Interactive Media for Diabetes Self-Management: Issues in Maximizing Public Health Impact

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Background**. Diabetes self-management presents a series of challenging tasks, and primary care, where the majority of cases of adult diabetes are treated, is hard-pressed to address these issues given competing demands. This article discusses how interactive media (IM) can be used to support diabetes self-management. **Methods**. Following a brief review of the literature, the 5 As framework for enhancing the effectiveness of health behavior counseling and the RE-AIM model for estimating and enhancing public health impact are used to frame discussion of the strengths and limitations of IM for diabetes shared decision making and self-management support. **Results**. Data and lessons learned from a series of randomized trials of IM for diabetes self-management education are summarized around 2 key issues. The first is enhancing patient engagement in decision making and includes enhancing user experience and engagement, improving quality of care, and promoting collaborative action planning and follow-up. The second is getting such resources into place and sustaining them in real-world primary care settings and involves enhancing participation at patient, clinician, and health care system levels and enhancing the generalizability of results. **Conclusions**. Key opportunities for IM to support diabetes self-management include assessment of information for shared decision making, assistance with problem-solving self-management challenges, and provision of follow-up support. A key current challenge is the linkage of IM supports to the rest of the patient's care, and collection of cost-effectiveness data is a key need for future research. **Key words:** diabetes; self-management; interactive media; computer; shared decision making; patient-centered care; 5 As; RE-AIM. **(Med Decis Making 2010;30:745–758)

This article discusses the literature on and lessons learned from the use of interactive media (IM) to support diabetes self-management. To provide context and understand why IM might be helpful, it is first necessary to summarize the considerable challenges faced by persons with diabetes. Diabetes is prevalent, serious, and costly both for individuals and society.[1,2] Well-controlled, multisite studies have convincingly demonstrated that diabetes can be prevented[3] and, once diagnosed, can be effectively managed to reduce complications.[4,5] Achieving these results, however, involves adherence to several challenging diabetes self-management tasks.

These regimen tasks include both lifestyle and medical care activities that must be performed from one to several times a day, including medication taking, blood glucose monitoring, healthy eating, foot care, and physical activity. Although some of these ongoing self-management decisions, such as food choices, might not be considered "medical decisions," they do directly affect a person's diabetes control and health. Moreover, these behaviors, which are complex themselves, affect each other and need to be adjusted for events such as illness, travel, and schedule disruptions. Possibly most challenging, these actions need to be performed 7 days a week for the rest of one's life.[6] In contrast to classic

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areas of medical decision making, diabetes self-management (DSM) decisions need to be made almost continuously. Attempting to cope with these regimen demands as well as functional limitations and the stress of everyday life can result in high levels of emotional distress and sometimes depression.[7] In addition to these daily DSM behaviors, preventive care activities such as lipid, blood pressure, and hemoglobin A_{1C} assays, as well as eye exams, need to be performed from 1 to several times a year.

Contextual factors also contribute to self-management challenges. Type 2 diabetes is more prevalent among racial and ethnic minority groups, especially Native Americans, African Americans, and Latinos.[8] It occurs more often among older persons; 23% of adults older than age 60 have diabetes,[1] and those who are overweight are much more likely to develop diabetes. These factors can exacerbate diabetes challenges because often these same individuals have fewer social economic resources and live in neighborhoods that are characterized by substantial barriers to healthy eating and regular exercise. A final, major contextual factor is comorbidity. Many adults with diabetes also have other chronic illnesses in addition to diabetes, and those conditions have their own self-care demands, which can either be congruent or conflict with diabetes management.[9]

Given the above challenges, patients and clinicians must work together to collaboratively set goals, make decisions, and develop action plans that are feasible, address metabolic needs, and are sensitive to patients' personal and cultural context. IM can help to structure and facilitate this process as well as provide patients with additional information, follow-up support, and resources.[10]

For background, I summarize the recent literature on use of the IM for diabetes self-management education (DSME) for adults. This brief review describes the type of IM interactions, study designs, and outcomes produced to date. I did not include programs that target only health care providers or technologies focused solely on blood glucose monitoring/adjusting medication based on blood glucose readings. Such programs are reviewed by Balas and others.[11]

There have been more than 20 randomized controlled trials of IM-based DSME. Most studies have focused on primary care, and many have targeted challenged or high-risk populations, including samples with low health literacy, who were not prior Internet users and were low income or medically underserved.[12] Newer studies have included sample sizes exceeding 300 patients and a variety of interactive technologies, including Internet, CD-ROM, DVD, interactive voice response (IVR) phone calls, secure e-mail messaging, telemonitoring, and touch-screen computers. All of these modalities are considered IM and collectively will be referred to as examples of IM. Many of these evaluations include a variety of target behaviors and outcomes. Boren and others[13] found that the 19 randomized controlled trials (RCTs) they reviewed targeted an average of 4.1 educational areas.

The results of these controlled studies have been mixed but generally positive. Boren and others[13] found that significant improvements were most likely on measures of learning/knowledge (60% of tests were significant), followed by measures of behavior change (53% significant), clinical outcomes (38% significant), and finally health status (22% significant). The magnitude of effects observed has generally been moderate. However, as Welch and Shayne[12] point out, part of the reason that effects have not been larger is that comparison conditions in these RCTs have often involved some level of interactive DSME rather than just usual care. Examples of such comparison conditions include minimal or moderate-intensity IM interventions compared to more intensive DSME and "enhanced usual care" that includes time materials and follow-up levels not usually part of usual care.

