COMMUNITY RESEARCH AND ACTION

Usability Evaluation of Diabetes MAP: An Internet-delivered Diabetes Medication Adherence Promotion Intervention

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Thesis under the direction of Professor William L. Turner

Usability testing ensures users are able to effectively, efficiently, and satisfactorily interact with a website. We evaluated the usability of an Internet-delivered health promotion intervention called Diabetes MAP.

We recruited adult T2DM patients (N=32) prescribed diabetes oral agents or insulin and receiving care at an academic medical center. Participants completed an enrollment survey to collect demographic information. Medical records were reviewed to collect medication and diabetes-related information. Participants received instruction on accessing Diabetes MAP, used the site independently for two weeks (n=29), then provided feedback via a survey (n=29) and/or a focus group session (n=27). Survey data were analyzed descriptively. Focus group data were coded and analyzed thematically.

Participants were, on average, 51.7±11.8 years old, female (66%), non-Hispanic White (60%), privately insured (78%), educated (31% with >12 years), and half had household incomes >$50,000. Average diabetes duration was 7.8±6.4 years; average A1C was 7.4 ± 2.0; and 38% used insulin. Most survey participants (75%) agreed Diabetes MAP was easy to learn and/or (89%) its information was clear and easy to understand. However, 28% reported navigational

challenges and/or (32%) difficulty recovering from errors. In focus groups, participants reported experiencing many errors, but liked the site's design and easy access to medication information. Participants recommended improving the site's user interface to facilitate quick, efficient completion of site-related tasks.

Usability issues, such as difficulty navigating, understanding, and completing tasks are barriers to using and benefiting from Diabetes MAP. Appropriate usability testing ensures Internet-delivered interventions work as intended to improve health behaviors and outcomes.

Approved:
William L. Turner, Ph.D.

Usability Evaluation of Diabetes MAP: An Internet-delivered Diabetes Medication Adherence Promotion Intervention

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To my greatest treasures – my Sean William, II, Ian Wesley, and Kohl Wynton – and to my life partner, Sean the Elder

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Recent health reform efforts, such as the Health Information Technology for Economic and Clinical Health (HITECH) Act and the Patient Protection and Affordable Care Act (PPACA), support the rapid adoption and "meaningful use" of health information technology (HIT) (Blumenthal, 2010; Glabraith, 2013). Among the aims of these efforts is the facilitation of improvements in health management and quality of care. Consequently, recent research has explored the feasibility of HIT, including web-based applications, as feasible media for healthcare delivery.

Web-based applications have been shown to be useful for health service delivery, particularly within patient-centered healthcare models and for behavior change interventions (Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004). While a substantially greater majority (~90%) of HIT implementations have yielded positive outcomes, some studies have highlighted negative outcomes, including poor patient satisfaction and user acceptance of HIT innovations (Buntin, Burke, Hoaglin, & Blumenthal, 2011). HIT validation techniques, such as user-centered design and usability testing, provided important insights regarding the efficacy of HIT innovations and their utility for health service delivery (Karsh, Weinger, Abbott, & Wears, 2010).

Web-based HIT applications have been particularly effective for improving diabetes health outcomes (McMahon, et al., 2005). Web-based interventions were efficacious delivery systems, especially for those managing chronic conditions that require self-management (Davis Kirsch & Lewis, 2004). Consumer- or patient-driven interventions for diabetes patients have yielded positive effects for intermediate health outcomes (Gibbons, et al., 2011). However,

essential to the success of consumer-based, web-based health interventions is user-centered design of interventions that are both usable and accessible to the targeted user population (Goldberg, et al., 2011).

The purpose of this study is to examine the usability of the Diabetes Medication Adherence Program (Diabetes MAP) – a web-based health intervention designed to improve medication adherence behaviors in diabetes patients. This study is situated within a larger grant-funded project to design, implement, and evaluate the effectiveness of a web-based application to improve medication adherence and diabetes health outcomes in patients with type 2 diabetes mellitus (T2DM). In examining the usability of Diabetes MAP, the following research questions are posed:

1. To what extent do diabetes patients find Diabetes MAP to be a user-friendly tool?
2. What are some of the usability challenges associated with Diabetes MAP?
3. What are some ways that the usability of Diabetes MAP can be improved?

In the following chapter, relevant literature pertaining to diabetes, medication adherence, and interventions that aim to promote medication adherence and improve diabetes health outcomes is reviewed. Then, methods for designing and testing the usability of technology-based health interventions are described. Finally, the web application, usability evaluation method, and findings from mixed methods analysis of patient reports of their experiences using Diabetes MAP are all described.

CHAPTER 1

LITERATURE REVIEW

Non-adherence to medications is a major public health problem, especially for patients with diabetes. Studies suggested patients with chronic diseases take only about fifty percent of the prescribed doses of their medications (Kocurek, 2009). For people with diabetes, suboptimal adherence to medications was associated with suboptimal glycemic control, increased risk of hospitalization and mortality, higher health costs and increased risk of long-term diabetes complications (Asche, LaFleur, & Conner, 2011; Balkrishnan, et al., 2003; Ho, et al., 2006; Sokol, McGuigan, Verbrugge, & Epstein, 2005; Krapek, et al., 2004; Rhee, et al., 2005; van Dulmen, et al., 2007). Studies in diabetes and other chronic disease contexts (i.e., human immunodeficiency virus [HIV]) suggested a patient's medication adherence depends on his/her disease-related knowledge, motivation, and skills (Amico, Toro-Alfonso, & Fisher, 2005; Fisher, Fisher, Amico, & Harman, 2006; Osborn & Egede, Validation of an Information–Motivation–Behavioral Skills model of diabetes self-care (IMB-DSC), 2010). Interventions that leveraged the use of web-based applications to address these factors were found to effectively improve adherence (Fisher, et al., 2011). In the following section, we review relevant literature pertaining to diabetes medication adherence, web-based interventions designed to improve diabetes self-care, and the methods used to evaluate web-based interventions, with a special focus on usability testing.

Diabetes Medication Adherence

Non-adherence to medications is a prevalent and serious public health concern. The World Health Organization (WHO) projected that 157 million Americans will be affected by at least one chronic condition that requires medication therapy (U. S. Centers for Disease Control and Prevention, 2013). It was estimated that from 33-69% of medication-related hospital admissions are attributed to poor medication adherence, resulting in about $100 billion in U.S. healthcare costs annually (Osterberg & Blaschke, 2005). Adherence to a medication regimen refers to the "extent to which patients take medications as prescribed by their healthcare providers" (p. 487). This definition implicates both patients and providers to a clinical agreement established between the two describing the patients' prescribed therapy.

Non-adherence to medications is especially prevalent and costly for people with diabetes, who manage both complex and multidimensional treatment regimens. The lack of adequate treatment adherence was prevalent in the diabetes population at rates ranging from 36-87% (Lee, Balu, Cobden, Joshi, & Pashos, 2006). The CDC (2013) estimated that improved chronic illness self-management and adherence would result in a 1:10 cost-to-savings ratio. Non-adherence to medication regimens is associated with many dire outcomes for patients managing chronic illness. Chronically-ill patients with higher adherence to their medications experience lower rates of hospitalization (Sokol, McGuigan, Verbrugge, & Epstein, 2005), fewer inpatient hospital days and emergency hospital visits, and more regular visits with their healthcare providers than non-adherent patients (Roebuck, Liberman, Gemmill-Toyama, & Brennan, 2011). When adherent patients faced higher pharmacy costs, their annual overall healthcare spending was also significantly lower than for non-adherent patients.

Patients with diabetes face unique outcomes and severe health consequences as a result of non-adherence to their medications. Only one in three patients with T2DM were found to have adequate (i.e., ≥90%) medication adherence to oral medications (Donnan, MacDonald, & Morris, 2002). Insulin adherence among T2DM patients was as low as 62% in some studies (Cramer, 2004). Consistently across multiple studies, suboptimal diabetes medication adherence was strongly associated with poorer glycemic control, higher blood pressure, LDL cholesterol levels, and higher rates of mortality (Balkrishnan, et al., 2003; Roebuck, Liberman, Gemmill-Toyama, & Brennan, 2011). Additionally, non-adherent patients encountered higher rates of healthcare utilization and hospitalization and increased medical costs (Asche, LaFleur, & Conner, 2011; Ho, et al., 2006; Lee, Balu, Cobden, Joshi, & Pashos, 2006; Sokol, McGuigan, Verbrugge, & Epstein, 2005; van Dulmen, et al., 2007).

Researchers have long studied the factors that posing barriers to medication adherence for patients managing chronic illness. Several studies cited regimen complexity, psychosocial factors (i.e., depression), health literacy and medication costs as patient barriers to taking diabetes medications (Odegard & Capoccia, 2007; Odegard & Gray, 2008). Other researchers noted the rising cost of medications as a barrier to medication adherence (Hepke, Martus, & Share, 2004). However, while adherent patients did encounter increased medication-related costs, this increase was more than offset by overall reductions in medical costs due to decreased healthcare utilization and hospital costs (Roebuck, Liberman, Gemmill-Toyama, & Brennan, 2011; Sokol, McGuigan, Verbrugge, & Epstein, 2005).

Evidence linking increases in diabetes medication adherence to subsequent improvements in other chronic illness outcomes, such as morbidity, mortality, quality of life, patient satisfaction, healthcare utilization, and costs, is limited and inconsistent (U. S. Centers for

Disease Control and Prevention, 2013). In a review of literature on the associations among diabetes treatment adherence, clinical and economic outcomes, scholars found consistently across studies that better adherence to treatment regimens was associated with improved glycemic control and decreased healthcare resource utilization (Asche, LaFleur, & Conner, 2011). Although studies showed that patients who are adherent to their medication have more positive health statuses, no causal relationship between the two has been found. Interventions that improve medication adherence in patients induced only modest effects on health outcomes of those patients (McDonald, Garg, & Haynes, 2002). The complex relationship between medication adherence and health outcomes necessitate the meticulous design of research on interventions promoting medication adherence behaviors, such that observed intervention effects can actually be attributed to the intervention itself.

Medication Adherence Interventions

Current methods for improving adherence to medications for chronic disease management are mostly complex and are not very effective, as full benefits of treatment are often not realized. Even the most effective methods have very few practical improvements in medication use and health (Haynes, Ackloo, Sahota, McDonald, & Yao, 2008). Current approaches to improving medication adherence for patients with chronic disease are typically complex, labor-intensive, and are modestly, but not predictably effective (McDonald, Garg, & Haynes, 2002). While no clear advantage of a particular method or approach was evident, comprehensive interventions that combine cognitive, behavioral, affective, informational, or social components were more effective than single-focus interventions (Kripalani, Yao, & Haynes, 2007; Roter, et al., 1998).

Research on medication adherence has aimed to deconstruct the complexity regarding factors related to adherence behaviors and associated health outcomes. A study aimed at deconstructing these factors highlighted how patients' diabetes medication-related knowledge, motivation, and self-efficacy skills were the modifiable factors related to medication adherence (Osborn & Egede, 2010). These factors mapped onto the Information-Motivation-Behavioral skills (IMB) model, which assumes that an individual's health-related information, motivations, and behavioral skills are determinants of health outcomes (Fisher & Fisher, 2002). Applied in the context of HIV prevention, the authors stated, "the extent to that individuals are well informed, motivated to act, and possess the behavioral skills required to act effectively, they likely to initiate and maintain patterns of HIV prevention behavior" (p. 45). This model informed adherence promotion interventions in diabetes (Fisher, Kohut, Schachner, & Stenger, 2011; Osborn & Egede, Validation of an Information–Motivation–Behavioral Skills model of diabetes self-care (IMB-DSC), 2010) and other disease contexts (i.e., HIV) (Fisher, Fisher, Amico, & Harman, 2006; Horvath, Smolenski, & Amico, 2013).

In light of the complexity of factors relating medication adherence to health outcomes and the complex structure of traditionally-delivered (i.e., face-to-face) interventions effectively promoting medication adherence behaviors, Internet-based interventions may be a feasible approach to delivery. Internet-based intervention that that leveraged technology as a delivery modality constituted viable approaches to improving diabetes medication adherence (Fisher, et al., 2011). This current study assumes this approach to intervention delivery, focusing on the Diabetes MAP, a web-based intervention designed for patients with T2DM that draws on the IMB model for promoting medication adherence behaviors. In the following section, we review the merits and challenges of designing web-based health interventions.

