DIABETES TECHNOLOGY & THERAPEUTICS
Volume 10, Number 1, 2008

DOI: 10.1089/dia.2007.0252

Usability Test of an Internet-Based Informatics Tool for Diabetes Care Providers: The Comprehensive Diabetes Management Program

STEPHANIE J. FONDA, Ph.D.,[1,2] CHRISTINE A. PAULSEN, Ph.D.,[3] JOAN PERKINS, M.A.,[1] RICHARD J. KEDZIORA, M.B.A.,[4] DAVID RODBARD, M.D.,[3] and SVEN-ERIK BURSELL, Ph.D.[1,2]

ABSTRACT

Background: Research suggests Internet-based care management tools are associated with improvements in care and patient outcomes. However, although such tools change workflow, rarely is their usability addressed and reported. This article presents a usability study of an Internet-based informatics application called the Comprehensive Diabetes Management Program (CDMP), developed by content experts and technologists. Our aim is to demonstrate a process for conducting a usability study of such a tool and to report results.

Methods: We conducted the usability test with six diabetes care providers under controlled conditions. Each provider worked with the CDMP in a single session using a "think aloud" process. Providers performed standardized tasks with fictitious patient data, and we observed how they approached these tasks, documenting verbalizations and subjective ratings. The providers then completed a usability questionnaire and interviews.

Results: Overall, the scores on the usability questionnaire were neutral to favorable. For specific subdomains of the questionnaire, the providers' reported problems with the application's ease of use, performance, and support features, but were satisfied with its visual appeal and content. The results from the observational and interview data indicated areas for improvement, particularly in navigation and terminology.

Conclusions: The usability study identified several issues for improvement, confirming the need for usability testing of Internet-based informatics applications, even those developed by experts. To our knowledge, there have been no other usability studies of an Internet-based informatics application with the functionality of the CDMP. Such studies can form the foundation for translation of Internet-based medical informatics tools into clinical practice.

[1]Joslin Diabetes Center and [2]Harvard Medical School, Boston, Massachusetts.
[3]American Institutes for Research, Concord, Massachusetts and Silver Spring, Maryland.
[4]Estenda Solutions, Inc., Conshohocken, Pennsylvania.

The views expressed in this article are those of the authors and do not necessarily reflect the position and policy of the Department of Defense. No official endorsement should be inferred.

An earlier version of this paper was presented as a poster at the annual meeting of the American Telemedicine Association in San Diego, May 2006.

INTRODUCTION

A REVIEW OF THE LITERATURE suggests that disease and case management programs can improve some aspects of diabetes care and outcomes, especially when combined with educational interventions, decision support, and reminders on performance issues.[1] Recently diabetes research has addressed whether the benefits of disease and case management can be realized as or more effectively through the use of new Internet-based care management tools. Much of this work shows that, compared with standard care, the Internet-based mode of delivery is related to improvements in diabetes-related individual-level outcomes and quality of care.[2–6]

Although Internet-based disease and case management tools are new to diabetes care and likely to change providers' workflow substantially, rarely is the usability of emerging disease and case management technologies addressed and reported. A technology is "usable" if it is compatible with normal workflow and easy to use, learn, and remember. Usability of a technology is important to consider because poor usability will be reflected in poor cost savings and clinical effectiveness in the *long term*; that is, even if a technology results in cost savings and clinical efficacy while under study, these things might not be sustained beyond the lifespan of the research if the new technology is not "usable."

This article presents a usability study of an Internet-based informatics application called the Comprehensive Diabetes Management Program (CDMP). The primary aim of the article is to demonstrate a process for testing the usability of an Internet-based informatics tool for disease and case management. The secondary aim is to show the results that such a study yields.

RESEARCH DESIGN AND METHODS

Because the structure of the usability test was dictated by the CDMP's functions and most readers are unfamiliar with the application, this section begins with an overview of the CDMP's origin and functions. The section then describes the design and methods of the usability test itself.