There are 3 key issues in evaluating the literature of interactive DSME programs. 1) *Who participates*? Recent reports on the "digital divide" have shown that although gaps still exist in Internet access between poorer, minority older adults and more affluent younger adults, these gaps are decreasing substantially. Interactive DSME programs have been designed for and shown to reach low-literacy, low-income, and older adult populations as well as those without prior Internet experience. At present, IVR automated telephone call systems are probably the best approach for reaching broad and diverse populations. Piette and colleagues[14,15] have conducted several IVR studies and shown IVR to reach and be effective for low-income Veterans Administration (VA) and county hospital populations.

The studies by Piette and others[14,15] bring up the second key issue: 2) *How much interpersonal contact is needed?* Although some studies have been successful with little or no staff contact, most of the more effective programs have involved moderate levels of human support. For example, in the IVR studies by Piette and others, automated records were reviewed by nurses who called participants having problematic blood glucose results. A controlled study by Tate and others[16] demonstrated that adding

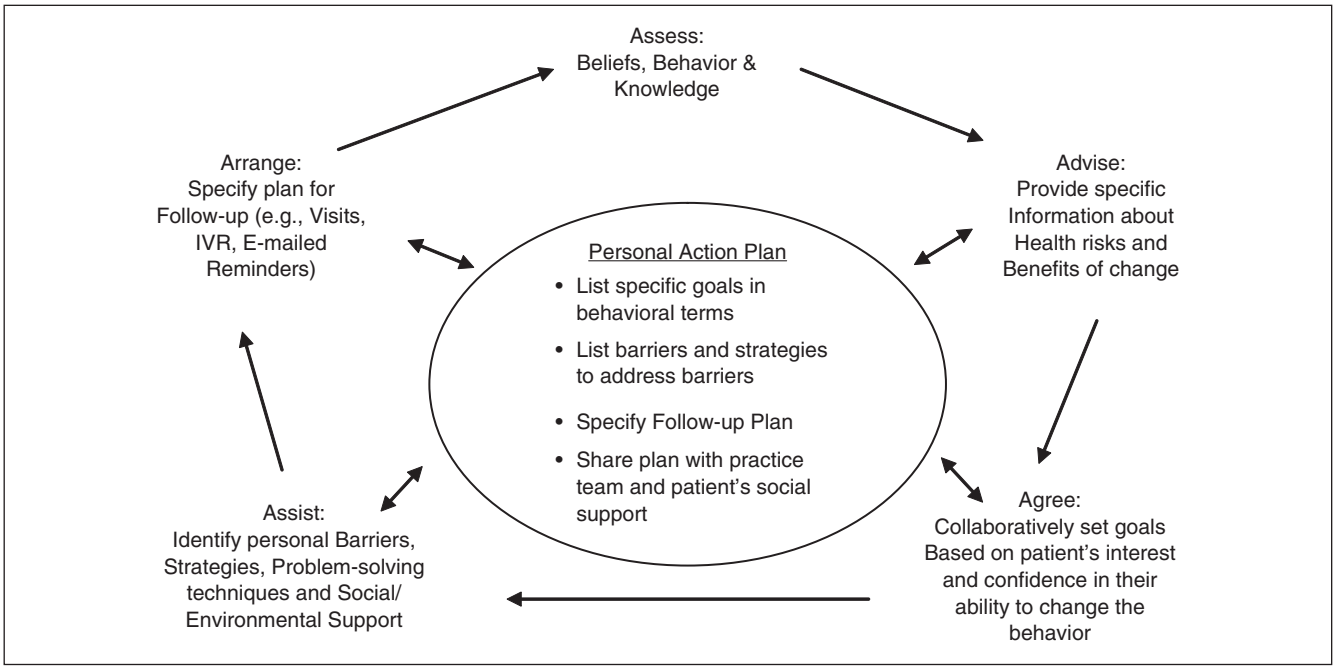


Figure 1 Five As self-management model: a guide for making decisions about self-management plans.

e-mail counseling support significantly enhanced weight loss compared to Internet alone.

The third key issue concerns 3) the *maintenance and generalizability of intervention effects*. Given the recency of most of the research on interactive DSME, it is not surprising that there are few reports of long-term follow-up or of effectiveness across different settings and outcomes. Future research should also investigate the comparative effectiveness of diabetes-specific IM v. more general chronic disease self-management programs such as those developed by Lorig and others.[17]

ENHANCING EFFECTIVENESS THROUGH COLLABORATIVE DECISION MAKING

Despite the challenges above, DSME approaches have been found to be effective.[18,19] Our IM research group has adopted a patient-centered care model recommended by the US Preventive Services Task Force known as the 5 As that summarizes evidence-based health counseling behaviors.[20,21] This conceptual model includes a sequence of activities that have been found to aid self-management for both diabetes and other chronic illnesses. As illustrated in Figure 1, these actions are summarized as "ask-advise-agree-assist-arrange." The 5 As model is patient centered because it emphasizes consideration of patient values, history, situation, and preferences throughout each of the 5 activities.

