DAYS did you test your blood sugar?
8. On how many of the last SEVEN DAYS did you test your blood sugar the number of times recommended by your health care provider?

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9. On how many of the last SEVEN DAYS did you check your feet?

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10. On how many of the last SEVEN DAYS did you inspect the inside of your shoes?

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<td>3</td>
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11. Have you smoked a cigarette – even one puff – during the past SEVEN DAYS?

  0. No
  1. Yes. If yes, how many cigarettes did you smoke on an average day?

Number of cigarettes: ____________________________

12. Which of the following has your health care team (doctor, nurse, dietitian, or diabetes educator) advised you to do? Please check all that apply:

- a. Follow a low-fat eating plan
- b. Follow a complex carbohydrate diet
- c. Reduce the number of calories you eat to lose weight
- d. Eat lots of food high in dietary fiber
- e. Eat lots (at least 5 servings per day) of fruits and vegetables
- f. Eat very few sweets (for example: desserts, non-diet sodas, candy bars)
- g. Other (specify):
- h. I have not been given any advice about my diet by my health care team.

13. Which of the following has your health care team (doctor, nurse, dietitian or diabetes educator) advised you to do? Please check all that apply:

- a. Get low level exercise (such as walking) on a daily basis.
- b. Exercise continuously for a least 20 minutes at least 3 times a week.
- c. Fit exercise into your daily routine (for example, take stairs instead of elevators, park a block away and walk, etc.)
- d. Engage in a specific amount, type, duration and level of exercise.
- e. Other (specify):
- f. I have not been given any advice about exercise by my health care team.
14. Which of the following has your health care team (doctor, nurse, dietitian, or diabetes educator) advised you to do? Please check all that apply:
   □ a. Test your blood sugar using a drop of blood from your finger and a color chart.
   □ b. Test your blood sugar using a machine to read the results.
   □ c. Test your urine for sugar.
   □ d. Other (specify):
   □ e. I have not been given any advice either about testing my blood or urine sugar level by my health care team.

15. Which of the following medications for your diabetes has your doctor prescribed? Please check all that apply.
   □ a. An insulin shot 1 or 2 times a day.
   □ b. An insulin shot 3 or more times a day.
   □ c. Diabetes pills to control my blood sugar level.
   □ d. Other (specify):
   □ e. I have not been prescribed either insulin or pills for my diabetes.

16. On how many of the last SEVEN DAYS did you space carbohydrates evenly through the day?

   0 1 2 3 4 5 6 7

17. On how many of the last SEVEN DAYS, did you take your recommended diabetes medication?

   0 1 2 3 4 5 6 7

OR

18. On how many of the last SEVEN DAYS did you take your recommended insulin injections?

   0 1 2 3 4 5 6 7

19. On how many of the last SEVEN DAYS did you take your recommended number of diabetes pills?

   0 1 2 3 4 5 6 7

Foot Care
20. On how many of the last SEVEN DAYS did you wash your feet?

   0 1 2 3 4 5 6 7
21. On how many of the last SEVEN DAYS did you soak your feet?

0 1 2 3 4 5 6 7

22. On how many of the last SEVEN DAYS did you dry between your toes after washing?

0 1 2 3 4 5 6 7

23. At your last doctor’s visit, did anyone ask about your smoking status?
0. No
1. Yes

24. If you smoke, at your last doctor’s visit, did anyone counsel you about stopping smoking or offer to refer you to a stop-smoking program?
0. No
1. Yes
2. Do not smoke.

25. When did you last smoke a cigarette?
☐ More than two years ago, or never smoked
☐ One to two years ago
☐ Four to twelve months ago
☐ One to three months ago
☐ Within the last month
☐ Today

Derived from: The Summary of Diabetes Self-Care Activities Measure: Results from 7 Studies and A Revised Scale
Appendix E: Perceived Diabetes Self-Efficacy Scale

Circle your response to each item.

