Enhancing Support via Interactive Technologies

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Despite some improvements in diabetes treatment processes, outcomes for many patients remain inadequate. Interactive health technologies (IHTs) can address many of the challenges that diabetes patients and their health systems face, and research on IHT applications for diabetes care are intensifying. This article describes recent evidence regarding the feasibility and impact of 1) clinic-based CD-ROM systems supporting behavior change; 2) automated telephone diabetes management allowing for ongoing monitoring and patient education between face-to-face clinical encounters; and 3) Web-based systems focusing on a range of diabetes management goals such as enhanced emotional support for patients and improved clinician adherence to treatment guidelines. Studies in each of these areas have been somewhat encouraging. However, intervention effects have been moderate, and researchers face significant challenges in designing and implementing definitive studies.

Introduction

In a sobering commentary on the state of diabetes care in the United States, Harris [1] notes that health outcomes remain poor for many patients, despite some improvements in technical indicators of diabetes treatment quality (*eg*, frequency of hemoglobin A_{1c} [HbA_{1c}] tests and ophthalmology visits). The persistent disconnection between technical performance indicators and effective diabetes care reflects a number of barriers to comprehensive care management facing both patients and their providers.

Many patients with diabetes lack the support they need to identify productive behavioral goals and circumvent the many obstacles to a healthy lifestyle. Only a small minority of patients are able to use clinic-based diabetes education services; many need better information about their illness, strategies for avoiding complications, and the services available in their communities. Even the most well-intentioned patients have difficulty tracking their many self-care activities such as adhering to medications, attending frequent medical visits, and self-monitoring their blood glucose. Newly diagnosed patients or those who lack social support may benefit from frequent (*eg*, weekly) follow-up by clinicians and health educators, although this usually is impossible given constraints on staffing, space, and reimbursement within most health care systems. Patients frequently have problems or questions that go unaddressed during office visits, and many feel isolated or frustrated by the burden of their disease. Such patients might benefit from the exchange of information and emotional support available through diabetes mutual-help groups, although access to these groups often is difficult at best.

All of these diabetes management challenges are compounded by other inadequacies of most health care systems, which make it nearly impossible to deliver services according to treatment guidelines. For example, many health "systems" lack integrated clinical records; their providers must develop treatment plans in the absence of critical information about their patients' medical history and experience with behavior change goals. Although advances in diabetes treatment research are occurring at a rapid pace, new evidence-based practice recommendations are often poorly disseminated. Thus, clinicians may be uninformed regarding optimal treatment strategies, especially when diabetes patients comprise a small proportion of their overall panel. Given increasing constraints on the time allotted to outpatient visits, comprehensive behavioral evaluations and patients' own treatment agenda typically are pushed aside in the interest of addressing their primary reason for seeking care. Most clinics have no on-site staff with expertise in diabetes education or behavior change techniques, and very few health systems have the technologic infrastructure allowing for easy provider-patient communication between face-to-face encounters.

Advances in information health technology (IHT) are designed to address these challenges, and a variety of IHTs have been studied in the context of diabetes care. This article describes some of the most important research in this area published during 2000 and 2001. Specifically, the review focuses on three types of IHTs for which there are recent findings from randomized trials: clinic-based CD-ROM systems, automated telephone disease management (ATDM), and Internet-based diabetes management supports. More general reviews of IHTs are provided by Balas *et al.* [2] and Krishna *et al.* [3]. Conceptual discussions of the role of IHTs in behavioral medicine are also available [4–8].

Clinic-based CD-ROM Systems

CD-ROM-based interventions have been explored as a novel strategy for delivering behavior change interventions efficiently and effectively in the context of busy primary care practices. These systems can be placed in clinic waiting rooms where they can reach large numbers of patients, require minimal staffing, and provide patients with self-paced and tailored educational messages. CD-ROM health education programs could also be used in other locations such as patients' homes, although such systems have not been rigorously evaluated. In contrast to standard paper-based educational material, CD-ROM-based systems can use audio and video to convey concepts and discuss treatment options more effectively. Feasibility testing of such systems consistently indicates that they are well received by patients [9]. However, rigorous studies evaluating impacts on treatment outcomes have been rare.