Assessment of the patient's current self-management behaviors is the first step in the 5 As sequence. The challenge for busy health care settings is how to conduct such assessments in an efficient way that does not require additional staff time. IM can help by having patients complete assessments online prior to or at the beginning of a visit via kiosk, touchscreen computer, or other hardware device. Assessment results can then be immediately scored and summarized for the next step, *advise*. Advice involves providing personalized feedback to patients on their risk and recommended health behavior change(s). This feedback and associated recommendations should be tailored to an individual's health status and family history, as well as his or her level of health literacy and numeracy, health beliefs, values, and preferences. When such information is available, IM can deliver highly tailored messages.

Advice should begin the process of the patient and provider *agreeing* on collaboratively set self-management goals. Ensuring that the patient is the primary decision maker in establishing such goals is often challenging,[22] especially for providers with many competing demands and who have been trained to give directive, authoritative advice. IM can keep patients engaged in establishing self-management goals through providing choices and

checking on self-efficacy levels throughout the decision-making process.[23]

The final 2 steps of the 5 As are essential but are usually performed less often than the other As.[24] *Assisting* patients with the development and implementation of problem-solving strategies to achieve their self-management goals is the most complex of the 5 As, and some have argued that it is beyond the scope of most primary care offices and should be referred to behavior change experts or disease management staff.[25] IM approaches to assisting patients have generally had users generate a list of barriers to each self-management goal and then select or develop tailored strategies in the form of an action plan.

Arranging for follow-up, the final "A," is conceptually much simpler but not often conducted.[24] A variety of IM modalities can be used to conduct follow-up contacts, including e-mail, websites, text messaging, social media, and automated IVR programs.

In summary, the 5 As conceptual model provides a useful, evidence-based series of patient-centered activities to support shared decision making and successful health behavior change. Our research group has used IM to facilitate or accomplish each of the steps in Figure 1. Next, I summarize our IM research related to 3 issues central to shared decision making in diabetes: 1) IM design and content to engage users and promote collaborative goal setting, 2) helping clinicians and patients to make action plans, and 3) providing follow-up support.

In conjunction with our multimedia partner, Intervision Media, we have developed a number of interactive DSME programs. Table 1 lists 8 randomized trials we have conducted, the DSME behaviors targeted, and the IM modalities involved. These programs have employed a variety of IM, including touchscreen computers, CD-ROM, DVD, the Internet, and IVR, but have all been based on the 5 As model and emphasize tailored, patient-centered goal setting, feedback, and barriers-based problem solving.

Enhancing User Engagement and Experience

For theoretical reasons, we have employed several common elements across our DSME interactive technology studies to enhance user engagement and experience. On the basis of social cognitive theory,[26] we have introduced our IM programs via video segments that explain the rationale for self-management and portray persons of different cultural backgrounds but represent type 2 diabetes patients in terms of age and body mass index (BMI), engaged in different self-management tasks.

On the basis of self-determination theory,[27] we offer participants choices among recommended actions. Our programs are tailored based on user characteristics, current self-management levels, barriers, progress, and self-efficacy levels. However, rather than recommending only one action or strategy, we provide a few alternative choices often, including a write-in/create-your-own option if users do not feel those suggested by the program fit their situation. Thus, key decisions throughout the program are shared, including behaviors targeted, goal difficulty, barriers, and strategies. The computer suggests recommended alternatives, but the user makes choices after considering this input. This enhances interactivity as well as user engagement and commitment to the actions selected.

Finally, on the basis of problem-solving theory,[28] our programs guide users through the steps of setting specific goals, identifying barriers to these goals, and developing strategies to overcome those barriers. These decisions are summarized in an action plan that is continually available to users, both online (or on the monitor) and in a hard copy printout. Users are directed to review their action plans at various points in the program and to revise them as necessary. We have demonstrated that improvements in problem-solving skill are a key mediator of DSME outcomes.[29]

Peer support. Social interaction, especially with peers, can keep users engaged with IM programs. One of our Internet-based DSME studies experimentally evaluated the effects of a peer support component.[30,31] All participants received basic self-management assistance, and half were randomized to a peer support condition that provided opportunities to exchange diabetes-related information, coping strategies, and emotional support. These opportunities included a peer-directed "Diabetes Support Conference" forum; a more structured, topic-oriented "Focus Forums" area; and the ability to engage in real-time live chat discussions.

This peer support intervention resulted in significantly enhanced perceptions of both diabetes-specific and general support as well as higher levels of website use compared to control conditions.[30,31] The literature on peer support is mixed, but this study provides support for its use as a strategy to enhance engagement. Although use decreased over time for all conditions, peer support produced

Table 1 Interactive Media Studies by Our Diabetes Self-Management Research Group

Study	Self-Management Focus	Interactive Media
Glasgow and others (1997)[58]	Healthy eating	Touchscreen
Glasgow and Toobert (2000)[59]	Healthy eating	In-clinic touchscreen
McKay and others (2001)[60]	Physical activity	Internet
Glasgow and others (2003)[31]	Eating, exercise	Internet
Glasgow and others (2004)[33]	Care guidelines, eating, exercise	In-clinic touchscreen
Glasgow and others (2006)[50]	Healthy eating	Computer
Glasgow and others (2009)[49]	Eating, exercise, blood glucose self monitoring, medication	Mailed DVD
Glasgow and others (2009)[32]	Eating, exercise, medication	Internet, interactive voice response

approximately twice the average number of log-ins throughout the 10-month-long program as did the non–peer support conditions.[31]

Simplified goals and self-monitoring. On the basis of feedback that some users in earlier programs had difficulty achieving goals—especially when attempting behavior changes in multiple areas—in our most recent Internet study,[32] we introduced a new component of very simple dichotomous initial goals. The goals are straightforward and very easy to track for the first 6 weeks of the 1-year program and are accompanied by online self-monitoring and immediate feedback on progress. Goals are set in all 3 self-management areas: healthy eating, regular physical activity, and medication-taking, which are targeted in this study. Examples of simple dichotomous dietary goals are not eating any fast foods that day or not drinking any sugary beverages that day. Participants are encouraged to self-monitor on a daily basis and receive immediate feedback.