Internet-based Health Intervention

Internet and computer use has soared over the past 25 years. Currently, 87% of American adults use the internet, with near-saturation usage among those living in households earning $75,000 or more (99%), young adults ages 18-29 (97%), and those with college degrees (97%) (Pew Research Center, 2014). As Internet usage rises in the United States, more people than ever are "online health seekers," who access health information through online sources (Pew Research Center, 2013). With more Americans accessing web-based sources each year, and as a growing proportion of Internet users access the web for health information, web-based health intervention is increasingly becoming a feasible approach to health service delivery.

Interventions designed to promote positive health behavior change have been delivered effectively through Internet-based technologies. One review compared the effectiveness of web-based and non-web-based health interventions, and found improvements in knowledge and behavioral outcomes for patients using web-based interventions (Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004). Scholars noted that the use of new information technologies, as opposed to other implementation delivery modalities (i.e., one-on-one counseling interventions, group sessions, tele-health, mail interventions, and policy interventions), may extend and improve the reach, adoption, implementation, and maintenance of interventions for an overall increased public health impact (Glasgow, McKay, Piette, & Reynolds, 2001). Interactive behavior change technologies (IBCT), such as patient websites, utilize software and hardware to promote and sustain behavior changes in patients.

IBCTs are one medium to provide diabetes patients with access to resources, web tools and health knowledge when, where, and through modalities that, otherwise, may not be available

(Piette, 2007; van Vugt, deWit, Cleijne, & Snoek, 2013). Studies showed Internet-based interventions to be effective, particularly for improving diabetes self-care behaviors (Barrera, Jr., Glasglow, McKay, Boles, & Feil, 2002; McMahon, et al., 2005). One benefit of e-Health and other technology-based interventions was cost-effectiveness relative to other types of delivery. One study examined the costs of developing Internet-based interventions for people living with HIV and revealed that, although developing an Internet-based medication adherence intervention was initially expensive, the monthly cost of implementing and delivering the intervention was low (Page, Horvath, Danilenko, & Williams, 2012).

There is great enthusiasm and promise regarding the use of patient websites for health intervention. Internet-delivered interventions are amenable to widespread dissemination, adoption, and maintenance for public health purposes (Bennett & Glasglow, 2009). Another benefit of web-based interventions is the potential for interactivity for users (Murray, 2012), and the potential to address the needs of diverse patient populations through incorporating individually tailored elements (Ramadas, Quek, Chan, & Oldenburg, 2011). Interventions for patients managing chronic illnesses through self-care practices should aim to meet user expectations regarding the tool's utility, and should be attentive to user-centered design standards.

However, myriad studies reveal challenges to using HIT for the management of chronic illness (Glasglow, et al., 2011; Lyles, et al., 2011). In particular, poorly designed patient websites discouraged usage by patients (Nijland, van Gemert-Pijnen, Boer, Steehouder, & Seydel, 2008; Yu, et al., 2012). The effects of the usability and accessibility of technology-delivered interventions and their features on patient outcomes have been researched in other contexts. One such study explored the feasibility of a web- and mobile technology-mediated intervention for

adolescents (Mulvaney, Anders, Smith, Pittel, & Johnson, 2012). In this pilot study, preliminary findings yielded no change in glycemic control (measured by A1C) for the intervention group, accompanied by an increase in glycemic control for the control group. The study underscored the importance of examining usability of technology-based interventions, while also highlighting the feasibility of the delivery modality.

A review of recent studies revealed benefits of patient web-based portals for patient outcomes, patient-provider communication, disease management, and access to and patient satisfaction with healthcare. While intervention effects were moderate but inconsistent, there was a high prevalence of issues related to the usability of interventions across studies (Osborn, Mayberry, Mulvaney, & Hess, 2010).

User Experience, Usability, and Usability Evaluation

User experience and user-centered design are core elements for designing and developing web applications. *User experience* "focuses on having a deep understanding of users, what they need, what they value, their abilities, and also their limitations" (U.S. Department of Health and Human Services, 2014). *User experience* is an application of information architecture that considers the context of users, user needs and behaviors, and the integration of a mix of content (Morville, 2004). Figure 1 depicts the qualities of *user experience*. A website should be useful, desirable, accessible, credible, findable, and usable.

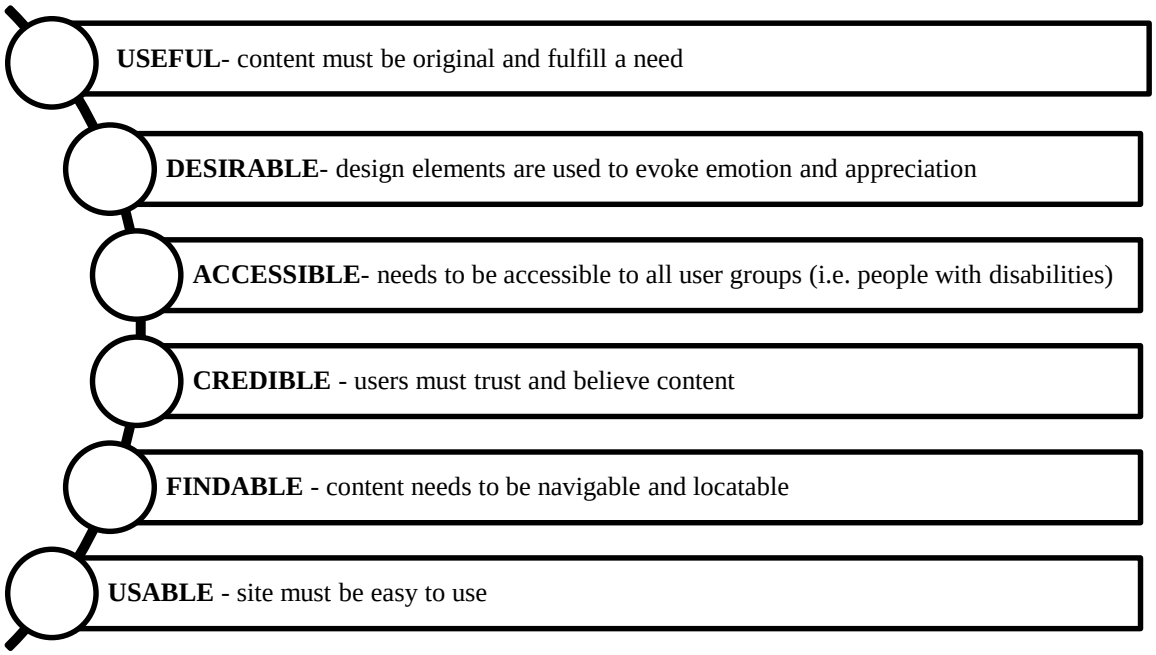


Figure 1. Facets of Web User Experience (U.S. Department of Health and Human Services, 2014).

This sixth factor listed above – usability – is a core tenet for constructing the web user experience and applying web user-centered design, and thus is the focus of the current study. A website's usability refers to the extent to which users can effectively, efficiently, and satisfactorily interact with a web user interface (U.S. Department of Health and Human Services, 2014). Web usability involves a combination of factors, including: 1) intuitive web design; 2) ease of learning a user interface; 3) efficiency of website use and task completion; 4) memorability; 5) error frequency, severity, and recovery; and 6) user subjective satisfaction. Usability concerns four major components of project design – user, tool, task, and environment (Yen & Bakken, 2012).

Usability is a key factor enabling user acceptance and adoption of Internet-based applications for disease management. Web-based health interventions that are not usable and

accessible to users can prevent patients from reaping the health benefits of using the website. This study endeavors to evaluate the usability of a web-based health intervention that features interactive and individually tailored components for diabetes patients. Usability testing and evaluation is conducted in order to determine if websites and their embedded tools are usable for web task completion for their targeted user bases.

Web usability testing entails evaluating a website by testing it with a group of representative users. Usability testing involves "a process of involving users to evaluate a system to ensure that is meets usability criteria" (Corry, Frick, & Hansen, 1997, p. 67). With a primary goal to improve the usability of a product, usability testing involves *real* users who participate in *real* tasks. Their interactions with the system and feedback regarding their experience is observed and recorded. Then finally, data are analyzed, and recommended changes are made (Dumas & Redish, 1999). For user testing, web usability is primarily assessed along three dimensions: 1) effectiveness, or the match between goal of users and the extent to which users can achieve them within a system; 2) efficiency, or the level of effectiveness that is achievable for an expenditure of resources in a system; and 3) satisfaction, or user attitudes toward using a product or system (Yen & Bakken, 2012).

There are many methods for evaluating the usability of a system, including: user testing of an existing site, focus groups, surveys, contextual or individual interviews, card sorting, wire-framing, click testing, personas, scenarios, task analysis, heuristic evaluation, expert review, remote user testing and satisfaction surveys (U.S. Department of Health and Human Services, 2014). Usability evaluation can occur at one or more of several junctures across the web system development life cycle, with usability testing typically occurring in the final stages of development. Common approaches to usability testing in the final stages of website design

include observation, interviews, and focus groups (Yen & Bakken, 2012). Usability evaluation methods vary by cost, timeframe, the number of users/evaluators needed, the types of data collected, and the level of structure required to complete the evaluation. The planning process for usability testing requires setting goals for the usability test, defining sample users, selecting tasks and scenarios, and determining how usability will be measured (Matera, Rizzo, & Carughi, 2006).

Web usability evaluation methods can employ expert-driven and/or user-driven approaches (Jaspers, 2009). Expert-based methods uncover potential usability problems by having evaluators inspect a user interface with an objective set of guidelines, heuristics, or questions in mind. User-based participatory methods introduce real end users to a user interface. These methods require them to talk through completing tasks and to explain what they are doing. User-based usability evaluation methods elicit feedback from representative users regarding their perceptions of a website's usability. User-based inspection methods usually require at least five representative users in order to elicit about 80% of the major usability issues existing within a system qualitatively (Nielson, 2000). For quantitative analysis, at least 20 representative users are needed for statistical analysis. Qualitative user testing methods are better suited for determining *why* or *how* to fix a problem, while quantitative methods help you to understand the number and type of issues encountered with a system (Rohrer, 2008).

User-based usability evaluation is used to provide evidence of the usability of a system based on the feedback from the target audience. Target users are given realistic tasks in realistic situations, and are given minimal assistance to do so (Petrie & Bevan, 2009). Formative user-based methods focus on users' behaviors, intentions, and expectations in order to understand the problems encountered and are conducted prior to the design of a system. Summative user-based

methods measure the product usability, and are used to test and establish user requirements at the end of the system design cycle. User-based evaluation methods require from 8-30 participants.

There is little research to date that examines the feasibility of using interactive web technology to support medication adherence and the salience of the features of these interventions for this population. The current study utilized a combination of summative user-based evaluation methods – focus groups and online usability questionnaires – to assess user perceptions of the usability of Diabetes MAP. Focus groups are a cost-effective and efficient method of evaluating usability that yield relatively valid data regarding a website's design (Vredenburg, Mao, Smith, & Carey, 2002). Focus group evaluation is an informal web user testing technique that elicits user thoughts and preferences regarding their experiences using a website. Online structured questionnaires enables web designers to learn if a website meets the needs and expectations of users, and to identify areas needing improvement.

Diabetes MAP

Diabetes MAP is a self-guided, individually tailored, web-based therapeutic intervention. Self-guided web-based interventions are interactive and are often highly dynamic in nature. They can be delivered in modularized behavior change and highly structured delivery formats (Barak, Klein, & Proudfoot, 2009). Diabetes MAP was designed to promote medication adherence in patients with T2DM in accordance the IMB model for diabetes medication adherence (Osborn & Egede, 2010). Content delivered through the Diabetes MAP website focused on improving diabetes- and medication-related knowledge, personal and social motivation to take medications, and medication adherence behavioral skills. The intervention was tailored to individual users' needs through a series of mechanisms that determine the most relevant content to display.