Glasgow *et al.* [10] have conducted a series of studies in which they developed and evaluated CD-ROM diabetes care supports designed to 1) assess patients' status with regard to health behaviors and self-care; 2) assist them in identifying behavior change goals and potential barriers to goal attainment; and 3) facilitate more effective communication about these issues between patients and clinicians. In a study targeting dietary behaviors and other cardiovascular risk factors these researchers developed a touch-screen computer CD-ROM system and located it in clinic waiting rooms for use by patients prior to scheduled outpatient visits. Following a tailored behavioral assessment, patients selected a specific self-management goal and identified their most prominent barriers to attaining that goal. Providers received tailored reports summarizing this information, which they used to negotiate treatment plans during the patient's visit. After the visit, patients met briefly with a health educator to review behavioral goals and collaboratively develop barrier-based intervention strategies. This sequence was repeated at a 3-month follow-up visit, and intervention patients received two monthly follow-up telephone calls between the visits to monitor their progress and support their efforts.

Compared to a stringent, randomized control condition in which patients received the same computerized assessment (but no tailored feedback) and unstructured physician encouragement, the active intervention improved outcomes for a variety of dietary behavior measures as well as serum cholesterol levels. Reductions in serum cholesterol were observed at the 3-month follow-up and maintained at 12 months (adjusted difference of 16 mg/dL) [11]. On average, the annual incremental cost of the intervention was $115 to $139 per patient and $8.40 per unit reduction in serum cholesterol. There was no intervention effect on HbA_{1c} levels.

In a recent follow-up study, these investigators evaluated a similar intervention and tested the incremental benefit of two types of long-term maintenance support: follow-up phone calls and enhanced support for accessing community resources [12••]. All groups received the CD-ROM clinic-based intervention and improved with regard to several measures of their dietary behavior, use of resources, self-efficacy, and lipid levels. Six-month changes were consistently as large as those observed at 3 months. Neither of the maintenance conditions demonstrated additional benefits over and above that provided by the baseline intervention. Recent data demonstrate that improvements were maintained at 12 months, with evidence that the telephone follow-up had some marginal impact [13].

Automated Telephone Disease Management in Diabetes Care

Automated telephonic systems have been studied for a number of years as a potential adjunct to nurse follow-up calls and face-to-face encounters with providers. A variety of chronically ill patients (including those with mental health and substance abuse disorders) can provide valid and reliable information using their touch-tone telephone or voice recognition technology during automated monitoring calls [14•]. One particular advantage of these systems is that they allow for frequent follow-up with patients who have difficulty accessing clinic-based services or who lack the computer supports necessary for many other IHTs.

Piette [15] evaluated ATDM with follow-up by a diabetes nurse educator as a strategy for improving diabetes treatment outcomes among patients recruited from a public health care system. The study found that patients reported health and behavioral information using automated calls consistently over the 12-month study period [16,17]. It also found that many patients used such calls to access self-care education, and that the information they reported could be used to identify individuals at greatest risk for developing problems [18]. Outcomes measured at 12 months indicated that the intervention improved patients' self-care in the areas of blood glucose self-monitoring, foot care, weight self-monitoring, and medication adherence [19]. The study also found decreases in HbA_{1c} levels, serum glucose levels, and diabetes-related symptoms associated with the intervention. Moreover, patients receiving the intervention were more satisfied with their health care than control patients, had greater confidence in their ability to perform self-care activities, and reported fewer symptoms of depression [20]. In a recently published study, the investigators replicated the prior trial in a Department of Veterans Affairs Healthcare System [21••]. Intervention effects on most end points supported the findings of the prior research. However, intervention-control differences were smaller because of the relatively good self-care and health status among participants at baseline.

Internet-based Supports for Patients and Clinicians

How might Internet-based supports be helpful?