The CDMP

Starting in 1998, a collaborative of diabetes and eye care experts and technologists from the Beetham Eye Institute at the Joslin Diabetes Center (Boston, MA), the Departments of Defense and Veterans Affairs, the Indian Health Service, and Estenda Solutions (Conshohocken, PA) developed a telehealth eye care program to increase access of patients with diabetes to appropriate eye care. Research has shown that the telehealth eye care program is clinically efficacious,[7–10] cost-effective,[11] and associated with patient adherence to annual, standard, dilated eye exams.[12] However, the collaborative recognized that the mitigation of diabetes-related vision loss requires care management of the whole patient, not just his or her eyes. Thus from 2001 to 2005, the collaborative developed the core components of a system intended to help health care providers, who are not necessarily diabetes specialists, use clinical guidelines and up-to-date patient-level information in the care management of diabetes patients. Given that about 21 million people in the United States[13] have diabetes and the number of physicians (particularly those who specialize in endocrinology) is not sufficient to meet their needs,[14] the collaborative designed a system primarily for nurse practitioners and care managers. The result was an Internet-based informatics system called the CDMP.

The core CDMP application was intended to incorporate a wide range of functions. For this article we discuss three major areas—individual patient data, care planning, and population analysis.

The CDMP collects, analyzes, and presents detailed and summary information about individual patients. The patient information includes diagnoses, lab tests, procedure history, medications, demographics, and allergy data. The CDMP uses these data in conjunction with clinical practice guidelines to generate "alerts" to the provider when a patient has experienced a particular health event, is overdue for a test or exam, or when results from a patient's recent laboratory test are outside of a predeter-

mined clinical range. In addition to generating "alerts," the CDMP uses these data to assess the patient's risk for complications of diabetes such as nephropathy, retinopathy and cardiovascular disease. To review all of these data and metrics at once, providers navigate to a one-page overview of key patient information called the "Snapshot" page (Fig. 1).

The CDMP also contains "modules" for presentation of patient information in specialty areas. One module records images and diagnoses from tele-retinal evaluations for diabetic eye disease that the patient might have received. Another module contains a brief patient questionnaire to help care managers and patients identify problems in the patient's self-care behaviors (e.g., diet, physical activity, self-monitoring of blood glucose, medication adherence, etc.) and psychosocial circumstances (e.g., self-rated health, social support, mood, etc.). This questionnaire can be completed alone by the patient using an online survey tool integrated within the CDMP, can be administered online by the provider using the aforementioned survey tool, or can be administered on paper and the data can be entered into the CDMP by a clinic clerk.

Further, the CDMP contains a Care Plan. The Care Plan covers the provider's notes about the patient's major anatomical and physiological systems, a profile of the patient's self-management goals and regimen, a listing and description of educational materials available at that clinic for the provider to give his/her patients, and "action items" with follow-up activities and timelines. The Care Plan is not automatically completed; rather, the designers intended that it be completed through discussion between the provider and the patient.

The CDMP can present aggregated data on a provider's, group's, or clinic's patient population. For example, the system can generate Diabetes Quality Improvement Project[15] statistics and other reports.

The CDMP is supposed to be flexible. Ranges for assessment and ranking of patient risks, for instance, can be defined according to an organization's needs and population. Care providers can activate or deactivate alerts and include or omit certain modules depending on the services available.

Usability testing

The guiding questions of the usability study design were: (1) What were the study participants' expectations and interpretation of the CDMP's functionality (conceptual model), and how did these compare with actual functionality? (2) Which parts of the CDMP were frustrating to study participants (navigation and information architecture)? (3) Which parts of the CDMP were confusing or easily misunderstood (content and terminology)? (4) How satisfied were the study participants with the CDMP, and how willing were they to use a system like this one in the future?

We conducted the usability testing in a Usability Lab. The Usability Lab is a controlled setting with a one-way mirror and recording equipment that make it possible to watch and audio- or videotape testing sessions unobtrusively. Each study participant received a brief, standardized introduction to the CDMP and training in the "think aloud" procedure so that observers could follow the participants' thought processes as they navigated the CDMP. We trained participants to think aloud by demonstrating the technique as if the test administrator were a test participant. Participants worked with a prototype of the CDMP for approximately 1.5 h, performing standardized, common tasks with a fictitious patient. The tasks were intended to represent what a provider might want to know and do with a new patient. Before beginning any session, we obtained written consent from each study participant using documents and processes reviewed and approved by several institutional review boards.