Table 1.
Diabetes MAP Web Features

Feature	Feature Description
"About" button	After adding medications on the "My Medications" page, users may click the "About" button to learn side effects, medication-specific information.
"Edit" button	Users may edit medication information on the "My Medications" page by clicking the "Edit" button for each medication.
Text message medication reminders	Users may click a button on the "My Medications" page to open a window for text message reminders. Users specify their cell phone carrier, and then designate the times to receive text message dosage reminders each day, as desired for each medication.
Text message refill reminders	Users may click a button on the "My Medications" page to open a window for text message reminders. Users specify their cell phone carrier, and then designate the time intervals (i.e. every 30, 60, 90 days) to receive text message refill reminders, as desired for each medication.
Email medication list	Users may click a button on the "My Medications" page to have a list of medications, frequencies, and dosages emailed to the email address used for login.
Print medication list	Users may click a button on the "My Medications" page to open a window to print a list of their medication names, frequencies, and dosages.
Access patient portal	Users may click a button on the "My Medications" page to open a window to the login page for the online patient portal.
Access information, motivation, and behavioral skills-related content	Users may navigate to the "My Tailored Tools" page and click on one of three domains (i.e., Information, Motivation, or Skills) to access up to IMB-based 40 video and static text content modules.
Recover user password information	Users may click the "Forgot Password" link, then enter their registered email address to have their password sent to their email account.
Edit account information	Users may navigate to the "My Account" page in order to update their user account information.

On the Diabetes MAP home page, users created a user account. After logging in, users were directed to the "My Medications" page (see Appendix A for images of webpages), to enter their diabetes and non-diabetes medications, dosages, and frequencies. On this page, users could learn about each of their medications, email or print a medication list, set up text message medication and refill reminders, or click a link to access the online patient web portal.

After learning about their specific medications, users were automatically directed to a medication checklist questionnaire. Here, users answered thirty questions regarding their medication adherence, knowledge, motivations, and skills. After completing the questionnaire, users were directed to the "My Tailored Tools" page that houses the remainder of the intervention content. Videos, static text and images were organized into three categories of modules located in three different sub-windows on the "My Tailored Tools" page. Table 1 describes the list of features embedded into the Diabetes MAP website.

Table 2.
Diabetes MAP Online User Tasks

Task	Task Description
Create an account	From the Diabetes MAP landing page, users click "First-Time User". Then, users enter an email address, a user-defined password, their mobile phone number, time zone, gender, date of birth, and security questions and answers. Users click "OK" to save information.
Login to user interface	Users enter their registered email address and password, then click "Enter".
Add medications	On the "My Medications" page, users click the "Add Medication" button. Users may search medication names, then select the dosage and frequency of doses for each one of their diabetes and non-diabetes medications.
Complete medication checklist questionnaire	After adding medications, users are directed to a Medication Checklist questionnaire. Users answer 29 questions to rate themselves on medication related knowledge, personal and social motivation, and medication-taking skills.

Based on user responses, modules proliferated under three domains – Information, Motivation, and Skills – to provide information and support to users around the areas that they indicated needing improvement in the checklist questionnaire. For example, patients could view a video about metformin, an oral medication frequently prescribed to patients with T2DM, or one on how to be "incognito" while taking medications in public spaces. Users could revisit the site, add/modify/delete medications, and view intervention content by re-entering their login information on the home page. Table 2 lists the tasks that users must complete to optimize their experience using Diabetes MAP.

CHAPTER 2

METHOD

Site Selection & Field Entry

The study took place in mid-sized city in the southeastern region of the United States. Adult diabetes patients were recruited from an academic medical center diabetes patient community using multiple recruitment mechanisms. This site was selected due to the availability of access for patients seen at the medical center to an online patient portal that is linked to the Diabetes MAP web application. Institutional review board approval to conduct the study was obtained from the academic medical center via expedited review.

This project was a part of an ongoing research project based in this academic medical center. The principal investigator leveraged ongoing relationships with administration in the diabetes and primary care clinics to collaborate on recruiting diabetes patients to be participants in the study. Together, the principal investigator, study coordinator, and medical center administration (i.e., nurse liaison, clinic director) from each of the clinics met to plan for recruitment that would not interfere with, or delay the flow of operations in each clinic.

Recruitment

A convenience sample was recruited using flyers, referrals from healthcare providers, medical center list-servs, and in-person solicitations. Adult T2DM patients aged 18 and older were recruited from the adult primary care and diabetes clinics. Additionally, participants were recruited from a pool of participants from a previous study who had indicated on informed

consent forms that they were willing to be contacted for future diabetes-related studies. The individuals from this list were contacted through their preferred method indicated on the consent form. The research team took targeted steps (i.e., culturally inclusive flyers) to enroll adult T2DM patients that were diverse with respect to age, gender, race, ethnicity, and experience.

Inclusion criteria.

- Individuals who were adults aged 18 years and older (confirmed via electronic health record)
- Individuals who have received a diagnosis for type 2 diabetes mellitus (confirmed via electronic health record)
- Individuals who were enrolled as a patient in the academic center's adult primary care or diabetes clinics
- Individuals who were currently being treated with oral and/or injectable diabetes medications (confirmed via electronic health record)

Exclusion criteria.

- Individuals who were non-English speakers (determined subjectively by a trained research assistant due to lack of resources available for translation services)
- Individuals who reported that they do not have a mobile phone or computer with Internet access
- Individuals who were unwilling and/or not able to give written informed consent
- Individuals who had unintelligible speech (e.g., dysarthria) (determined subjectively by a trained research assistant)
- Individuals with delirium or a severe cognitive impairment (determined by a reported lack of orientation to person, place, and time)

- Individuals with a severe hearing or visual impairment (participant self-report)
- Individuals with a caregiver who administers all medications (participant self-report)

Enrollment

Eligible patients were identified by a clinic staff member and notified of the opportunity to participate in the research project. Participants were also recruited in waiting rooms via flyer/email solicitation and from a pool of individuals who had consented previously to be contacted for future diabetes-related studies. Interested patients contacted the study coordinator, who then described the study procedures, as well as the benefits and costs of participating. Participants attended an enrollment meeting, wherein informed consent was obtained by having participants read an IRB-approved consent form and then agree to the procedures. The schedule for participant compensation was also explained in the enrollment meeting. Participants were reimbursed at the close of the study for time spent and transportation to and from the study site for the enrollment meeting. Figure 2 depicts the flow of participants from recruitment to study completion. Of those who were eligible and consented to participate (N=32), 84% (n=27) completed all parts of the study. Three participants completed the enrollment survey (ES) only, and two participants completed the ES and follow-up web usability survey (WUS).

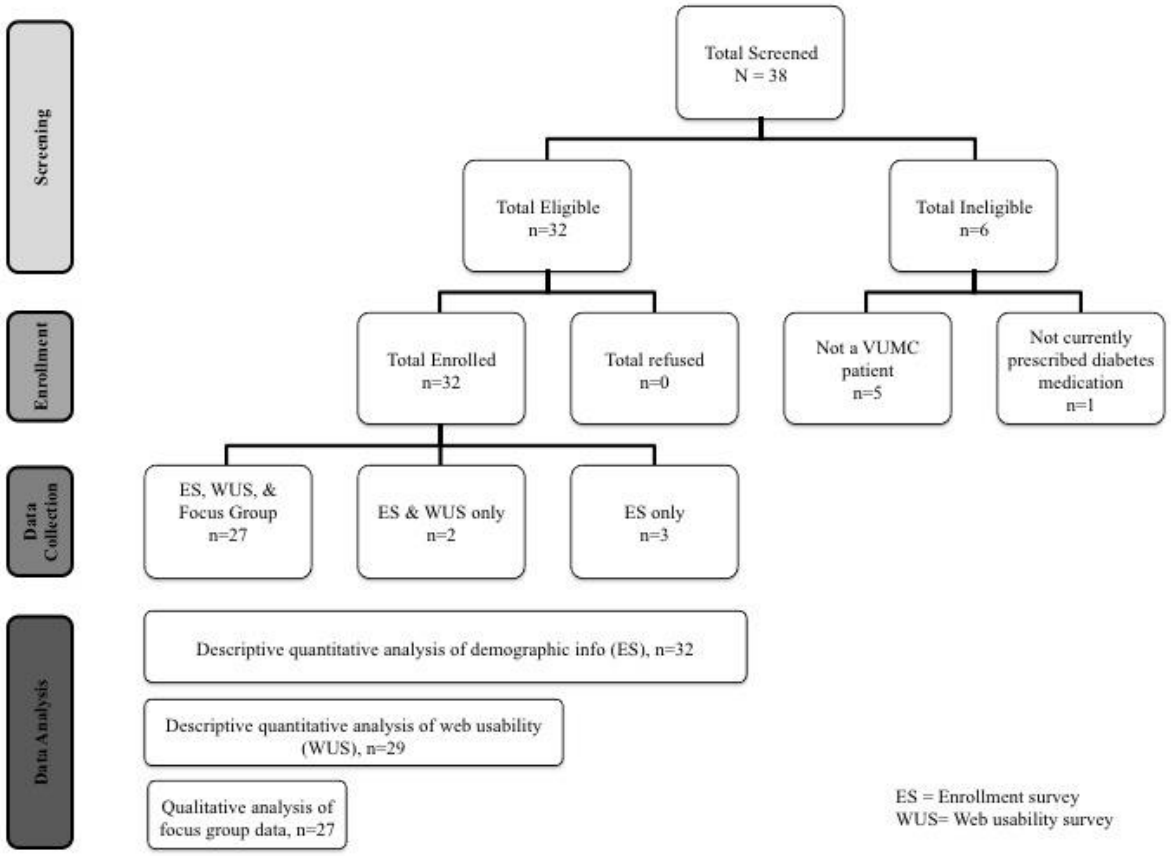


Figure 2. Participant Flowchart

Data Collection & Handling

Qualitative and quantitative data collection methods were utilized across four data collection points: (a) an enrollment meeting, (b) electronic chart review, (c) a follow-up survey, and (d) a focus group session.

Enrollment meeting. During the enrollment meeting, eligible participants completed the ES to officially enroll in the study. A trained research assistant received an interview protocol to follow administered the ES interview. Participants also had the option of completing a paper version of the survey, or an electronic survey on a laptop during the enrollment meeting.

Enrollment meetings took place in a private space in the academic medical center and took 30-45 minutes to complete. A trained research assistant entered survey data into a Research Data Capture (RedCAP) database (Harris, et al., 2009). Self-report data on participants' of medication knowledge, medication adherence, health literacy, general computer usage, and health communication preferences were collected in the ES.

Electronic chart review. After the enrollment meeting, diabetes diagnoses, hemoglobin A1c (HbA1c) history, medication history, and other diabetes-related health information were extracted for each participant via electronic health chart review.

Web Usability Survey and Focus Group. After exploring the Diabetes MAP website in other settings (i.e., home, work, etc.), Study participants were asked to complete the web usability survey (WUS) individually prior to the start of the focus group interview (paper or electronic version). The WUS took 15-30 minutes to complete.

Participants returned to the medical center for the in-person focus group interview, were asked to share their experiences using the Diabetes MAP website, and given the opportunity to provide feedback. Two to five participants attended each one of nine focus group sessions. A trained research assistant conducted the focus group interview. Interviewers received a semi-structured focus group protocol to follow with *a priori* questions regarding users' experiences with the website (see Appendix B for focus group protocol). The focus group interviewer demonstrated features and tasks that were ideally performed within Diabetes MAP, while eliciting responses from participants on their impressions of them. This is a method similar to the *pluralistic walkthrough* usability evaluation method "uses group meetings where users, developers, and human factors people step through a scenario, discussing each dialogue element"

(Nielsen, 1995, para. 1). Focus group interviews ranged from 60-90 minutes, and were audio-recorded.

Transcripts were created from the focus group audio recordings and were de-identified of participant demographic information. The recordings and transcripts from focus groups were saved electronically, password-protected and retained on a secure server in the medical center. Survey data was recorded and stored electronically. Original paper copies of the surveys were filed in a locked file cabinet in the medical center. Original audio-recordings of participants and written field notes will be retained in this location for up to ten years, and then will be destroyed.

Participant identifiers were retained only for financial and regulatory research purposes. Participant identifiers were password-protected and stored separately from any associated data. Participants were given randomly assigned codes associated with their identifiable information. Only the participant identification code was included on any data files. Participants were compensated $25 for their time at the enrollment meeting, $8 per hour for each full hour spent exploring the website (up to ten hours; times was recorded using the web analytics software), $35 for participation in a focus group session, and $15 for completion of the WUS. Participants earned up to $155 for full study participation and received payment within six weeks of the close of the study.

Measures

Demographics and basic diabetes information. Self-report data on diabetes diagnosis (i.e., length of time with diabetes, type of diabetes), diabetes medication types (i.e., oral or IV injected medications, number of diabetes medications), and demographics were collected from

each participant via the ES. Demographic variables included race/ethnicity, gender, years of education, annual household income, occupation, and health insurance status.

Glycemic control. Patients' most recent hemoglobin A1c (HbA1c) was extracted through electronic chart review. HbA1c provides a snapshot of a person's average glucose control for the previous 2-3 months prior to the test (American Diabetes Association, 2013). For the current analysis, the most recent HbA1c (A1C) is proxy for glycemic control.