Although this study is ongoing, participants have self-monitored fairly consistently over the first 6 weeks of the program. They have entered self-monitoring data on 64% to 67% of days across all 3 behavior change areas, and on days that self-monitoring data are entered, users have, with some exceptions in the physical activity area, almost always achieved their goals.

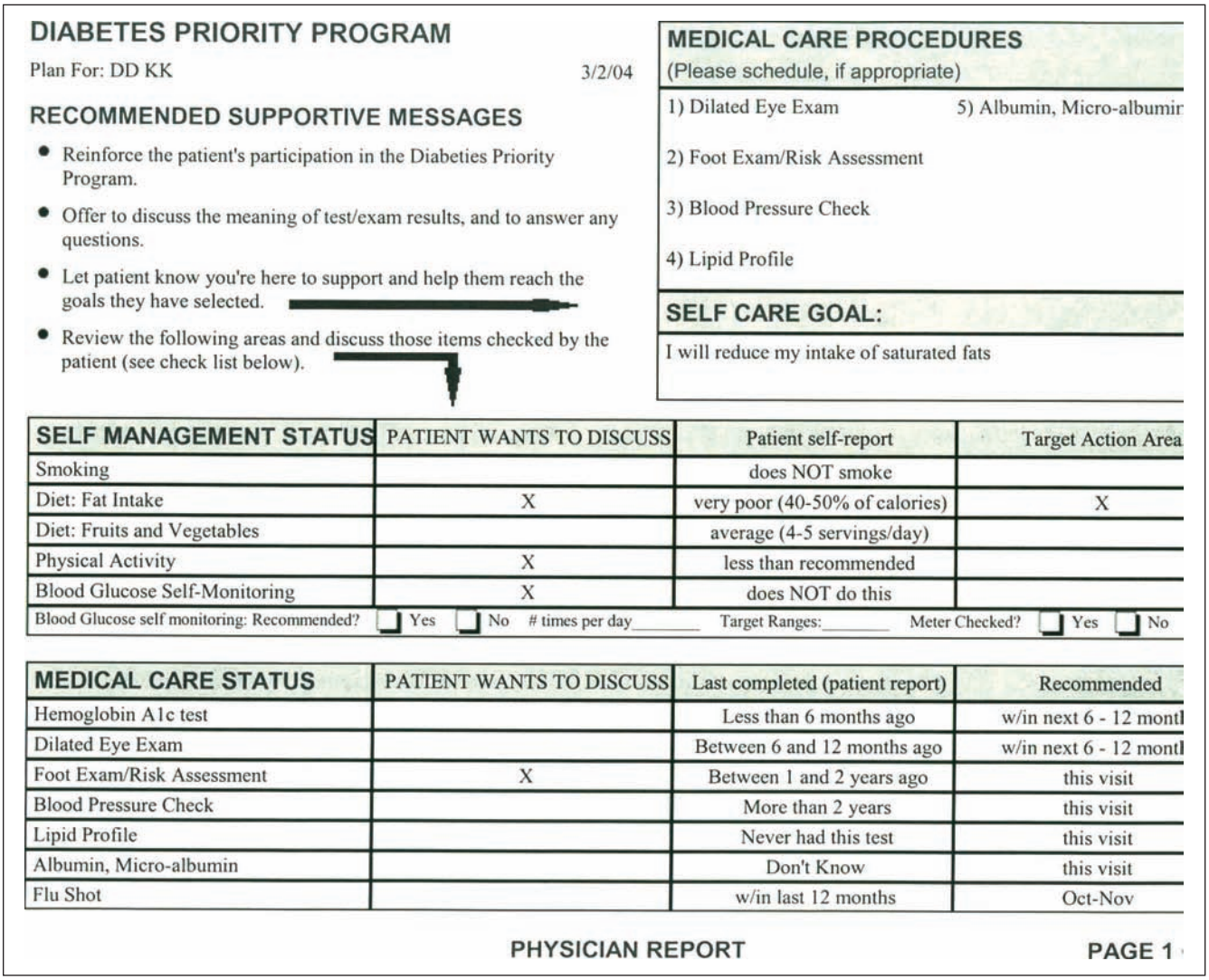
Enhancing Shared Decision Making and Quality of Care via Action Plans

All of our IM DSME interventions have contained features to enhance collaborative care and to promote discussions between patients and providers. These strategies have usually engaged the patient via an initial IM interaction to present relevant content and intervention options and to assess patient status on and preferences regarding the target behaviors or self-management criteria. Patients are then prepared for their upcoming discussion with their provider, and both patients and health care team members are prompted via one or more interactive mechanisms to discuss relevant diabetes care and self-management issues.