Participants

We sampled potential participants from the American Institutes for Research (AIR) (Concord, MA) database of over 3,000 individuals who have participated in usability tests over the past few years. A study representative called potential participants, described the study to them, and then screened interested potential participants for eligibility. Potential participants were eligible if they reported having at least some comfort with computers, even if

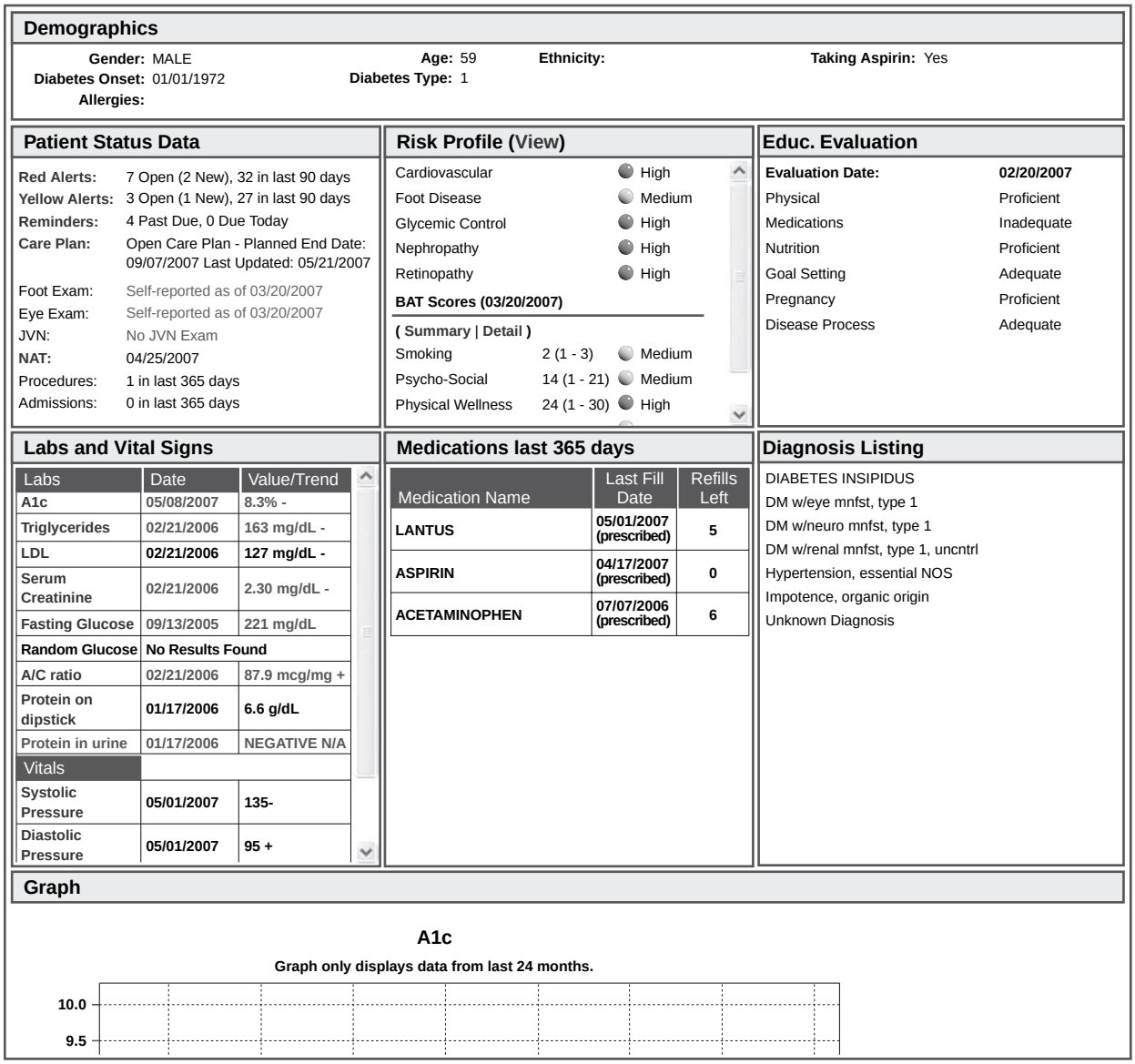

FIG. 1. Patient snapshot page with fictitious patient data. BAT, Behavior Assessment Tool; DM, diabetes mellitus; JVN, Joslin Vision Network; LDL, low-density lipoprotein; mnfst, manifestations; NAT, Nutrition Assessment Tool; NOS, unspecified or not otherwise stated.

they were still beginners, and were likely future users of the CDMP (i.e., health care providers, particularly nurse practitioners and care managers).