Website usability. Participant perceptions of Diabetes MAP's usability were assessed using ten individual items adapted from the Computer System Usability Questionnaire (CSUQ) (Lewis, 1993). Items included questions like, "Overall, it was easy to learn to use Diabetes MAP" and "When I make a mistake in Diabetes MAP, I recover easily and quickly." Responses ranged from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating endorsement of the website's usability.

Data Analysis

Qualitative methodologies focus on "how people perceive their worlds and how they interpret their experiences" (Rubin & Rubin, 2012, p. 15). As described above, qualitative data were collected through focus group interviews and were transcribed. Selective coding for web usability themes was performed on the transcript data. Selective coding acknowledges a central phenomenon in a study, and " is the process by which all categories are unified around a central 'core' category" (Corbin & Strauss, 1990, p. 15). Codes were analyzed and interpreted using *theoretical thematic analysis*. *Theoretical thematic analysis* is a "top-down", deductive approach to qualitative analysis, whereby researchers may analyze and interpret data around a theoretical or analytic area of interest with great detail (Braun & Clarke, 2006). Coding and

analysis centered on the six sub-themes of usability: (a) intuitive web design, (b) ease of learning the user interface, (c) efficiency of use, (d) memorability, (e) errors and recovery, and (f) user subjective satisfaction. This coding schema facilitated the identification of concepts within categories among user reports of usability-related issues, challenges, and recommendations for Diabetes MAP.

Survey data were also examined. Demographic data from the ES were analyzed descriptively to characterize the sample of users. Health chart review data were used in order to verify participants' eligibility, A1C, and number of diabetes medications. WUS data were analyzed to quantify and synopsize user reports of the Diabetes MAP website usability.

Qualitative Data Quality

Focus group usability evaluations were conducted until near-saturation of concerns was reached. Counts of the numbers of total and new issues introduced in each focus group were analyzed to determine if a significant proportion of the total major usability issues (e.g., ≥80%) were found early in the study. To ensure the quality and trustworthiness of qualitative analyses, the investigator and study coordinator met for debriefing sessions after each focus group to discuss themes and to review RA-written field notes. Disagreements about the meanings of participant responses and comments were reconciled through discussion and consensus. We conducted comparative analysis via methods and analyst triangulation to compare data across data collection methods (i.e., electronic and paper surveys), data sources (i.e., survey and focus group data) and data reviewers (i.e., RA and PI) (Patton, 1999). Negative case analysis was highlighted wherever present in the data. Finally, rich descriptions are provided in this report that reflect concepts, categories, and themes prevalent in the data.

CHAPTER 3

FINDINGS

Participant Demographics

We recruited a racially, ethnically, and health status-diverse, locally representative (i.e. academic medical center patients) patient sample, although not representative of the national diabetes population. On average, participants were 51.7 ± 11.8 years old, female, educated, non-Hispanic White, and privately insured. Half of the participants had annual household incomes greater than $50,000.

The sample also spanned a broad range of educational attainment, glycemic control, and diabetes duration. Users had diabetes diagnoses that ranged from 0 to 20 years. Almost 40% of the sample consisted of insulin users. The average A1c for participants was 7.4, which is well above the threshold for acceptable glycemic control (≥6.5%) (American Diabetes Association, 2014). All participants had access to computers or cell phones, yet evinced multiple levels of comfort using the Internet and computer/digital technologies. This diversity ushered in a broad range of perspectives, areas of expertise, and sources of motivation for improving the usability of a diabetes web-based health intervention. Table 3 presents the characteristics of participants who completed the baseline assessment with means, standard deviations and percentages.

Usability Survey Data

Users offered moderate to favorable ratings for the usability of *Diabetes MAP*. On a scale of 1 to 5 with higher values representing more favorable ratings of usability, the average rating

across all individual items assessing usability was 3.86. Table 4 shows the number of respondents, the average rating, and the proportion of "endorsers" that either responded 4 – "agree" or 5 – "strongly agree" with the usability items.

Table 3.
Demographic characteristics of participants (N=32)

	Mean ± SD or n (%)	Range
Age (years)	51.7 ± 11.8	26.7 – 73.4
Female	21 (66)	
Race/Ethnicity		
Black (non-Hispanic)	8 (25)	
Hispanic	3 (9)	
Asian	2 (6)	
White (non-Hispanic)	19 (60)	
Education (years)	16.3 ± 2.8	12.0 – 24.0
Annual Household Income		
Less than $14,999	3 (9)	
$15,000 to $24,999	3 (13)	
$25,000 to $49,999	9 (28)	
$50,000 and $74,999	7 (22)	
$75,000 or more	9 (28)	
Number of Diabetes Medications	1.8 ± 0.8	1.0 – 4.0
Insurance Status		
Private insurance	25 (78)	
TennCare/Medicare	6 (19)	
No insurance	1 (3)	
Diabetes duration (years)	7.8 ± 6.3	0.0 – 20.0
Insulin users	12 (38)	
A1C (n=31)	7.4 ± 2.0	4.9 – 15.8

[1] One participant had no A1c included in medical records at the time of data collection.

The highest ratings (≥4.2) and highest proportion of "endorsers" (≥80%) resulted from the following items: 1) "the information provided in Diabetes MAP is easy to understand," and 2) "the information (such as help videos, on-screen messages, etc.) provided in Diabetes MAP is

clear". The lowest ratings (≤3.6) and lowest proportion of "endorsers" (≤62%) resulted from the following items: 1) "it is easy to navigate the Diabetes MAP website," 2) "the information provided in Diabetes MAP is effective in helping me complete tasks on the website", and 3) "when I make a mistake in Diabetes MAP, I recover easily and quickly."

Table 4.
User Perceptions of Diabetes MAP Usability

	Respondents[1, 2] n	Endorsers[3] n (%)	Mean ± SD
It is easy to navigate the Diabetes MAP website.	29	18 (62)	3.6 ± 0.9
My user interaction(s) with Diabetes MAP are pleasant.	27	20 (74)	4.0 ± 0.9
The organization of information in Diabetes MAP is clear.	27	17 (63)	3.8 ± 0.9
The information provided in Diabetes MAP is effective in helping me complete tasks on the website.	27	15 (56)	3.6 ± 0.9
The information provided in Diabetes MAP is easy to understand.	28	25 (89)	4.3 ± 0.7
It is easy to find the tools and information that I need.	27	18 (67)	3.8 ± 0.9
The information (such as help videos, on-screen messages, etc.) provided in Diabetes MAP is clear.	27	23 (85)	4.2 ± 0.8
When I make a mistake in Diabetes MAP, I recover easily and quickly.	26	15 (58)	3.5 ± 0.9
Overall, I feel comfortable using Diabetes MAP.	28	19 (68)	3.9 ± 1.0
Overall, it was easy to learn to use Diabetes MAP.	28	21 (75)	3.9 ± 1.0

[1]Number of participants who provided a response for each item on a scale of 1 (strongly disagree) to 5 (strongly agree)
[2]Some participants indicated that items were "Not Applicable" to their experience
[3]Percentage of respondents who entered 4 (agree) or 5 (strongly agree) for an item

Focus Group Findings

Participants shared their experiences exploring the features and performing tasks using Diabetes MAP. Users identified challenges and issues using the website, and offered recommendations for how it can be improved. Participants cited a total twenty-four unique usability concerns over nine focus group sessions. The concerns were sorted into six dimensions of usability: (1) intuitive web design, (2) ease of learning, (3) efficiency of use, (4) memorability, (5) user subjective satisfaction, and (6) error frequency and severity. A substantial majority (83%) of these unique issues were reported after only two focus group sessions. See Appendix C for a full list of issues and their reported incidence across focus group sessions.

Concerns about error frequency and recovery constituted the most prevalent issue area across focus groups. The two most prevalent specific issues of all were reported in each of over half of the focus group sessions and pertained to the error frequency and severity dimension of usability. Participants frequently reported having encountered web browser compatibility-related problems and difficulty logging to the website. Also prevalent were concerns regarding the website's efficiency of use and the intuitive web design. See Appendix D for the prevalence of reports of usability concerns across focus groups by usability dimension. In the following sections and in Tables 5 – 10, each of the six dimensions of usability issues noted by participants and the recommendations that users provided to improve the website is discussed.

Intuitive web design concerns and participant recommendations. Participants reported overlooking and missing out on the benefits of many features and functions due to inadequate web design. Intuitive web design denotes a "nearly effortless understanding of the architecture and navigation of a website" (U.S. Department of Health and Human Services,

2014, para. 4). By the end third focus group session, all six usability concerns regarding intuitive design of the website were reported at least once by a participant.

Table 5.
Participant Concerns and Recommendations Regarding Intuitive Web Design

Issues	**Examples of Participant Response(s)**
Placement/layout of functionality/content not intuitive	*You [are] asked ten questions. "Okay, do you know why you are taking this medicine?" Yes. "Do you know the side effects from this?" No. When I say no, I expect an answer immediately. So it's in the right now.*
Navigation - scrolling required to access site features/tasks	*When I filled out the survey, I realized how much I missed, like texting. Where was that? I am really frustrated because I would love that. The fact that I missed all that other stuff tells me that it was not accessible … I got frustrated when I was entering that medication and thought, heck!*
Issues navigating using buttons/navigation menu	*What we were saying earlier about having to, reload a whole page to go to something … Maybe have a Back button.*
Tailoring mechanism unclear to users	*The only [medication] taken from my list that came up in My Tailored Tools was metformin. My glimepiride was not there at all, even though it was under the "My Medications" thing.*
Navigation - need to be able to navigate away from Help videos	*Even if she just loaded, and you could skip her, like, skip intro. Like maybe you don't want her to talk you through ... You can just skip her, and then it will just give you a regular website, with nobody talking to you.*
Unclear that background was actually Help videos	*Well, no at first I saw her and I was going, "What is she doing?" And then finally I figured out you clicked that thing and she talked.*
Recommendations	**Examples of Participant Response(s)**
Minimize or eliminate the distracting "Pam" Help videos	*She is a very lovely woman. She takes up two-thirds of the screen every single time! I was scrolling all the way down. It may sound silly, but, you know, I am busy … Finally, at the very bottom, there is this much [gestures with fingers] content.*
Need more intuitive placement of features	*Make the system clearer. I guess, organize. We were talking about if [medication content] were better in the tailored section or the medications section. Make it more organized to where things are where they are supposed to be.*

One prevalent concern that emerged in this domain pertained to the navigability of the website within and between webpages. Participants were generally unaware of the individual tailoring mechanism behind the medication checklist questionnaire, and of the reasons for having to provide information, such as the time zone and mobile phone number (important for text

message reminder set-up). Users frequently encountered design issues, as a result of having to scroll from help videos to see webpage content and features.

Although some users though the "Pam" Help videos were pleasant, some users were not able to get the Help videos to function properly, and others never new that there were even videos to play for Help information. Many participants suggested that the Help videos be minimized or eliminated to improve the design and navigability of the website. Other respondents noted some misplaced content and features across webpages, and made recommendations regarding intuitive layout. Table 5 summarizes the primary concerns expressed by participants and their recommendations regarding the intuitive web design of Diabetes MAP.

Ease of learning and participant recommendations. Users encountered issues with the instructions and directions that were given for accessing the site and its features. A website's ease of learning refers to "how fast a user who has never seen the user interface before can accomplish basic tasks" (U.S. Department of Health and Human Services, 2014, para. 4). All user interface-learning concerns were cited by the third focus group session.

Users noted the *a priori* instructions handout lacked the detail necessary to spell out to users what tasks should have been performed. Further, users pointed out how the directions embedded within the website were unclear and, at times, misguiding and misdirecting. Users wanted Help videos to be functional, accessible, useful, and recallable when needed. Users also wanted clear, detailed instructions on how to optimize their experiences using the site. Table 6 summarizes the major interface learning issues and recommendations that were reported by participants.