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Disagree nor Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is difficult for me to find effective solutions for problems that occur with managing my diabetes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I find efforts to change things that I don’t like about my diabetes are ineffective.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I handle myself well with respect to my diabetes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I am able to handle things related to my diabetes as well as most other people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. I succeed in the projects I undertake to manage my diabetes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. Typically, my plans for managing my diabetes don’t work out well.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. No matter how hard I try, managing my diabetes doesn’t turn out the way I would like.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. I’m generally able to accomplish my goals with respect to managing my diabetes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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Derived from the Psychometric Properties of the Perceived Diabetes Self-Management Scale (PDSMS)
Appendix F: Diabetes Knowledge Test

Circle the letter of the correct answer. There is only one correct answer per question.

1. The diabetes diet is:
   a. the way most American people eat
   b. a healthy diet for most people
   c. too high in carbohydrate for most people
   d. too high in protein for most people

2. Which of the following is highest in carbohydrate?
   a. Baked chicken
   b. Swiss cheese
   c. Baked potato
   d. Peanut butter

3. Which of the following is highest in fat?
   a. Low fat milk
   b. Orange juice
   c. Corn
   d. Honey

4. Which of the following is a “free food”? 
   a. Any unsweetened food
   b. Any food that has “fat free” on the label
   c. Any food that says “sugar free” on the label
   d. Any food that has less than 20 calories per serving

5. Glycosylated hemoglobin (hemoglobin A1) is a test that is a measure of your average blood glucose level for the past:
   a. day
   b. week
   c. 6-12 weeks
   d. 6 months

6. Which is the best method for testing blood glucose?
   a. Urine testing
   b. Blood testing
   c. Both are equally good

7. What effect does unsweetened fruit juice have on blood glucose?
a. Lowers it  
b. Raises it  
c. Has no effect

8. Which should **not** be used to treat low blood glucose?  
a. 3 hard candies  
b. 1/2 cup orange juice  
c. 1 cup diet soft drink  
d. 1 cup skim milk

9. For a person in good control, what effect does exercise have on blood glucose?  
a. Lowers it  
b. Raises it  
c. Has no effect

10. Infection is likely to cause:  
a. an increase in blood glucose  
b. a decrease in blood glucose  
c. no change in blood glucose

11. The best way to take care of your feet is to:  
a. look at and wash them each day  
b. massage them with alcohol each day  
c. soak them for one hour each day  
d. buy shoes a size larger than usual

12. Eating foods lower in fat decreases your risk for:  
a. nerve disease  
b. kidney disease  
c. heart disease  
d. eye disease

13. Numbness and tingling may be symptoms of:  
a. kidney disease  
b. nerve disease  
c. eye disease  
d. liver disease

14. Which of the following is usually **not** associated with diabetes:  
a. vision problems
b. kidney problems
c. nerve problems
d. lung problems

15. Signs of ketoacidosis include:
   a. shakiness  
b. sweating  
c. vomiting  
d. low blood glucose

16. If you are sick with the flu, which of the following changes should you make?
   a. Take less insulin  
b. Drink less liquids  
c. Eat more proteins  
d. Test for glucose and ketones more often

17. If you have taken rapid-acting insulin, you are most likely to have a low blood glucose reaction in:
   a. less than 2 hours  
b. 3 – 5 hours  
c. 6 -12 hours  
d. more than 13 hours

18. You realize just before lunch time that you forgot to take your insulin before breakfast. What should you do now?
   a. Skip lunch to lower your blood glucose  
b. Take the insulin that you usually take at breakfast  
c. Take twice as much insulin as you usually take at breakfast  
d. Check your blood glucose level to decide how much insulin to take

19. If you are beginning to have a low blood glucose reaction, you should:
   a. exercise  
b. lie down and rest  
c. drink some juice  
d. take rapid-acting insulin

20. Low blood glucose may be caused by:
   a. too much insulin  
b. too little insulin  
c. too much food  
d. too little exercise

21. If you take your morning insulin but skip breakfast your blood glucose level will usually:
a. increase
b. decrease
c. remain the same

22. High blood glucose may be caused by:
   a. not enough insulin
   b. skipping meals
   c. delaying your snack
   d. large ketones in your urine

23. A low blood glucose reaction may be caused by:
   a. heavy exercise
   b. infection
   c. overeating
   d. not taking your insulin

Derived from the Diabetes Research and Training Center at the University of Michigan