A study to increase adherence to National Committee on Quality Assurance (NCQA) diabetes care guidelines is summarized to illustrate the type of shared decision-making elements we have employed. This group-randomized practical effectiveness trial[33,34] was conducted with 886 type 2 diabetes patients of 52 primary care providers throughout Colorado. The study compared a touchscreen assessment/feedback/priority setting and decision-making program to a comparison condition that involved touchscreen assessment and feedback on general health risks.

The Diabetes Priority Program intervention involved having primary care patients come to their next diabetes visit 30 minutes early to complete assessment and feedback portions of the program. A touchscreen computer sequence first inquired how long it had been since the user had received each of 11 services in the NCQA/American Diabetes Association (ADA) Physician Recognition program measures, including both laboratory assessments (e.g., HbA_{1C} and low-density lipoprotein [LDL] assays) and patient-centered interactions that involved counseling (e.g., nutrition therapy). The program then focused on creating an action plan in a self-management area of the patient's choice.

Three print-outs were produced: 1) for the patient—an action plan and prioritized list of diabetes services for which the patient might be due; 2) for the physician—a summary of the patient's needed assessments and self-management goals (Figure 2), including prominent notation of areas the patient



DIABETES PRIORITY PROGRAM

Plan For: DD KK 3/2/04

RECOMMENDED SUPPORTIVE MESSAGES

- Reinforce the patient's participation in the Diabeties Priority Program.
- Offer to discuss the meaning of test/exam results, and to answer any questions.
- Let patient know you're here to support and help them reach the goals they have selected.
- Review the following areas and discuss those items checked by the patient (see check list below).

MEDICAL CARE PROCEDURES
(Please schedule, if appropriate)

1) Dilated Eye Exam
2) Foot Exam/Risk Assessment
3) Blood Pressure Check
4) Lipid Profile
5) Albumin, Micro-albumin

SELF CARE GOAL:

I will reduce my intake of saturated fats

SELF MANAGEMENT STATUS	PATIENT WANTS TO DISCUSS	Patient self-report	Target Action Area
Smoking		does NOT smoke	
Diet: Fat Intake	X	very poor (40-50% of calories)	X
Diet: Fruits and Vegetables		average (4-5 servings/day)	
Physical Activity	X	less than recommended	
Blood Glucose Self-Monitoring	X	does NOT do this	

Blood Glucose self monitoring: Recommended? ☐ Yes ☐ No # times per day_____ Target Ranges:_____ Meter Checked? ☐ Yes ☐ No

MEDICAL CARE STATUS	PATIENT WANTS TO DISCUSS	Last completed (patient report)	Recommended
Hemoglobin A1c test		Less than 6 months ago	w/in next 6 - 12 montl
Dilated Eye Exam		Between 6 and 12 months ago	w/in next 6 - 12 montl
Foot Exam/Risk Assessment	X	Between 1 and 2 years ago	this visit
Blood Pressure Check		More than 2 years	this visit
Lipid Profile		Never had this test	this visit
Albumin, Micro-albumin		Don't Know	this visit
Flu Shot		w/in last 12 months	Oct-Nov

PHYSICIAN REPORT **PAGE 1**

Figure 2 Sample printout for physician for shared decision making.

wished to discuss; and 3) a detailed printout for the office's designated "care manager." The care manager was a clinic staff member trained to conduct a brief follow-up session with the patient after the physician visit.

The program was well implemented for a real-world effectiveness study (e.g., 92%–100% of intervention patients completed touchscreen computer, physician goal setting, and care manager meeting components). The Diabetes Priority Program significantly improved both recommended laboratory assays and patient-centered aspects of diabetes care that patients received compared to those in randomized control practices, and these differences were maintained at a 1-year follow-up.[35]

Follow-Up Support

The final element of the 5 As model—arrange follow-up support—is challenging for most primary care offices.[36] IM has tremendous potential to increase the consistency of follow-up support. Our diabetes IM programs have used 1 of 2 approaches to arranging such support and enhancing maintenance. One approach, based on social-ecological theory,[37] has been to connect patients with their choice of multiple resources in their community at the levels of family, friends, neighborhood, work, and media supports. An IM-based program focused on enhancing community support proved equally effective in maintaining behavior change out to a 7-year follow-up assessment

as a much more intensive series of support group meetings following an initial series of group sessions based on the Mediterranean lifestyle program.[38,39]

The second IM approach is a gradually faded series of IVR phone calls over an 8-month follow-up period. These IVR calls have combined brief motivational messages with reminder prompts to return to different sections of our website DSME program. Future IM-based approaches to enhancing follow-up will likely combine different modalities, including text messaging, blogs, and other social media.

ENHANCING PUBLIC HEALTH IMPACT

Although IM-based DSME programs have been demonstrated to be efficacious, they are not routine parts of clinical care for most diabetes patients; thus, their public health impact is limited. To enhance such translation, our research group has employed the RE-AIM framework to develop, evaluate, and report on IM programs for DSME.[40,41] RE-AIM is an acronym for reach, effectiveness, adoption, implementation, and maintenance.[40,41] Table 2 provides definitions and IM examples of these RE-AIM dimensions. *Reach* refers to the percentage of potential participants who are exposed to an intervention and their representativeness. Reach and *effectiveness* (Table 2) relate to individuals or intended end users. Effectiveness concerns both the intended or positive impacts of an intervention and possible negative or unintended consequences on quality of life and related factors.