From the pool of potential participants, we enrolled six health care providers. Usability tests typically rely on small samples, as a small number is sufficient for determining the major usability issues and soliciting the full range of feedback.[16,17] If the testing sessions had uncovered new information each time, we would have continued to enroll participants until we attained saturation.

Measures

To address the four objectives of the usability study, the usability test collected observational, survey, and interview data. Table 1 shows the correspondence between the guiding questions of the usability test and the type of data collected.

Table 1. Sources of Data Used to Answer Research Questions

Research question	*Data sources*
1. To what extent will users develop an accurate conceptual model of the CDMP?	• Observational data • Subjective responses to interview questions
2. Are the CDMP navigation and information architecture easy to use and understand?	• Observational data • Subjective responses to interview questions • Responses to usability survey (section on ease of use)
3. Is the content/terminology easy to comprehend?	• Observational data • Subjective responses to interview questions • Responses to usability survey (sections on content and support features)
4. Do users report satisfaction with the CDMP? Do they report an interest in using a technology like the CDMP in the future?	• Observational data • Subjective responses to interview questions • Responses to usability survey (sections on visual appeal and performance)

While participants used the CDMP, we collected observational data by recording participants' mouse movements, observing the paths they used to complete each of the study tasks, noting verbalizations made by participants throughout the sessions, and recording errors and other key incidents such as when participants made the same types of errors repeatedly across tasks. We allowed participants to complete each of the study tasks without interruption so that we could observe participants' tendencies and decision-making processes.

The interview data addresses participants' overall impressions of the CDMP and what they liked or disliked about it. It also addresses specifics such as the pages that the participants found most helpful for familiarizing themselves with the fictitious patient, how intuitive the participants found the CDMP's graphing features, whether the CDMP's drop-down menus contained all expected choices, and whether the participants wanted additional reports.

Survey data were collected using a questionnaire developed by AIR called the Usability Score (patent pending). The AIR Usability Score is internally validated and used as standard practice in AIR's usability evaluations. It has 25 Likert-scale questions covering visual appeal (e.g., application was appealing, application was designed with the user in mind), content (e.g., page layouts were logical, information was complete), ease of use (e.g., options were clear at every stage, the steps required to complete a task were in logical order), performance (e.g., the system responded quickly and worked properly), and support features (e.g., the application gave an appropriate amount of feedback and the error messages gave instructions on how to recover). Responses range from "strongly disagree" (scored as 1) to "strongly agree" (scored as 5). Higher scores indicated the participant had a more favorable impression of the technology's usability.

Analyses

For the observational and interview data, we reviewed the paths and verbalizations (from the "think aloud" process) for each participant to look for trends. When two or more participants made similar errors or verbalizations about a specific issue, we flagged the issue as a potential usability problem. Here we report only those problems and strengths that were identified by two or more participants. For the survey data, we computed means and standard deviations (SDs) for each of the subscales as well as the total scale scores. We computed the means and SDs for descriptive purposes only; the small sample size did not permit a statistical analysis of the Usability Score data.

RESULTS

Table 2 shows characteristics of the six study participants. Five were nurses, of whom three were diabetes educators working exclusively

Table 2. Characteristics of the Study Participants

Profession	*Employment setting*	*Percent of patients with diabetes*
R.N.	Home health care nurse	10%
R.N.	Urban hospital	40%
R.N., Diabetes Educator	Urban hospital	100%
M.D.	Urban hospital	90%
R.N., Diabetes Educator	Urban outpatient clinic	100%
N.P., Diabetes Educator	Urban hospital	100%

with people with diabetes. The two remaining nurses, a home health nurse and a nurse in an urban hospital, worked with diabetes patients about 10% and 40% of the time, respectively. The final participant was a physician who predominantly saw patients with diabetes.

Table 3 presents means and SDs for the subdomains of the AIR Usability Score. On average, the participants' responses were neutral to favorable (mean total score = 3.65; SD = 0.86). Participants gave slightly higher scores on average to questions about visual appeal (mean = 3.87; SD = 0.73) and content (mean = 3.87; SD = 0.78) than to questions about ease of use (mean = 3.50; SD = 0.82), performance (mean = 3.50; SD = 0.94) and support features (mean = 3.50; SD = 0.97).

Conceptual model

Participants wanted and expected the ability to customize the CDMP for their own use. For example, one participant said, "I use a different target for HDL [high-density lipoprotein]. I would want to be able to change these targets for my patients." Another said, "I want to be able to use templates." And another said, "Will the hospitals get to customize it?"