Studies among people with diabetes indicate that even computer novices are willing to use Internet-based diabetes education programs [22]. Like clinic-based CD-ROM systems, Internet-based diabetes self-care support can reach large numbers of patients with little marginal cost to them or third-party payers (Table 1). Such systems can also enhance the educational experience by using audio and video to get

Table 1. Advantages and disadvantages of three IHTs in support of diabetes care

Advantages/disadvantages	CD-ROM systems	ATDM	Internet-based supports
Reaches large numbers of patients with relatively little staffing increase	Yes	Yes	Yes
Audio and video enhance the communication experience	Yes	No	Yes
Self-paced and tailored learning	Yes	Yes	Yes
Rapid updates once distributed	No	Yes	Yes
Usually can be delivered without specialized technical assistance	Yes	No	Yes
Usually link to electronic medical record systems	No	No	Yes
Accessible from multiple locations	No	Yes	Yes
Can facilitate patient-patient and clinician-patient communication between face-to-face encounters	No	Yes	Yes
Requires patients to access a computer	Yes	No	Yes
Research evidence for feasibility	Yes	Yes	Yes
Research evidence for effects on treatment outcomes	Yes	Yes	No

ATDM—automated telephone disease management; IHTs—interactive health technologies.

their messages across. As with ATDM systems, an Internet-based approach is potentially available 24 hours per day. However, unlike both clinic-based CD-ROM systems and ATDM, the Internet can allow for rapid dissemination of new information and (perhaps most importantly) real-time and asynchronous communication between patients as well as between patients and clinicians.

How feasible are Internet-based diabetes supports?

McKay *et al.* [23] established that diabetes patients will use Internet support services. Individuals who participate in Internet-based diabetes self-management programs are similar to nonparticipants in gender, insulin use, and computer familiarity, although users tend to be somewhat younger and diagnosed more recently [22]. Other investigators have found that diabetes-related health risk assessments are also feasible via the Internet and can identify large numbers of at-risk individuals for brief counseling or other behavior change techniques [24].

In a recent study conducted at the Joslin Diabetes Center, Boston, MA, investigators developed a series of chat rooms allowing diabetes patients and their families to interact with each other and with diabetes professionals [25]. The goal of the chat rooms was to motivate patients who felt isolated, "burned-out," or otherwise mentally unable to continue with their self-care. Analysis of user profiles indicated that participants were sociodemographically diverse, older, and more likely to be women than the typical Internet user. Half of all participants used insulin, and 23% had diabetes for at least 15 years. Process evaluation of the topics discussed in the chat rooms showed that, despite their emotional focus, half of all postings related to concrete self-management issues. Forty-two percent of all postings were related to advice for dietary planning, carbohydrates, and other food concerns whereas emotional support accounted for only 18% of the messages.

Impact of patient-focused Internet interventions

The most definitive controlled trials of Internet-based diabetes support to date have been conducted by McKay *et al.* [26••] at the Oregon Research Institute, Eugene, OR. In one recent study, sedentary adults with type 2 diabetes were recruited via e-mail posting to diabetes UseNet groups, listservs, and websites, and were randomized either to an Internet information-only condition or to the active condition consisting of the "D-Net Active Lives" website. Active Lives participants were assessed on-line for their physical activity behaviors and led through a process in which they identified the personal benefits of behavior change, selected goals, scheduled activities, and identified potential barriers to completing the plan. Intervention participants were encouraged to log onto the website weekly to review their plan and access other services such as an on-line log of their progress and personal counseling and support. Over the 8-week period, individuals received biweekly tailored messages from their personal coach (an occupational therapist) who reviewed their progress and provided emotional support. Participants also had the ability to communicate with other members in the intervention group via a chat area. Individuals assigned to the information-only condition were able to access diabetes-specific articles in the website's library as well as real-time blood glucose tracking with graphic feedback.

Seventy-eight individuals from 31 states and provinces in the United States and Canada met eligibility criteria and were randomized into the study. At follow-up, both intervention and control groups improved in their self-reported physical activity; however, there were no discernable intervention-control differences. Data on patients' use of the site showed a rapid decrease over the 8 weeks of the study. Intervention patients who used the system on at least three occasions reported greater change in moderate-to-vigorous physical activity than those who used it less often. In a follow-up study, investigators evaluated the separate and combined effects of Internet-based diabetes self-management and peer support among 320 diabetes patients recruited from primary care practices. Three-month and 6-month outcomes suggest improvements in all study arms, but little evidence for significant effects associated with either the personalized self-management coach or the peer support conditions (McKay, Personal communication).