In RE-AIM, adoption and implementation operate at the setting or contextual level. *Adoption* refers to the participation rate and representativeness of both the settings (worksites, medical offices) in which an intervention is conducted and the intervention staff (physicians, health educators) who deliver the intervention. Although adoption is as important as reach, far less attention has been devoted to it. *Implementation* refers to the extent to which components of an intervention are delivered consistently as intended and the costs of such delivery. Implementation is often problematic, especially when a program is conducted in applied settings by regular staff having numerous other responsibilities beyond delivery of an intervention protocol.

Maintenance has indices at both the individual and setting levels. At the individual level, it refers to the long-term results of an intervention a minimum of 6 months following the last intervention contact. For most DSM behaviors, long-term maintenance has proven challenging, and the factors that influence maintenance may be different from those that influence initial behavior change.[42]

At the setting level, maintenance refers to the institutionalization of a program.[43] This is the extent to which intervention settings will continue a program (and which components of the intervention are retained or modified) once the formal research project and supports are withdrawn.

The relationships among various RE-AIM dimensions are as important as the results on any given dimension. Expanding on the work of Abrams and colleagues,[44] who proposed that impact = reach × efficacy, RE-AIM hypothesizes that the overall public health impact of an intervention is a function of all 5 RE-AIM dimensions. Glasgow and colleagues[45,46] have proposed RE-AIM summary indices for determining overall impact. To have broad public health impact, an intervention must do reasonably well on all or most RE-AIM dimensions. It is not enough to have a highly effective intervention if it has poor reach, is adopted by only a few settings, or can only be implemented by a handful of highly trained specialists.

Participation

Although DSME has been recognized as an evidence-based practice by the Centers for Disease Control and Prevention (CDC) Community Guide Task Force, the ADA, and systematic reviews,[18] only a minority of diabetes patients have received DSME.[47] In most settings, DSME is offered as a series of classes requiring in-person meetings on a weekly basis or several times within 1 week. To reduce participant burden, Kaiser Permanente Colorado has condensed its basic DSME program into two 2- to 3-hour-long class sessions, 1 week apart. Still, participation rates have been lower than desired, and our research group has partnered with diabetes education to evaluate whether a DVD version of the DSME course sent via the mail could enhance reach—while still producing effectiveness results similar to those of the in-person classes.

A DVD version of the DSME program was developed that included the same content as the classes but was formatted into 7 sections corresponding to the American Association of Diabetes Educators (AADE) 7 key self-management behaviors[48] plus an introduction and a conclusion. This project[49] also addressed a methodological limitation of standard RCTs that prohibits them from obtaining a true estimate of participant reach. This limitation is that due to the ethical requirement for informed consent,

Table 2 RE-AIM Model Elements, Definitions, and Interactive Media Intervention Example

RE-AIM Element	Definition	Interactive Intervention Example
Reach	The number, percentage of those invited and eligible who participate and their representativeness	From the pool of eligible patients, 40% of those invited to an Internet self-management intervention participated. Those declining were more likely to be Latino and male.
Effectiveness	Amount of change in temporally appropriate outcomes and impact on quality of life or any adverse (iatrogenic) effects	Seventy percent of those randomized to an automated eye exam reminder phone call program had their eyes examined compared to 42% in the control condition. There were no differences between conditions on other preventive services, adverse events, or quality of life.
Adoption	Number, percentage, and representativeness of settings and staff invited who participate	Forty-six percent of medical offices approached to participate in an Internet diabetes self-management education (DSME) program evaluation took part. Participating clinics were larger, had more diabetes patients, and offered more wellness activities.
Implementation	Extent to which a program or policy is delivered consistently and the time and costs of the program	The average number of log-ins in an Internet physical activity intervention was 25.2. Usage decreased over the 24-week intervention, and number of overall log-ins and use of the social support forum were associated with greater improvement.
Maintenance (individual level)	Long-term effects on key outcomes and quality-of-life impact	At a 6-month follow-up, there was 60% attrition in a touch screen computer DSME. Those responding lost an average of 9 pounds. A mail follow-up of initial nonrespondents revealed an average weight loss of 4 pounds among this group.
Maintenance (setting level)	Extent to which a program or policy is sustained, modified, or discontinued following initial trial or study period	Of 24 clinics participating in an in-office, computer-assisted DSME, 6 continued the program unchanged, 10 requested substantial changes or added their own components, and 8 discontinued the program.

participants must be willing to participate in any of the conditions to which they could be randomized. Thus, persons having strong preferences for one intervention or who are unable or unwilling to participate in one of the potential interventions (e.g., a DSME class) are unlikely to consent. To address this issue, we employed a hybrid preference-randomized design (Figure 3), in which half of potentially eligible patients were randomized prior to initial contact to traditional RCT consent procedures. The other half was randomized to "choice" consent procedures in which they were offered both the DSME class and the mailed DVD and allowed to choose which they preferred.