Participants' expectations about what the application could do were not always congruent with the application's functionality. For instance, participants expected to be able to order labs from within the system, rather than having to use a separate system for ordering labs. Some comments were: "I'm assuming I can order the labs from somewhere in here"; "It would be nice if the system could recognize seasonal issues, like reminding patients to get flu shots in the late fall"; "I'm guessing it's saving my work as I go along"; and "I'm looking for a way to sign this order. If I ordered it, it should ask you to OK the lab and then generate a letter."

Navigation and information architecture

Participants found it easy to read and understand the patient-specific clinical pages, such as the "Snapshot" Page. One participant said, "I like this page." Another participant said, "This is a good summary." Other sections of the CDMP were more challenging for participants to navigate successfully without some hesitation. Some comments were: "I'm not sure how to get back from another page"; "What am I under?"; and "I had to play around to find stuff." The page names noted on the navigation bar were not helpful to participants.

Table 3. Means and Standard Deviations from the "Usability Score"

Participant	*Appeal*	*Content*	*Ease of Use*	*Performance*	*Support*	*Total*
1	4.20 (0.84)	3.80 (0.84)	3.60 (0.55)	3.60 (0.55)	4.00 (0.00)	3.84 (0.62)
2	4.60 (0.55)	4.40 (0.89)	3.80 (0.45)	3.20 (0.84)	3.00 (1.00)	3.80 (0.96)
3	3.60 (0.55)	3.80 (1.10)	4.40 (0.55)	3.80 (1.30)	4.60 (0.55)	4.04 (0.89)
4	3.40 (0.55)	3.40 (0.55)	3.20 (0.84)	3.20 (0.84)	3.20 (0.45)	3.28 (0.61)
5	3.40 (0.55)	3.80 (0.45)	2.80 (0.84)	3.20 (0.84)	2.80 (1.30)	3.20 (0.87)
6	4.00 (0.71)	4.00 (0.71)	3.20 (0.84)	4.00 (1.22)	3.40 (0.89)	3.72 (0.89)
Total	3.87 (0.73)	3.87 (0.78)	3.50 (0.82)	3.50 (0.94)	3.50 (0.97)	3.65 (0.86)

SDs are shown in parentheses.

Participants wanted lists presented differently. For example, regarding the list of the fictitious patient's diagnoses, one person said, "I want the diabetes-related diagnoses first." Another said, "Why do I have to search through this whole list? I wouldn't do it. I don't have time." The same comment applied to the medications list.

Content and terminology

Participants did not quickly grasp all content and terminology: "I don't know what these mean. What's a '1' on this scale? It should be spelled out." "Why is green an alert?" Lastly, "Will 'close' close the window? I don't know what it means to close an alert."

Satisfaction

Participants reported being enthusiastic about the layout of the CDMP, the types of data available on its clinical pages, and the CDMP's ability to share up-to-date patient data online and securely among team members. One participant reported that she "loved the CDMP" and thought it was "visually beautiful." Another reported that the CDMP "seems like a wonderful program" and thought it would fill a "need that providers have." Several participants said the program was "easy to read." At least three participants said a strength of the CDMP was that an entire team could use it to share information about their patients. The participants who were nurses reported they could envision using the CDMP in their practices.

DISCUSSION

This article describes the methodology and results of a usability study of an Internet-based informatics application called the CDMP. A broader purpose of this article—beyond the questions addressed in the usability test—is to demonstrate to clinicians and technologists a process to follow for usability testing in their development endeavors. Although there have been studies related to the user interface design of other types of systems,[18–21] a usability study among patients using an Internet-based diabetes management program,[22] and considerable effort has been expended on developing applications to suit a variety of medical purposes, to our knowledge there are no other usability studies for a system with the purpose, functionality, and intended mode of application as the CDMP. This study can provide a model for others who are developing large-scale applications for disease management.

The usability study was informed by the principles of user-centered design (UCD). UCD is concerned with what users' expectations are for how something should work and what it should do, with how users interpret the clues that a particular device or technology provides about its functioning and content, and how users interpret feedback from the device or technology.[23] The focus of the usability study itself, then, was study participants' perspectives on the CDMP's conceptual model, navigation and information architecture, and content and terminology, as well as their overall satisfaction with the CDMP and likelihood of using a system like this one again. As user input is collected and analyzed, it leads to refinements of the system under design. Future input from people who use the refined CDMP, ideally next in "real" settings, will lead to further enhancements.