Table 2. Challenges to advances in research on diabetes IHTs

Patients and providers can become desensitized to IHT messages. Maintaining their interest and behavior changes is difficult.
Improvements in care processes (*eg*, visit scheduling and hemoglobin A_{1c} testing) among "usual care" patients participating in the study can be a potent intervention in their own right and make it difficult to discern intervention effects.
Little is known about the characteristics of IHTs that patients will find most useful or desirable. As a result, interventions can "miss the mark" by focusing on issues that fail to engage study participants.
Diabetes treatment outcomes in many health systems have improved making it difficult to show intervention effects without screening patients for baseline risk and/or accruing large samples.
Technologic innovations continue to be developed and disseminated rapidly. As a result, "usual care" in many studies remains a moving target.
Both IHTs and their evaluation can be costly and require researchers to devote a substantial amount of time developing applications, enrolling appropriate patients, and partnering with IHT vendors and technical support staff.

IHTs—interactive health technologies.

Impact of provider-focused Internet interventions

Internet-based systems have also been studied as a means of promoting clinician adherence to diabetes treatment guidelines. In one recent nonrandomized study, investigators developed a Web-based diabetes care management system featuring reminders regarding practice guidelines, patient registries, and performance reports. The intervention was implemented with 13,325 managed care diabetes patients aligned with 190 primary care providers [27•]. Investigators found that providers who accessed the system more frequently were more adherent to guidelines regarding the frequency of lipid screening and retinal examinations. In a second recently published nonrandomized study, investigators examined whether an IHT-based comprehensive diabetes management system, including a care manager, ongoing patient education, and supports for improvement in primary care quality, was associated with improved outcomes 1 year later [28•]. Ongoing follow-up included in-clinic patient education sessions, ongoing feedback to primary care providers regarding needed services, and nurse telephone calls. At 12 months, the study showed improvements in patients' physiologic status (glycemic control, lipids, and blood pressure) as well as in the quality of their diabetes care (foot examinations, retinal examinations, and lipid screening).

Challenges to Research on Interactive Technologies

Long-term maintenance of behavior changes

One of the most difficult challenges facing behavioral intervention studies is maintaining behavior changes over extended periods of time (Table 2). This problem is one that researchers have faced for years, particularly when attempting to modify long-standing lifestyle behaviors such as physical activity, nutrition, and smoking. Behavioral psychologists have asserted that this occurs because the activities and skills required for the maintenance phase of behavior change differ from those in the initial phase, and therefore require a new set of intervention strategies to prevent relapse [29,30]. Unfortunately, IHT studies are also susceptible to this problem as evidenced by the drop-off in Internet use among participants in the study by McKay *et al.* [26••]. Providers also are susceptible to relapsing into undesirable habits. In a multisite study of physician reminders, Demakis *et al.* [31•] demonstrated that clinicians can become desensitized to the impact of computer-based messages and return to baseline behavior levels after initial behavior changes. In the context of these findings, Glasgow and Toobert's [12••] attempt to evaluate two potential maintenance interventions is particularly important, even though neither was found to be very effective. Thus, research is badly needed on how to make IHT interventions more attractive to users and how to vary the presentation of information in order to maintain participants' interest without changing the underlying message.

Intervention effects compared to what?

One important challenge for IHT diabetes management studies is that the regimented schedules imposed as part of the research design often lead to improvements in the control group that obscure potential benefits of the intervention being studied (Table 2). Investigators have examined ongoing support for scheduling, confirming, and documenting medical follow-ups (typically received by both intervention and "usual care" patients in many IHT trials) as an intervention in its own right. Laffel *et al.* [32] found that diabetes patients receiving this scheduling support over 24 months experienced substantial benefits, including more frequent visits, improved glycemic control, and lower rates of severe hypoglycemia. In reality, most IHT studies compare an "enhanced" intervention to this type of minimal (although potentially very potent) management support and often are underpowered to observe an intervention effect over and above this comparison group level. This problem may have impacted studies cited in this review [12••,26••] and has foiled evaluators of novel diabetes technologies for some time [33]. Future methodologic research should explore greater use of passive sources of clinical trial data (*eg*, electronic medical records) and ways to incorporate comparison group "intervention effects" into sample size estimates.