There was a higher participation rate in the choice than in the randomized consent condition (48% v. 37% among those confirmed eligible, $P < 0.02$), indicating that the RCT requirements likely produced lower estimates of reach than could be expected under nonresearch conditions. When offered choice, 4 times as many eligible members selected the DVD as the class condition (39% v. 9%, $P < 0.001$). Combined with analyses indicating that the DVD produced outcomes generally equivalent to the DSME class, this suggests that the DVD is a good way to increase reach and public health impact.[49]

Reach and adoption. Participation issues are important at the setting and health care provider levels[5] (adoption) as well as at the patient level (reach). Two studies by our group employing similar interactive DSME interventions, but differing in location of the intervention, provide data on factors influencing reach and adoption. Although separate DSME studies, they employed identical recruitment procedures with highly similar target populations and outcome measures, had identical inclusion/exclusion criteria, and were conducted within the same geographic area.[33,50]

One IM intervention was delivered in the patient's primary care office immediately prior to a diabetes visit (in-office). Following the 20- to 30-minute interactive computer session, this intervention involved brief encouragement from the physician and a 15-minute review session with a care manager from the practice. The second IM intervention was

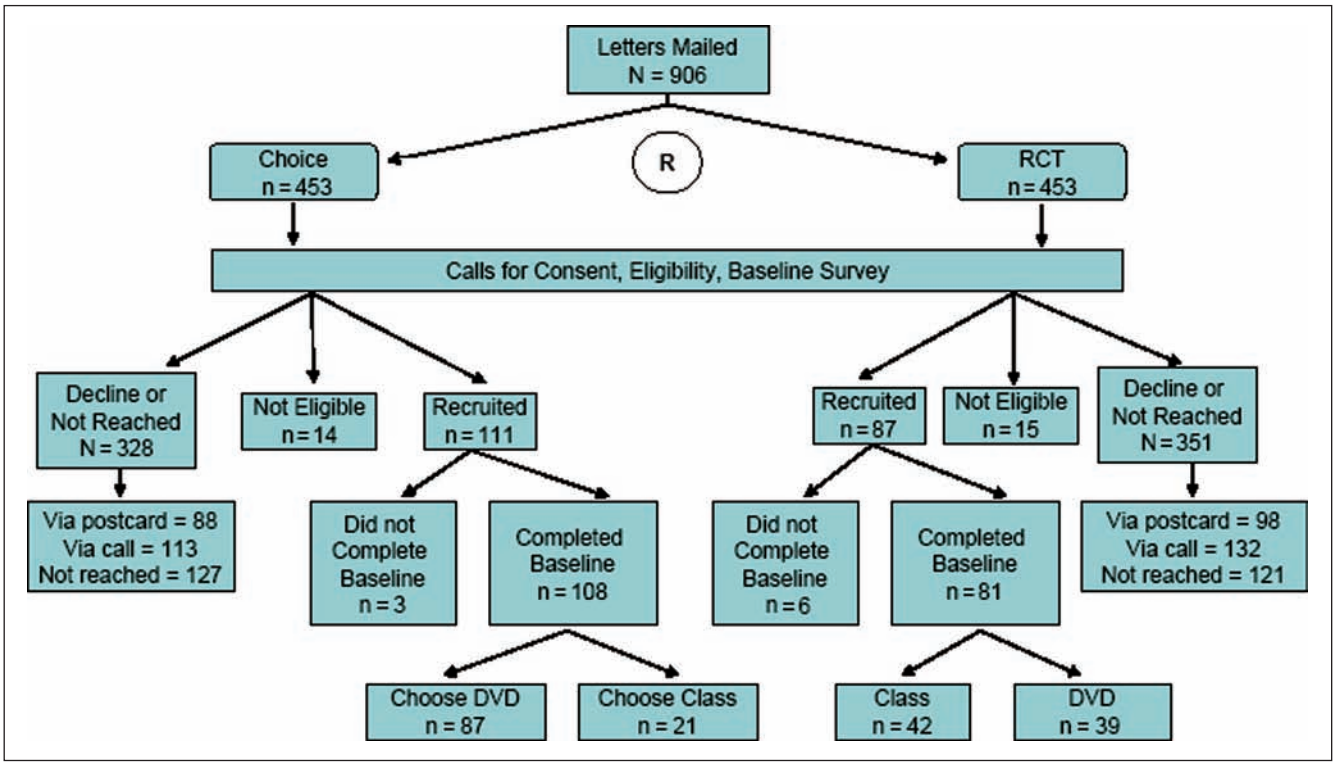


Figure 3 Experimental design used in the diabetes self-management education (DSME) DVD study.

also initiated through primary care offices but involved meeting at a different location (central location) for the IM visit and to meet with a health coach.

The in-office study was adopted by only 6% of primary care providers approached, compared to 47% of those invited to participate in the central location study. In retrospect, this was not surprising since the in-office study involved a change in clinic procedures and required staff time, whereas the central location study did not. In contrast, the in-office study resulted in a 50% participation rate among eligible patients compared to a 41% patient participation rate in the central location study that involved a separate visit. Thus, one of the complexities involved in maximizing public health impact is balancing patient intervention burden with setting/provider burden.

Generalizability

One of the key reasons for the gap between research and practice results[51] is that programs are often disseminated following efficacy studies without the effects of contextual factors on program outcomes being understood.[52] Often for reasons of experimental control, interventions are conducted in a single setting, using highly skilled staff paid by the research project and with relatively homogeneous samples of patients. Such conditions do not permit investigation of generalizability.

From the RE-AIM perspective, it is helpful to know the "robustness" of results across 3 levels of contextual factors. These levels are setting (e.g., organization, clinic, or community), staff (those who deliver the intervention or, if automated, intervention modality), and patient characteristics.