Regarding the results, the participants gave the CDMP neutral to favorable survey scores overall. For the survey subdomains, they scored the application's visual appeal and content higher than its ease of use and support features. From the observational data, the participants' conceptual model included the ability to customize functions and the expectation that certain functions could be performed within or by the application since they were listed as tasks for the provider. The participants generally found the navigation and information architecture of the CDMP easy to understand but sometimes had difficulty navigating among sections of the application. They wanted lists to reflect their intuition about ordering, such as diabetes-related diagnoses appearing at the top of a diagnoses list. The participants occasionally were confused by the CDMP's content and terminology, such as the meanings for "alerts" and "reminders" and of rating scales. The results overall confirm the need to conduct usability testing of Internet-based informatics applications, even those developed by experts in the content area and technologists.

Ultimately the purpose of usability testing is to make informed modifications to the technology. Modifications resulting from this study included: reorganization of lists per the participants' suggestions; adoption of standard user interface elements such as on/off radio buttons; changes in the navigation bar by regrouping and rewording items; the addition of help text to improve the support features of the application; the revision of training materials to make more explicit the CDMP's customizability; the revision of names for certain tasks and buttons (e.g., the "close" button for "alerts" is now called "done"); and the addition of information to explain terms, scales, and risk profiles. Several suggestions were postponed until feedback is available from providers who are managing patients within their own clinics using the application.

There are several limitations to this study. One is that we did not recruit providers who work in remote settings and/or in clinics that do not have electronic medical records. Providers in these settings may have different perspectives on how an Internet-based informatics tool for diabetes care management should work. For example, providers in remote settings might not find certain tasks and alerts within the application useful because of the limited availability of specialty services in their area, and providers in clinics without electronic medical records might desire an easier user interface for data entry into the CDMP. Another limitation is that studies with small samples often raise the question of whether all of the main issues were identified. Although no new issues emerged by the sixth participant and samples of about six people tend to be appropriate for usability testing,[16,17] there is still the possibility that a larger, more heterogeneous group might have uncovered new issues. Both limitations can be overcome by using the iterative testing procedure typical of UCD.

Future work will focus on the usability of the CDMP from the perspectives of people using it for patient care. This work will provide a foundation for future cost- and clinical effectiveness studies. Once usability is established, then effectiveness studies will not be confounded by problems with the application itself.

ACKNOWLEDGMENTS

This project was supported by a grant (DoD/USAMRAA; DAMD17-03-2-0062) from the Department of Defense to S.-E.B..

REFERENCES

1. Norris SL, Nichols PJ, Caspersen CJ, Glasgow RE, Engelgau MM, Jack L, Isham G, Synder SR, Carande-Kulis VG, Garfield S, Briss P, McCulloch D: The effectiveness of disease and case management for people with diabetes. Am J Prev Med 2002;22:15–38.
2. Meigs JB, Cagliero E, Dubey A, Murphy-Sheehy P, Gildesgame C, Chueh H, Barry MJ, Singer DE, Nathan DM: A controlled trial of web-based diabetes disease management: the MGH Diabetes Primary Care Improvement Project. Diabetes Care 2003;26:750–757.
3. McMahon GT, Gomes HE, Hickson Hohne S, Hu TM, Levine BA, Conlin PR: Web-based care management in patients with poorly controlled diabetes mellitus. Diabetes Care 2005;28:1624–1629.
4. Kwon HS, Cho JH, Kim HS, Song BR, Ko SH, Lee JM, Kim SR, Chang SA, Kim HS, Cha BY, Lee KW, Son HY, Lee JH, Lee WC, Yoon KH: Establishment of blood glucose monitoring system using the Internet. Diabetes Care 2004;27:478–483.
5. Shea S, Weinstock RS, Starren J, Teresi J, Palmas W, Field L, Morin P, Goland R, Izquierdo RE, Wolff LT, Ashraf M, Hilliman C, Silver S, Meyer S, Holmes D, Petkova E, Capps L, Lantigua RA: A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus. J Am Med Inform Assoc 2006;13:40–51.
6. Montori VM, Dinneen SF, Gorman CA, Zimmerman BR, Rizza RA, Bjornsen SS, Green EM, Bryant SC, Smith SA, Translation Project Investigator Group: The impact of planned care and a diabetes electronic management system on community-based diabetes care: the Mayo Health System Diabetes Translation Project. Diabetes Care 2002;25:1952–1957.
7. Aiello LM, Bursell SE, Cavallerano J, Gardner WK, Strong J: Joslin Vision Network Validation Study: Pilot image stabilization phase. J Am Optom Assoc 1998;69:699–710.
8. Bursell SE, Cavallerano JD, Cavallerano AA, Clermont AC, Birkmire-Peters D, Aiello LP, Aiello LM, Joslin Vision Network Research Team: Stereo nonmydriatic digital-video color retinal imaging compared with Early Treatment Diabetic Retinopathy Study seven standard field 35-mm stereo color photos for determining level of diabetic retinopathy. Ophthalmology 2001;108:572–585.
9. Cavallerano AA, Cavallerano JD, Katalinic P, Tolson AM, Aiello LP, Aiello LM: Use of Joslin Vision Network digital-video nonmydriatic retinal imaging to assess diabetic retinopathy in a clinical program. Retina 2003;23:215–223.