Opening the black box

As described earlier, Zrebiec and Jacobson [25] developed a series of diabetes chat rooms to address patients' need for

emotional support and found that most patients preferred to use them for accessing information about nutrition and diet. This study illustrates our continuing lack of understanding with regard to how patients will use IHTs and what impact that use can have on their knowledge, attitudes, and behaviors. Recently, investigators have begun to "deconstruct" patient-based Internet interventions so as to identify the specific mechanisms through which they may be effective, and whether there are clinically important subpopulations for which they may be particularly helpful. In one such study, investigators randomized novice Internet users to four conditions, receiving 1) diabetes information only; 2) a personal self-management coach; 3) a social support intervention; and 4) both a personal coach and support [34]. After 3 months, they found that participants receiving the social support intervention perceived that they were receiving more diabetes-specific as well as general support. This was true whether or not patients received additional support by the personal coach. The mechanisms linking social support to changes in health outcomes have been well documented [35,36], and the results of this study are important because they demonstrate that diabetes support is amenable to change via the Internet. More "basic science" such as the studies by Zrebiec and Jacobson [25] and Barrera *et al.* [34] would allow interventionists to develop more potent IHT-based services.

Identifying changes in the context of secular trends

Key performance indicators for diabetes care have improved over recent years in many health care systems. Although this is unquestionably a positive development for patients, it poses particular challenges for research on novel IHT-based interventions. For example, mean HbA_{1c} levels in many systems of care have decreased, and it can be difficult to improve on this baseline. In our own study of Veterans Affairs patients, we found that baseline HbA_{1c} levels were unexpectedly good (mean = 8.5%) and showed no overall intervention effect as a result, despite a 1.1% improvement in HbA_{1c} among patients with baseline values greater than 9% [21••]. Glasgow and Toobert [12••] faced a similar challenge (baseline mean HbA_{1c} = 7.5%). Thus, researchers as well as clinicians must be increasingly creative with regard to identifying important, measurable, and proximal outcomes of their interventions.

Cost challenges in technology-based research

Limiting study eligibility to patients with problems on a given health indicator such as HbA_{1c} can address the problem just described. However, such restrictions decrease the pool of potential enrollees and can increase the time and effort required to achieve sufficient statistical power. Moreover, the development of technology-based interventions can be extremely expensive and time-consuming. Such interventions frequently require that researchers partner with outside technology firms and/or information resources personnel within their health care system. Each of these groups faces competing demands and incentives that can differ substantially from the researchers, and managing the relationship can itself become costly.

Conclusions

Interest in IHT-based solutions to diabetes management problems remains intense. Research over recent years has focused on the use of clinic-based CD-ROM systems, ATDM, and the Internet, both for supporting patients and promoting guideline-recommended clinician services. Each of these interventions poses unique advantages and disadvantages. Ultimately, a complementary approach in which multiple technologies are used simultaneously will be the most effective way to incorporate them into diabetes care. Feasibility studies and process evaluations indicate that people with diabetes will use a variety of IHTs appropriately and report that they are satisfied with the experience. Although sociodemographic barriers to technology use remain a concern, studies demonstrate that a wide range of patients, including technology novices, the elderly, and less educated patients, are willing to participate in technology-based diabetes management studies.

A growing body of research suggests that IHTs can improve the quality of diabetes care by addressing several of the major challenges facing both patients and providers. Studies cited here represent some of the most rigorous evaluations and indicate that clinic-based CD-ROM systems can be valuable and improve some of the most difficult-to-change health outcomes such as cholesterol levels. ATDM systems have been studied most extensively; recent clinical trials indicate that these systems can also improve the process and outcomes of diabetes care. Feasibility data on the use of Internet-based services suggests that they are well received by a range of patients. Despite ongoing concerns about these systems' ability to reach sociodemographically vulnerable individuals, many of these patients are comfortable and willing to use services such as Web-based chat rooms. Studies of the impact of Internet supports are less common. Those conducted thus far suggest that these systems improve patients' perceptions of diabetes-specific and general support but may not impact their health behavior or physiologic outcomes.

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