Table 6.
Participant Concerns and Recommendations Regarding of Ease of Learning

Issues	Examples of Participant Response(s)
Instructions accessing/using the website unclear	*In my department, when we have something new, especially with the computer software, whatever, a new program or something for employees to change, it goes step by step what to do … This one, maybe, it will help with the research, with the new people, here's a sheet of paper. If you go step by step, you can give it to anybody, even in the street, and they can do it.*
Directions within website unclear	*You're supposed to add everything you can? See, I didn't understand it that way. Nothing. Nothing told me, and I couldn't get the girl to talk either.*
Help videos not useful for completing tasks/accessing features	*Not after the first time I went on there. I mean, I listened to her the first time I went on there, but then, I think I could have done it without her.*
Help videos dysfunctional	*Pam's bobbing and weaving, and Pam is slowing down the loading of the page. And I actually, sometimes, saw her image, even though when she was talking, blacked out.*
Recommendations	**Examples of Participant Response(s)**
Users want more detailed instructions and directions on using the website.	*If people get instructions beforehand, you know, they can say, "Okay, well off to here, you know, here's these and they mean that." You know, it should be obvious.*
Users want Help videos to be easy to access.	*I didn't find it very useful of her just being on there. Because I couldn't figure out how to get her to say anything. I spent a lot of time initially trying to get her to talk. It never could do it.*

Efficiency of use and participant recommendations. Users encountered time inefficiencies as several junctures while using the website. Efficiency of use refers to "how fast an experienced user can accomplish tasks" (U.S. Department of Health and Human Services, 2014, p. para. 4). Concerns regarding efficiency of use constituted the second most prevalent of usability sub-category (n=13) noted across focus groups. In particular, users reported extended durations of page loading and speculated that it was due to the large "Pam" Help videos. This issue was exacerbated as users attempted to access Diabetes MAP via other digital devices. Users expressed frustration with not being able to save progress toward completing website tasks, even when automatically logged out. Finally, users wanted easy methods of completing

simple tasks, such as entering time zone information (i.e., a simple drop-down box rather than the time zone map). Users wanted to be able to track and save progress toward tasks and the capability to access the site from multiple digital platforms. Table 7 summarizes user reports of efficiency of use issues and participant recommendations.

Table 7.
Participant Concerns and Recommendations Regarding Efficiency of Use

Issues	**Examples of Participant Response(s)**
Progress not saved	*If you do half of it, and you try to do something else, and the computer freezes or logs you out, you have to start all over again.*
Page loading time too long	*But the moving around kind of bothered me a little bit. It's closed the site down. A waste, I think.*
Time zone locator difficult to use	*First of all it wanted you to select what time zone you're in. It would just remain blank and wouldn't let me select a time zone, but then the next day it did.*
Automatic logout problematic	*But if you even scrolled or clicked up around that corner… It would log you out when you weren't even on intending to. Like I clicked on that diabetes map like thing… And it logged me out.*
Compatibility with other digital devices	*I felt it's like it's a little heavy to start with. Um, my laptop still cannot open it. iPads can open it, but needs a lot of time, even I have high speed. When you open it in iPad, some clips, reader clips, you cannot get unless you are in desktop or laptop.*
Difficulty scrolling using child windows	*Sometimes when I was looking at the videos, I would try to make a selection. The bar on the right hand side would not go all the way down to the bottom. If it did, then it would hit the bottom and come back up. I couldn't make it stop.*
Recommendations	**Examples of Participant Response(s)**
Users want to be able to save their progress	*If there is a possible way, which is, I'm sure it is, to save it and come back to it to finish it?*
Users want more flexibility to use other electronic devices.	*I think first thing I would address is to make this friendly to all electronics. Cell phone is number one and then a home computer is important.*

Memorability. Website memorability refers to the extent to which a user, after visiting a site, can remember enough to use it effectively in the future (U.S. Department of Health and Human Services, 2014). The memorability of Diabetes MAP, its features and tasks was primarily

complicated by its confusing web address (URL). When users forgot or mistyped the web address, they resorted to using search engines or searched for links on the partnering medical center's webpage to try to find the site. Users reported barriers to accessing the website due to the complex URL in three of nine focus groups.

Users also frequently reported forgetting the actual purpose of the website. They noted that they were reminded of its purpose only after exploring the website and seeing primarily medication-related information. Users wanted a simple, recognizable, and memorable web URL for the site, and want to be able to find it through an online search in an efficient manner. Table 8 summarizes the few memorability concerns and recommendations that were reported in this study. It is important to note, in almost half (n=4) of the focus group sessions, users conveyed that they had, at some point not been clear on the purpose of the website after being introduced to it with accompanying website information (i.e., handout).

Table 8.
Participant Concerns and Recommendations Regarding Memorability

Issues	**Examples of Participant Response(s)**
Confusion regarding purpose of site/features	*I didn't even realize it was just for taking medications until we came to this focus group … But, I sort of realized it was all about medications, because I didn't see all of the other things I was kind of looking for.*
Complicated URL - not locatable	*Do you plan to use a user-friendlier name? My hope is Vanderbilt was specifically picked to be something you could find. We weren't able to get an EDU, because that that's just not allowed. But, having to type that long URL is a little much.*
Recommendations	**Examples of Participant Response(s)**
Users want a shorter, simpler URL.	*I didn't have any problem with it, but I can see that it would be better to have a little more user friendly name or, on the app, do you plan to make it part of My Health at Vanderbilt?*
Users want the website to be searchable online.	*Another thing, you know, if you go to under the medical center's "Diabetes Map", it will give you directions how to get to the diabetes center.*

Error frequency and severity concerns and participant recommendations. Users voiced error-related usability concerns in focus groups more that any other sub-category. Error frequency and severity considers "how often users make errors while using a system, how serious the errors are, and how users recover from the error" (U.S. Department of Health and Human Services, 2014, para. 4). Although saturation of concerns for this usability sub-category was reached by the fourth focus group, at least one of five error-related concerns was reported in every single focus group session.

Chronologically, the error-related problems reported by users were confronted very early in the user engagement process with Diabetes MAP. First, the highest reported usability issue across focus groups pertained to web browser compatibility issues and error messages faced prior to accessing the website. These errors surfaced, despite the fact that participants were given a handout with web browser requirements upon enrollment in the study (see Appendix E). Some users encountered overwhelming barriers to accessing the site due to the difficulty of creating an account and logging into their accounts. On occasion, users reported enlisting the help of personal and study-related technical support resources to recover from more severe errors and barriers to using the site.

Table 9.
Participant Concerns and Recommendations Regarding of Error Frequency and Severity

Issues	Examples of Participant Response(s)
Web browser compatibility issues/error messages	*I used Internet Explorer when I typed it all in, it kept going to a cannot-find-page error. And it did it three or four times … And then I just wiped everything again and tried it again.*
Error message/difficulty at login	*Just getting on it! It kept coming back with an error on the page.*
Difficulty searching /finding correct medication name	*Finally the one I was on came up, but they used the scientific name and a different amount and like… I just selected it because.*
Difficulty searching /finding correct medication name/dosage combination	*You list the medications it would bring up a whole bunch of them you know with scientific names along with the name you use and the same dose, but like 20 different and you don't know which one you're on.*
Required technical support to use website	*I just happened to know this computer guy who was coming in my room to do some other work and I asked him … I said "can you get this website up?" It took him a while, and this is all this man does is IT work. He had to go to tools, he did the pop up, there was that one thing that said remove the pop ups and once that was done, it was OK, but I fooled around for days on that, so that part is not good.*
Recommendations	**Examples of Participant Response(s)**
Users want a simplified, streamlined set-up process.	*Make it … I'm not saying, very easy, you know. But, if I am trying to log in information, I don't want to search for 30 minutes to go and do information for 20 seconds.*
Users want more flexibility regarding web browsers and settings	*I would probably use it more except I couldn't use it at work because it wouldn't work with my computer at work. And then I tried using it on my phone and my kindle and really couldn't get it to work on that either. I did have a new computer that I just bought at home. I could use it at home, but I was really limited because of that platform.*

Users wanted a simplified, streamlined process of getting acquainted and accessing Diabetes MAP. Acknowledging the prevalence of web browser-related issues, users called for web browser compatibility that encompasses multiple browsers, and that is more flexible and inclusive of older, more common versions of the web browsers. Table 9 reviews the error-related issues, and the recommendations for improvements offered by participants.

User subjective satisfaction concerns and participant recommendations. User subjective satisfaction concerns were reported in the lowest number of focus group sessions (n=2). User subjective satisfaction refers to the extent to which users like the website (U.S. Department of Health and Human Services, 2014). Users who did report dissatisfaction with either the website or its features cited the non-user-friendliness its user interface as the primary culprit. In these discussions, participants expressed overall frustration from exploring the website. Overall, participants wanted critical usability issues to be eliminated so that they optimally engage and receive the benefits of the website. Table 10 describes the participants' concerns and recommendations regarding their satisfaction with the website.

Table 10.
Participant Concerns and Recommendations Regarding User Subjective Satisfaction

Issues	**Examples of Participant Response(s)**
Non-user-friendly interface	*I'm not an IT person, but I'm a supervisor in my department, and I deal with about 15 employees, and many lives, so I do not have a problem for what I do so far. But this one over here, it was like going against brick wall, okay? It was not friendly whatsoever.* *Just a little note on it, if you haven't thought about suicide, this website would make you do so.*
Recommendations	**Participant Response(s)**
Eliminate usability problems that frustrate users and discourage them from using the website.	***On average, users rated the usability of Diabetes MAP and its features moderately to favorably.

In focus groups, participants uncovered several critical usability issues regarding the Diabetes MAP website, endorsed the site's design along some dimensions of usability, and offered detailed recommendations for how the site can be improved overall. Consistent across data collection methods were user concerns with how useful the Help materials embedded in the website for completing website related tasks, and thus achieving the optimal user experience.

The usefulness of website Help materials was only moderately endorsed via the WUS, and then was cited as a concern in five of nine focus groups sessions. Usability survey items least endorsed by participants were related to the site's navigability, helpfulness of Help materials, and error-making and recovery.

The most prevalent theme across data collection methods was observed in user reports of the website's error-related experiences. In the survey, making errors and recovering from them was the least endorsed usability dimension for the Diabetes MAP website. In focus groups, participants cited error-related issues more frequently across focus groups than any of the other six dimensions of usability. Participants described their frustration and annoyance due to encountering web browser and website errors and error messages.

Survey data revealed favorable ratings for the site's accessibility and clarity of help information that was available. These survey data aligned with the ease of learning dimension of usability. These favorable user survey ratings were parallel to user assessments of ease of learning the Diabetes MAP in focus group sessions. Only four specific usability issues were presented in focus group sessions. These four issues were cited 11 times across five focus group sessions, making ease of learning one of the least prevalent dimensions of usability concerns highlighted in focus groups.

CHAPTER 4

DISCUSSION & CONCLUSION

Discussion

Usability evaluation methods are issue-focused and designed to assess the extent to which real-life users can easily, efficiently, and effectively perform web-related tasks in a system. User-based, participatory usability evaluation of web-based applications center participants and their experiences with a website to gauge and elicit user conceptualizations of usability – related problems and solutions (Jaspers, 2009). In this study, with deployed mixed methodologies and multiple methods identify user-based challenges to using the Diabetes MAP site around six major dimensions of web usability. The users were real diabetes patients who provided descriptions of their actual experiences using the site and recommendations for improving it.

In addition to highlighting major usability concerns with the design of Diabetes MAP, participants also offered positive remarks regarding the usability of some features. One participant reported using the "Forgot Password" feature, which facilitated the secure delivery of his user account information and allowed him to login. This positive experience reflected a user who encountered an error, but then efficiently and effectively recovered from it. Another participant reported using the web browser requirement handout given to participants to make a decision regarding accessing Diabetes MAP via a desktop computer or mobile digital device. She described reading the user specifications, then choosing to access the site on a computer web browser, as recommended in the user requirements. Zang and Dran (2000) coined the term, "dissatisfier," for factors that, when present, make a website functional and usable, and when

absent, dissatisfying. By contrast, a "satisfier" is a positive, motivating factor in web design that add value to a website by improving user satisfaction. In this study, participants provided feedback on both positive/motivating and dissatisfying/de-motivating elements of the usability of the Diabetes MAP website.

Users also described multiple strategies for overcoming usability challenges and barriers to using Diabetes MAP. Some examples of participant approaches to troubleshooting included: 1) entering incorrect information in order to proceed to other locations on the site, 2) creating web browser bookmarks, 3) employing alternative methods for locating the Diabetes MAP website, and 4) trial and error. Trial and error was a particularly salient approach to troubleshooting, as it was mentioned in four of nine focus group sessions. Users attempted and innovated new ways of engaging and navigating the website in order to explore the full reaches of its potential. This feedback underscores the importance of employing web user evaluation methods that reveal positive attributes of website design and usability and strategies employed by users, in addition to those that identify usability concerns within a system.