10. Chow SP, Aiello LM, Cavallerano JD, Katalinic P, Hock K, Tolson A, Kirby R, Bursell SE, Aiello LP: Comparison of nonmydriatic digital retinal imaging versus dilated ophthalmic examination for nondiabetic eye disease in persons with diabetes. Ophthalmology 2006;113:833–840.
11. Whited JD, Datta SK, Aiello LM, Aiello LP, Cavallerano JD, Conlin PR, Horton MB, Vigersky RA, Poropatich RK, Challa P, Darkins AW, Bursell SE: A modeled economic analysis of a digital teleophthalmology system as used by three federal healthcare agencies for detecting proliferative diabetic retinopathy. Telemed e-Health 2005;11:641–651.
12. Fonda SJ, Bursell SE, Lewis DG, Garren J, Hock K, Cavallerano J: The relationship of a diabetes telehealth eye care program to standard eye care and change in diabetes health outcomes. Telemed J E Health 2007 Dec 19 [Epub ahead of print].
13. National Institute of Diabetes and Digestive and Kidney Diseases: National Diabetes Statistics Fact Sheet: General Information and National Estimates on Diabetes in the United States, 2005. Bethesda, MD: National Institutes of Health, U.S. Department of Health and Human Services, 2005.
14. Rizza RA, Vigersky RA, Rodbard HW, Ladenson PW, Young WF Jr, Surks MI, Kahn R, Hogan PF: A model to determine workforce needs for endocrinologists in the United States until 2020. Diabetes Care 2003;26: 1545–1552.
15. Fleming BB, Greenfield S, Engelgau MM, Pogach LM, Clauser SB, Parrott MA: The Diabetes Quality Improvement Project: moving science into health policy to gain an edge on the diabetes epidemic. Diabetes Care 2001;24:1815–1820.
16. Dumas JS, Redish J: A Practical Guide to Usability Testing. Portland, OR: Intellect Books, 1999.
17. Virzi RA: Refining the test phase of usability evaluation: how many subjects is enough? Hum Factors 1992;34:457–468.
18. Carroll AE, Marrero DG, Downs SM: The HealthPia GlucoPack diabetes phone: a usability study. Diabetes Technol Ther 2007;9:158–164.
19. Chaikoolvatana A, Haddaw P: The development of a computer based learning (CBL) program in diabetes management. J Med Assoc Thai 2006;89:1742–1748.
20. Silvey GM, Macri JM, Lee PP, Lobach DF: Direct comparison of a tablet computer and a personal digital assistant for point-of-care documentation in eye care. AMIA Annu Symp Proc 2005;689–693.
21. Kushniruk AW, Patel VL: Cognitive and usability engineering methods for the evaluation of clinical information systems. J Biomed Inform 2004;37:56–76.
22. Kaufman DR, Pevzner J, Hilliman C, Weinstock RS, Teresi J, Shea S, Starren J: Redesigning a telehealth diabetes management program for a digital divide seniors population. Home Health Care Manag Pract 2006;18:223–234.
23. Norman DA: The Design of Everyday Things. New York: Basic Books, 2002.

Address reprint requests to:
Stephanie J. Fonda, Ph.D.
Joslin Diabetes Center
One Joslin Place
Boston, MA 02215

E-mail: fondasj@gmail.com

This article has been cited by:

1. 2008. Current literature in diabetes. *Diabetes/Metabolism Research and Reviews* **24**:6, i-x. [CrossRef]