One of the strengths of this study was the number of participants engaged and focus groups sessions held. Twenty-seven participants attended nine focus groups. This sample size exceeds the recommendations of user-based methods for evaluating usability, for which only as few as five participants are needed to identify 80% of major usability issues in a system (Nielson, 2000). In the current study, over 80% of the usability issues presented by participants were reported in the first two focus groups after only eight participants have participated in focus group sessions.

Study Limitations

Limitations to this study include the reliance on user-based participatory usability evaluation methods to assess the usability of the website. Industry guidelines, heuristics and protocols have been developed and are utilized by usability experts who are trained specifically in human-computer interaction evaluation methodologies. Studies have shown both expert-driven (i.e., heuristic analysis) and user-driven usability evaluation methods to be equally effective and efficient for addressing web usability problems (Tan, Liu, & Bishu, 2009). However, user-based usability evaluation, including methods that involve focus group elicitation, are effective approaches for understanding how users frame their most critical design issues for web-based interventions (Jaspers, 2009). In this study, we deployed this user-driven approach to understanding how patients, themselves, engage a diabetes health website. This approach provided a rich and in-depth understanding of participant-identified usability concerns for a web-based health intervention for diabetes patients.

This study also relies on retrospective self-reports of users' experiences using the Diabetes MAP website. Other usability evaluation methods, such as think-aloud protocols, cognitive walk-throughs, and remote user testing facilitate real-time data collection of user interactions with a system (Nielsen, 1995). These methods are useful for understanding user engagement profiles, user experience contexts, how they each impact when and how users experience usability challenges, and the processes by which tasks are performed. The current study is focused, rather, on understanding the user thoughts and motivations regarding their perceptions of the usability of the Diabetes MAP intervention.

While usable and effective online health tools are powerful media for quick and dynamic knowledge distribution and health care delivery, there are still yet challenges to providing equitable access of these resources to a broad population. In this study, a racially and ethnically

diverse study sample was recruited from an academic medical center in order to elicit feedback from patients from a variety of backgrounds. This effort stemmed from the knowledge of significant disparities that exist regarding access and use of Internet health information along dimensions of race, ethnicity, education and income levels. Still, the study sample (i.e., primarily non-Hispanic White, well educated, middle income, and privately insured) does not necessarily reflect the general demographics of patients with diabetes. Thus, this study has limited generalizability beyond a population with these characteristics. However, studies have shown that racial and ethnic health and healthcare disparities still remain after differences in income, access, and insurance status have been considered (Sarkar, et al., 2011). In particular, individuals with little to no access to the Internet encounter a barrier to Internet-delivered interventions and may not experience the benefits of using web-based resources (Gilmour, 2007).

Conclusion

Usability issues, such as difficulty navigating, understanding, and completing tasks are barriers to using and benefiting from Diabetes MAP. Inherent to usability evaluation, user testing and user-centered design is the principle of iterative evaluation, which segues into future directions for the study. Presented here is a mixed-methodological, multi-method evaluation and analysis of the usability of a web-based diabetes health intervention. However, usability testing and user-design necessitate an iterative testing-refinement process in order to design a product that best suits and serves targeted users. Another iteration of usability testing and evaluation should follow a period of refinement and revision of the Diabetes MAP intervention to ensure that the recommended changes do, in fact, result in improved ratings of usability (Bailey, 2005). Once deemed usable to patients for which the website was designed, the Diabetes MAP

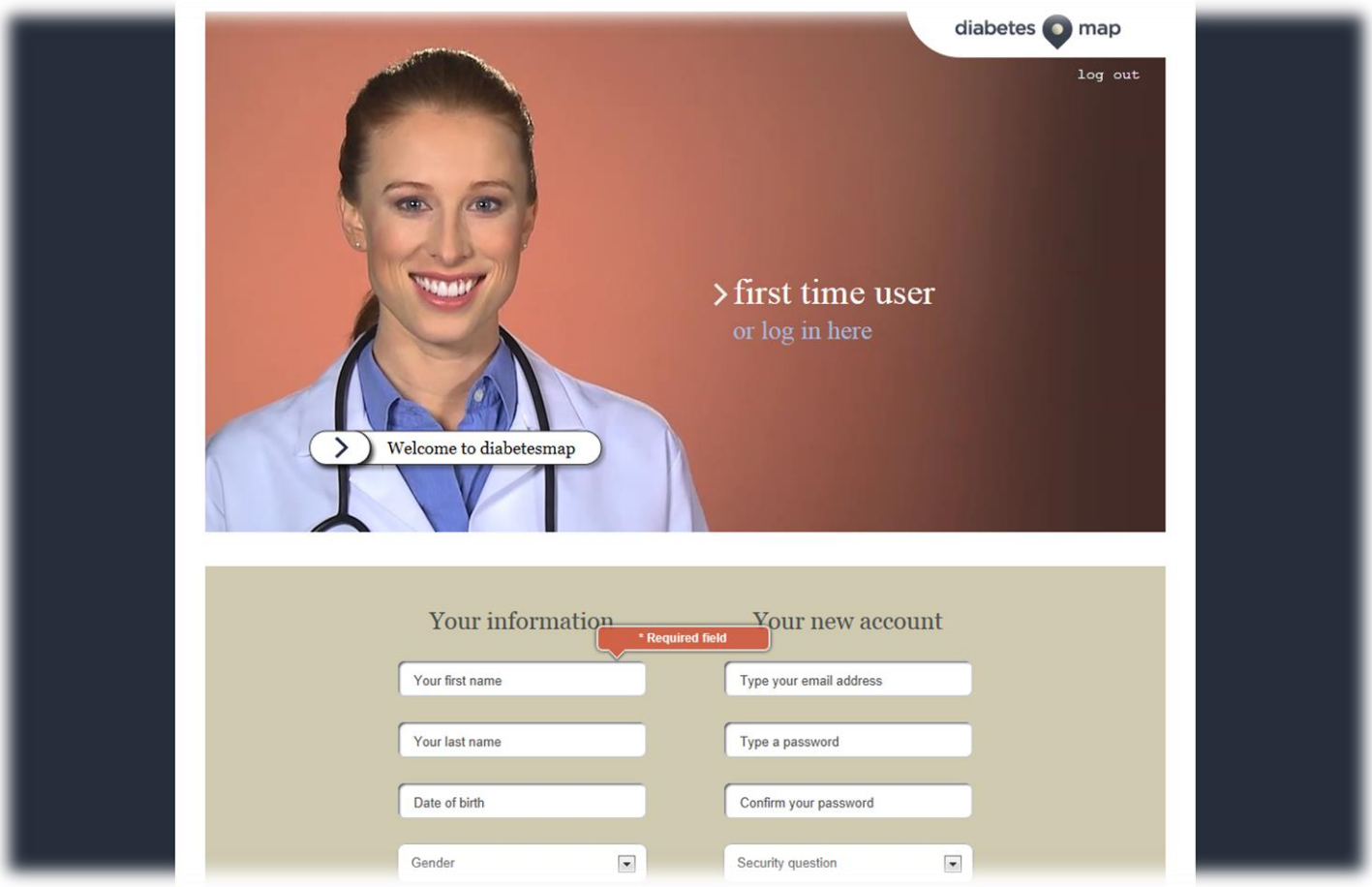
intervention should be tested to see if it is, in fact, an effective disease management intervention that improves medication adherence and subsequent health outcomes for diabetes patients.

This study, and its implications that inform how web-based interventions should be designed and tested, are both timely, especially as patients are more frequently accessing health information online and are increasingly being directed to web-based resources and tools for health care and services delivery. This has become so much of a priority for public health that the "use of health communication strategies and HIT to improve population health outcomes, health care quality, and to achieve health equity" is now a *Healthy People 2020* goal (U.S. Department of Health and Human Services, 2014)

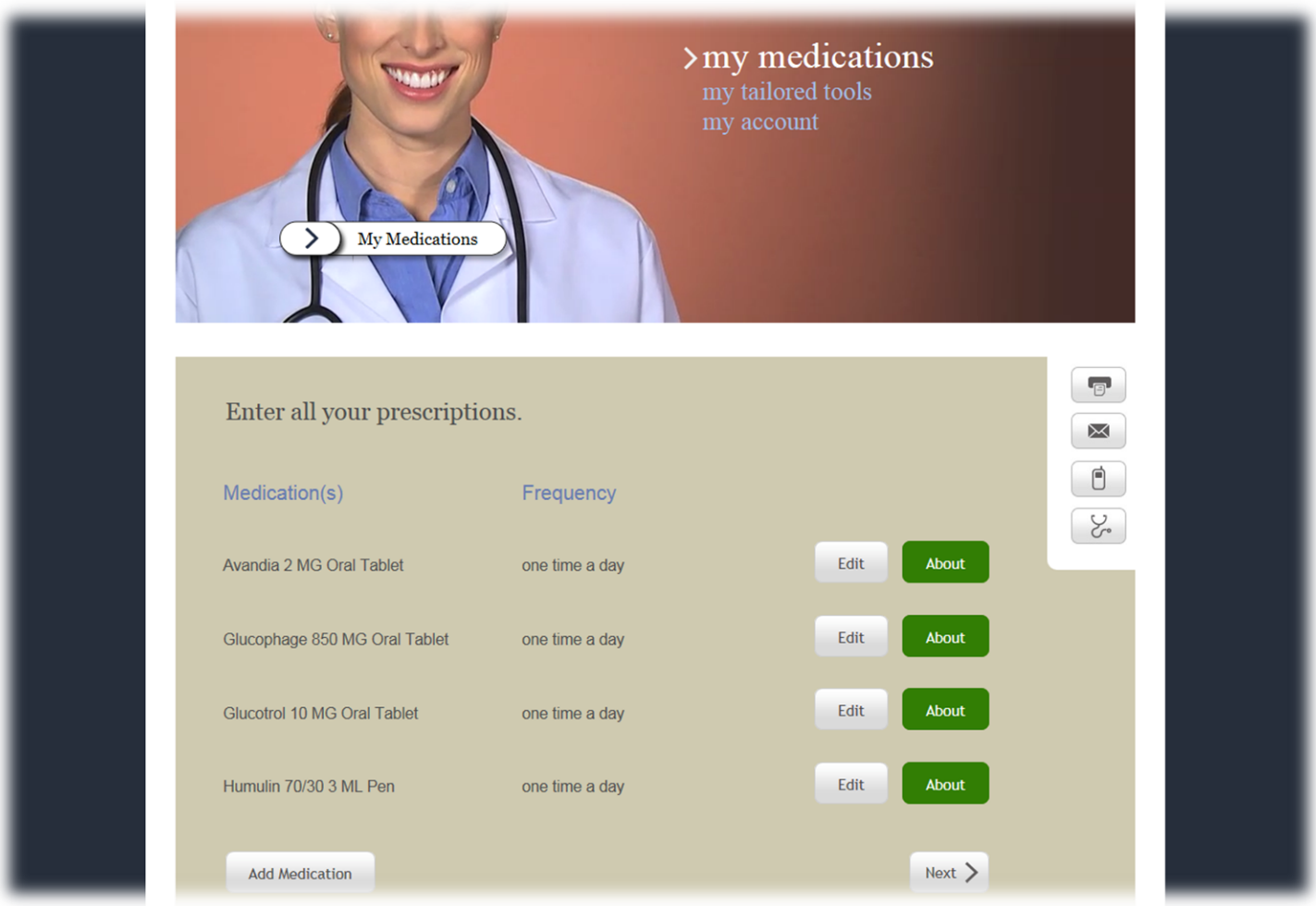
The findings of this study underscore the importance of user testing and usability evaluation for the design of web-based health interventions and highlights the need for usability testing that not only centers the needs and values of users, but also engages them in the design process. Future studies should utilize appropriate usability evaluation methods, including user-driven approaches in order to ensure that subsequent effects of Internet-delivered interventions on health behaviors and outcomes can be attributed to the intervention and not usability errors.

APPENDIX

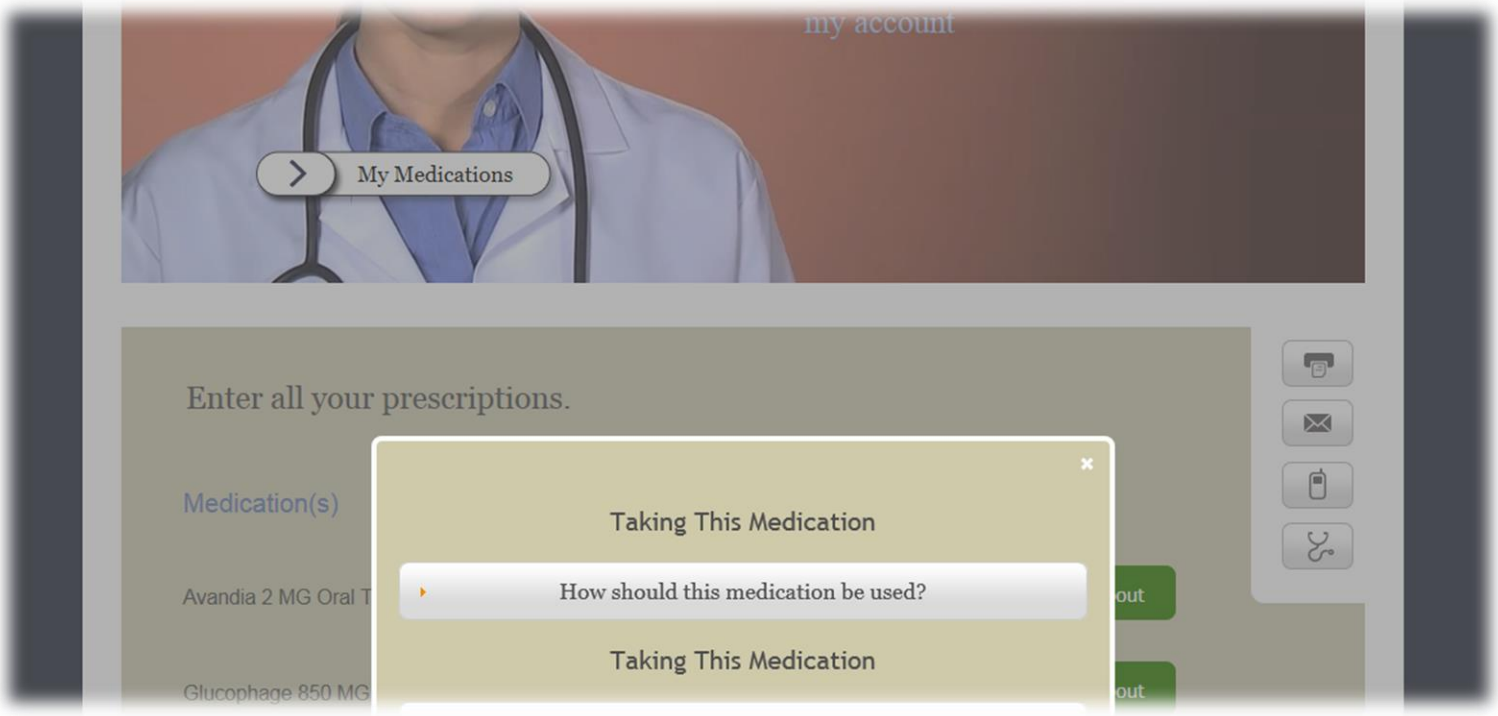
Appendix A. Images of Webpages in *Diabetes MAP*



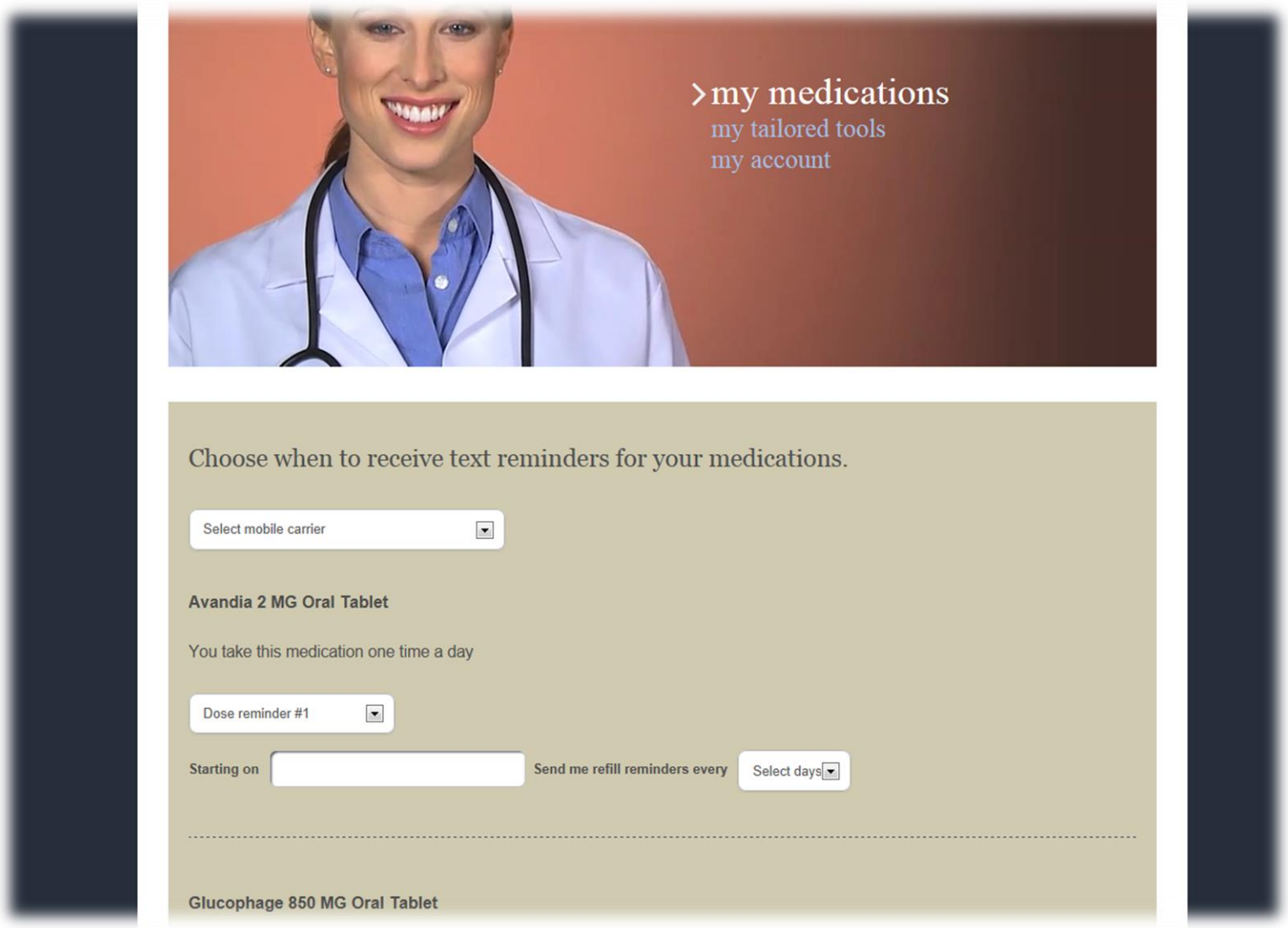
Home page, user account creation, and login



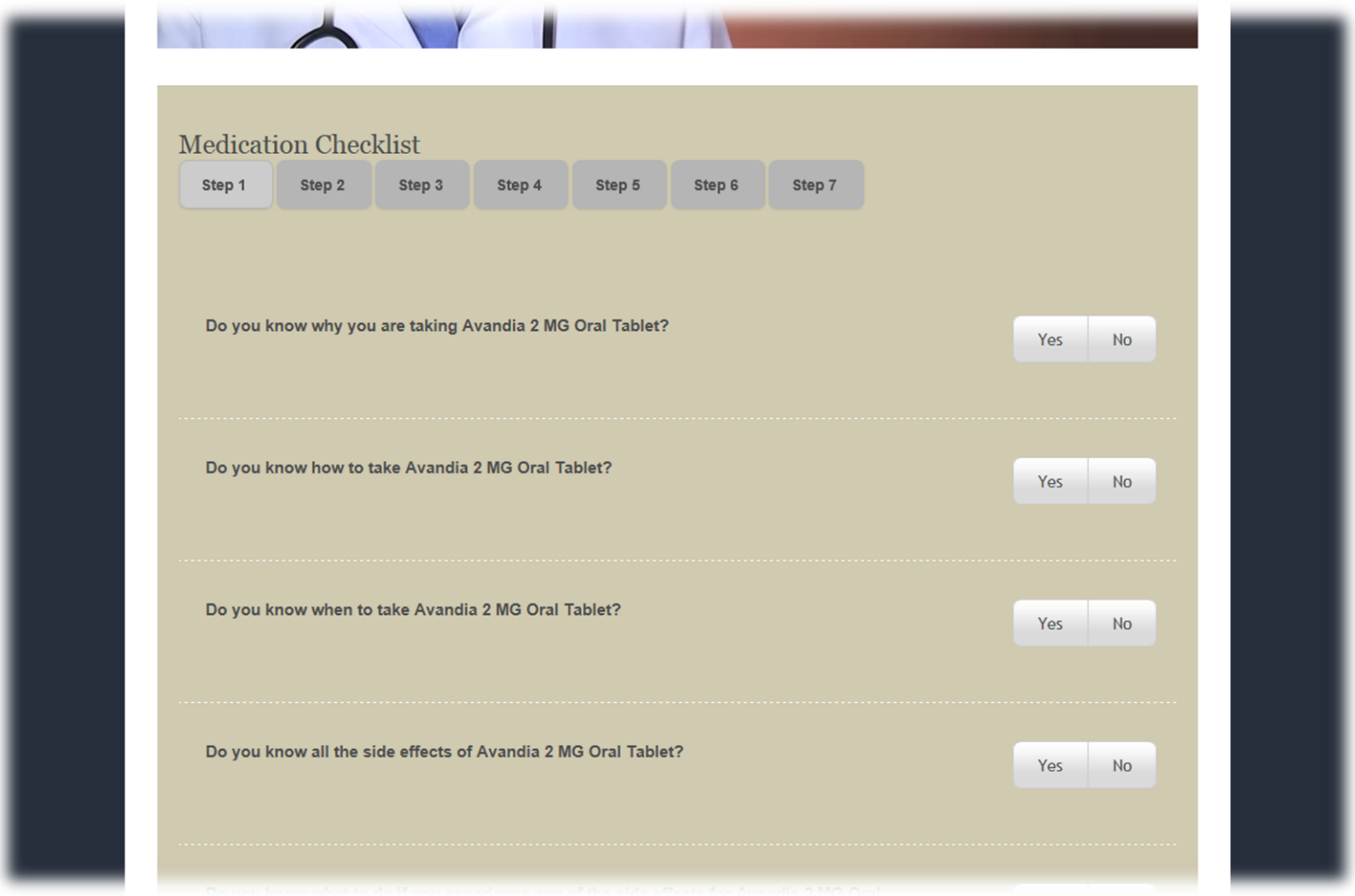
"My Medications" page with print/email list, text reminders, and MHAV features



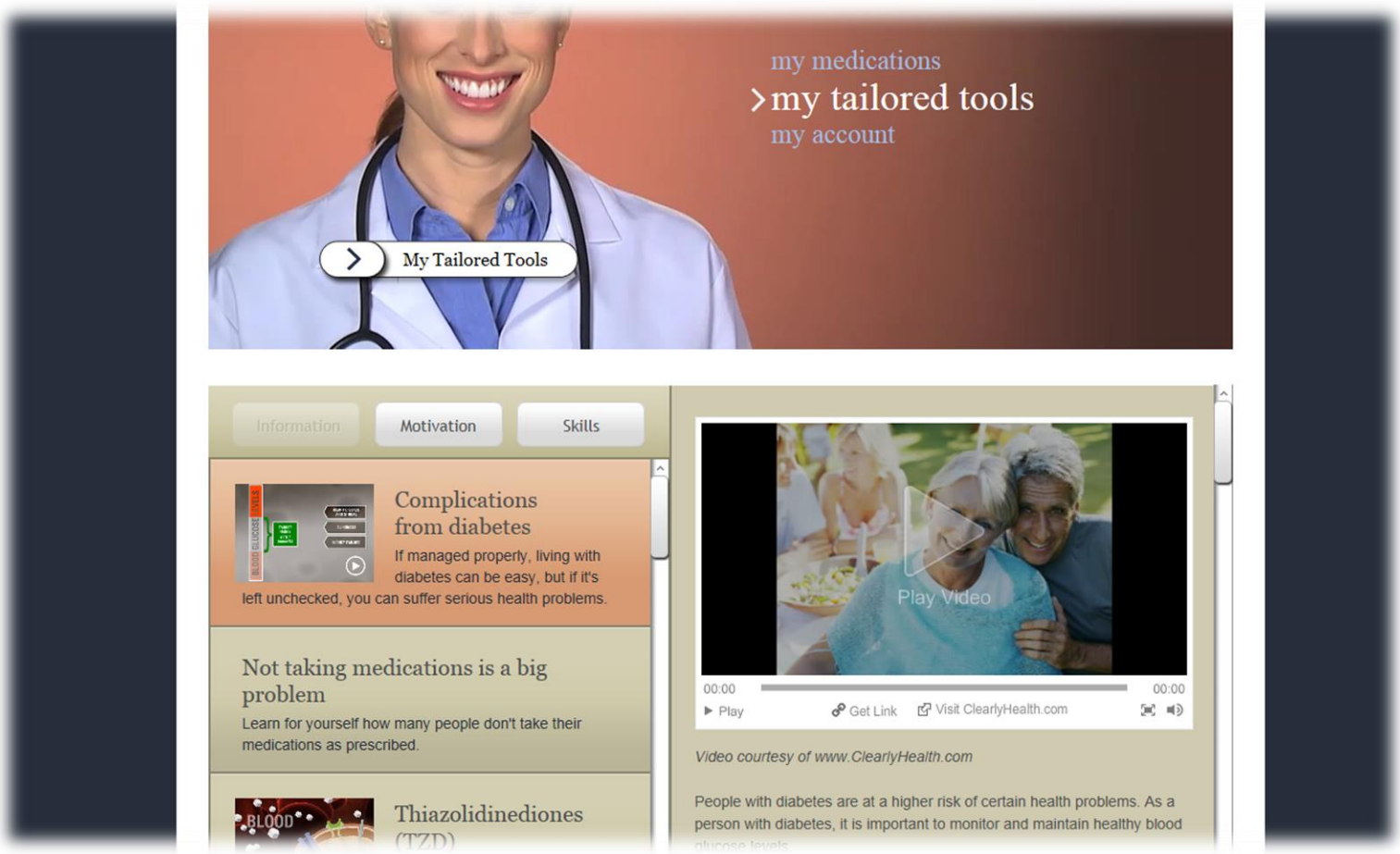
Learn about medications through the “About” feature on the “My Medications” page



Text message reminder set-up linked from the "My Medications" page



Medication checklist questionnaire



"My Tailored Tools" page with information, motivation, and skills-based content

Appendix B. Focus Group Protocol

Part I: INTRODUCTION (4 minutes)	• Thank you for agreeing to meet with us. I'm _____ from the Center for Health Services Research at Vanderbilt University Medical Center. I also have my colleague _____ present to take notes for us. • We are speaking with participants to get various impressions of the Diabetes MAP website, a site for diabetes patients to help them manage their medications. The study is being funded by the National Institute of Diabetes and Digestive and Kidney Diseases. • As researchers, we would like to talk with you about your user experience with the Diabetes MAP and gather any feedback that you may have. What we learn from today's discussion will help us improve the website and understand how websites like Diabetes MAP impact the way patients manage their medications. • This is an open discussion, so there is no right or wrong answers to any of our questions. Everything discussed here today will be kept confidential, so please be open and honest with your comments. Also, you do not have to answer any question you do not feel comfortable with. • I would like begin with introductions. Let's go around the room. Please say your name. Can we start with you, _____?
Part II: GROUND RULES (1 minute)	• I'd like to discuss some ground rules for our discussion. First, we need to make sure that this is a safe place for each of you to share your thoughts and opinions about the topics we will discuss. It is important that each person's opinion is respected, and that each person feels comfortable enough to offer a different point of view. The purpose of this group is to ensure that we hear from all of you, so please, respect others' opinions and feel free to offer different ones. • Second, please leave enough time for other people to respond. We would like to hear from all of you. • Finally, if you have not offered an opinion on a topic, I may ask your opinion. If you would like to comment, please do so, but there is absolutely no pressure to. You can always tell me that your opinion has been said by others or that you don't have anything to say at this point. • Finally, just some housekeeping issues: The bathrooms are located (*indicate location*). If you need to use the bathroom during our discussion, feel free to do so, but please be as quiet as possible when you open and close the door because we are recording everything. This session will take about 90 minutes. Please turn off your cell phones. • At this time I'm happy to answer any questions or concerns you have before we begin.
Part III: Focus Group Questions OPENING (3 minutes)	**OPENING** • How long have you had diabetes, and how long have you been taking medications?

TOPIC #1
(8 minutes)
	Topic #1: Challenges with Diabetes MAP
	
	• What challenges did you encounter with the Diabetes MAP website?
	  o **Probe:** What specific features were challenging?
	  o **Probe:** What about the features was challenging?

TOPIC #2 (5 minutes)	**Topic #2: Most Favorite Aspects** • What did you like the most about the Diabetes MAP website? o **Probe**: What about this component did you like?
TOPIC #3 (5 minutes)	**Topic #3: Least Favorite Aspects** • What did you like least about the Diabetes MAP website? o **Probe**: What about this component did you not like?
TOPIC #4 (5 minutes)	**Topic #4: Specific Features of Diabetes MAP** *(demonstrate how to create an account)* • What was your experience creating an account like? *(demonstrate how to log in)* • What was your experience logging in like? *(demonstrate how to add medications)* • What was your experience like adding medications in Diabetes MAP? *(demonstrate how to view medication information)* • What was your experience viewing medication information like? *(demonstrate how to email a medication list, print a list, and how to view online patient portal)* • What was your experience using these tools like? *(demonstrate how to set up text message reminders)* • What was your experience with the text message reminder system? *(demonstrate how to view My Tailored Tools content)* • What was your experience using My Tailored Tools?

TOPIC #5
(5 minutes)
	Topic #5: Benefits
	
	• What else about the Diabetes MAP website did you find valuable or helpful?
	  o **Probe**: How useful did you find the website resources, like the Help videos and Diabetes MAP instruction sheet useful?
	  o **Probe:** What do you think about the text message reminder function? Emailed medication list? Printed list? Link to online patient portal?
	  o **Probe**: What do you think about the content in the "My Tailored Tools" section?

TOPIC #6 (5 minutes)	**Topic #6: Barriers to Using the Website** • What barriers to using the website did you encounter in your daily life?

TOPIC #7
(7 minutes)
	Topic #7: Ideal Conditions
	
	• What conditions do you think are necessary for someone to have the best experience using the Diabetes MAP website?
	  o **Probe**: How long do users need to use the site?
	  o **Probe**: How many times do you think users need to be able to access the website?

	○ **Probe**: Who all should have access to the website?
TOPIC #8 (8 minutes)	**Topic #8: Modality Preference** • Do you prefer using websites, like Diabetes MAP, to other ways of learning how to manage your medications? ○ **Probe**: Why or why not? ○ **Probe**: What other ways would you have liked to receive information on managing your diabetes medications? ○ **Probe**: What about that mode of delivery makes it your preference?
TOPIC #9 (8 minutes)	**Topic #9: Improvements** • How can the Diabetes MAP website be improved?
CLOSING (5 minutes)	• Those were all the questions that we wanted to ask. Do you have any final thoughts about the Diabetes MAP website that you would like to share? • Thank you so much for your time.

Appendix C.

Usability Concerns by Focus Group Session

		Focus Group Number									
#	Issue	1	2	3	4	5	6	7	8	9	Total Count
1	Error message/difficulty at login	X	X		X	X			X	X	6
2	Complicated URL - not locatable	X	X		X						3
3	Time zone locator difficult to use	X					X				2
4	Difficulty searching for/finding correct medication name	X	X		X						3
5	Difficulty searching for/finding correct medication dosage	X	X						X		3
6	Progress not saved	X	X		X						3
7	Tailoring mechanism unclear to users	X									1
8	Directions within website unclear	X				X	X				3
9	Help videos dysfunctional	X									1
10	Help videos not useful for completing tasks/accessing features	X	X			X					3
11	Confusion regarding purpose of site/features	X	X		X		X				4
12	Placement/layout of functionality/content not intuitive	X					X		X		4
13	Automatic logout problematic	X	X								2
14	Web browser compatibility issues/error messages	X	X	X	X	X	X	X			7
15	Non-user-friendly interface		X						X		2
16	Instructions accessing/using the website unclear		X	X		X	X				4
17	Navigation - scrolling required to access site features/tasks		X	X						X	3
18	Page loading time too long		X		X		X				3
19	Navigation - need to be able to navigate away from Help videos		X								1
20	Issues navigating using buttons/navigation menu		X	X					X		3
21	Unclear that background was actually Help videos			X							1
22	Compatibility with other digital devices				X			X			2
23	Required technical support to use website				X						1
24	Difficulty scrolling using child windows								X		1
	NUMBER OF ISSUES IN EACH FOCUS GROUP	14	15	5	9	5	7	2	6	2	
	NUMBER OF NEW ISSUES	14	6	1	2	0	0	0	1	0	
	NUMBER OF TOTAL ISSUES REPORTED TO DATE	14	20	21	23	23	23	23	24	24	
	PROPORTION OF TOTAL ISSUES REPORTED TO DATE	0.58	0.83	0.88	0.95	0.96	0.96	0.96	1	1	
	NUMBER OF PARTICIPANTS IN THIS FOCUS GROUP										
	NUMBER OF TOTAL PARTICIPANTS ENROLLED TO DATE										

Appendix D.

Usability Concerns by Sub-Category				
#	Issue	Usability Dimension	Number of Focus Groups Issue is Reported	Prevalence of Issues Reported by Usability Dimension
16	Instructions accessing/using the website unclear	Ease of learning	4	11
8	Directions within website unclear	Ease of learning	3	
10	Help videos not useful for completing tasks/accessing features	Ease of learning	3	
9	Help videos dysfunctional	Ease of learning	1	
6	Progress not saved	Efficiency	3	13
18	Page loading time too long	Efficiency	3	
3	Time zone locator difficult to use	Efficiency	2	
13	Automatic logout problematic	Efficiency	2	
22	Compatibility with other digital devices	Efficiency	2	
24	Difficulty scrolling using child windows	Efficiency	1	
14	Web browser compatibility issues/error messages	Errors	7	20
1	Error message/difficulty at login	Errors	6	
4	Difficulty searching/finding correct medication name	Errors	3	
5	Difficulty searching/finding correct medication name/dosage combination	Errors	3	
23	Required technical support to use website	Errors	1	
12	Placement/layout of functionality/content not intuitive	Intuitive design	4	13
17	Navigation - scrolling required to access site features/tasks	Intuitive design	3	
20	Issues navigating using buttons/navigation menu	Intuitive design	3	
7	Tailoring mechanism unclear to users	Intuitive design	1	
19	Navigation - need to be able to navigate away from Help videos	Intuitive design	1	
21	Unclear that background was actually Help videos	Intuitive design	1	
11	Confusion regarding purpose of site/features	Memorability	4	7
2	Complicated URL - not locatable	Memorability	3	
15	Non-user-friendly interface	User subjective satisfaction	2	2

Appendix E. *Diabetes MAP* Instructions for Participants

Welcome to DIABETES MAP

- **Diabetes MAP is a website for patients with diabetes that is designed to help patients take their medications.**

- **To get started with the website, you will need to create a user account. After logging in, you will be asked to enter information pertaining to your medications. You will then be asked a series of questions regarding your medications.**

- **After completing these questions, you will be directed to a series of modules that are tailored to your specific needs pertaining to taking your diabetes medications.**

- **The following are some of the other features included on the website:**
  - Help Videos with tips on how to use the website
  - Helpful information specific to your medications
  - Capability to print your medication list or have it sent to your email box
  - Ability to set up text message reminders
  - A quick link to the online patient portal
  - Individually-tailored tools to with informational, motivational, and skill-building tips

- **You may explore to Diabetes MAP anytime and as long as you would like according to you specific needs.**

- **You will be compensated $8 per hour of use of Diabetes MAP, up to ten (10) paid hours.**

Happy exploring!

Appendix F. *Diabetes MAP* Web Browser Requirements for Participants

Diabetes MAP Web Browser Requirements

- Website: **www.mc.vanderbilt.edu/webapps/diabetesmap**
- Please be sure that you are using the latest version of your internet browser.
- Diabetes MAP runs best on:
  - Internet Explorer 8+ (standard mode only)
  - Firefox 3+
  - Google Chrome 3+
  - Safari 4+
- It runs on both PC and Mac.

➢ Please be advised to turn off all compatibility or Quirk modes on your web browser.

➢ Please log out of Diabetes MAP and close your web browser after each session.

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