A recent study[53] illustrates the types of robustness analyses we have conducted. It was conducted in both health maintenance organization (HMO) and private practice, fee-for-service settings. The intervention was the "central location" study above that involved diabetes participants coming in for 2 computer-assisted intervention sessions on healthy eating and regular exercise, after which they met with a health coach to review action plans to ensure their personal relevance. This staff member also conducted brief follow-up calls at 1 and 4 weeks later to check on progress and revise goals and strategies as needed. We purposely used health coaches with

different levels of education and experience working with diabetes patients.

Finally, we investigated effects of patient characteristics, including age, sex, ethnicity, annual income, marital status, number of comorbid conditions, whether prescribed insulin, baseline BMI, perceived support for diabetes self-management from one's health care team, and baseline self-efficacy for ability to self-manage one's diabetes.

Robustness was analyzed using the RE-AIM categories. For reach, we found that a higher percentage of non-HMO than HMO patients participated (54% v. 38%, $P < 0.001$). The only information available on nonparticipants was age and gender, and these factors did not differentiate participants from nonparticipants. Regression analyses were used to evaluate both main effects and interactions with treatment condition (moderator effects) of the 11 patient characteristics noted above on dietary and physical activity behavior change, HbA_{1C}, and lipid outcomes. There were no significant patient moderator effects on dietary and physical activity outcomes or on lipid ratio. Two of the 11 interaction terms were significant on HbA_{1C} outcomes, indicating that glycemic treatment effects varied depending on patient age and baseline self-efficacy level.

The largest effects were on adoption rates by HMO v. non-HMO physicians. Three-quarters of HMO physicians invited participated (75%) compared to only 18% of non-HMO physicians. There were no differences in participation rates between internal medicine v. family practice physicians. Finally, the intervention was delivered very consistently by all health coaches with no differences across staff on implementation and only one significant Treatment × Interventionist interaction on outcomes.

In summary, the intervention effects were robust across patient and health coach characteristics, but the HMO v. non-HMO setting influenced both patient and physician participation. These participation differences were likely due to the more centralized decision making about clinic participation at the HMO setting and because HMO patients had a much greater variety of alternative health promotion programs available to them than did non-HMO patients.

KEY OPPORTUNITIES AND CHALLENGES

The 5 As framework for DSME support suggests several opportunities for multimedia approaches to enhance the effectiveness and efficiency of diabetes care. Table 3 summarizes the potential for IM contributions to each of the 5 As using a 1 to 5 rating, with 5 being the greatest opportunity, along with a summary of key strengths and limitations of current IM approaches.

Assessment is one of the greatest strengths of multimedia DSME. It is possible to administer, score, and provide immediate, error-free feedback to patients and providers with great savings in staff time. Low-literacy patients can have questions presented via audio and proceed at their own pace. The primary current assessment limitation is difficulty capturing and summarizing open-ended content.

Multimedia approaches can provide highly tailored, personally relevant *advice* and feedback via a variety or combination of modalities. The main limitation is that advice from a computer may not have the same impact as from one's personal physician or other trusted source.

Achieving *agreement* and developing collaboratively set goals could benefit from further research. Strengths of IM include powerful tailoring engines to generate highly individualized alternative goals and providing patient choice. Current challenges include importing patient goals into electronic medical records.

Assistance with problem solving is a relative strength of IM as busy clinics often do not have the time or training to help patients develop detailed, individualized action plans. Current challenges include generation of solutions to novel situations that were not programmed into the computer and integrating action plans with the patient's ongoing care. Together, the first 4 As can be integrated to enhance patient-centered care and produce "activated patients."[54] This patient activation in DSM involves both traditional decision support (e.g., deciding to intensify treatment or have a given test) and more ongoing daily lifestyle-related activities.

Finally, *arranging* follow-up support presents a huge opportunity for multimedia DSME. This is the area of the 5 As that is delivered least consistently in usual care.[21,24] Building on encouraging IVR research,[14,15] IM approaches can attempt repeated contacts at little or no additional cost and could be conducted via a variety or combination of modalities, including e-mail or cell phones.

In summary, the 5 As model suggests several ways that IM approaches can be used to enhance the consistency and the efficiency of patient-centered DSME. The goal should not be to eliminate or replace interactions with providers but to determine how IM can best be used to inform, support, and enhance patient-centered care and shared decision making.

Table 3 Key Opportunities and Challenges for Interactive Media-Based Diabetes Self-Management Education (DSME) within the 5 As Areas

5 As Area—Rating[a]	Key Opportunities	Key Challenges	Advantages over Traditional Face-to-Face Clinician Interventions
Assess—5	Administering and immediate scoring of scales	Limited ability to summarize open-ended responses	Time-saving, automatic immediate error-free scoring
Advise—3	Provide personally relevant, highly tailored feedback	Hard to evaluate patient reaction	Ensures use of patient variables and preferences if designed into interactive media (IM)
Agree—3	Generation of alternatives; allowing patient choice	Recording nonstandard goals; interoperability of electronic medical records	Ensures patient choice, "SMART" goals, integrated assessment of motivational interviewing elements, and electronic records of goals
Assist—4	Identifying barriers, record of action plan	Solutions to new situations; integration with ongoing care	Great time savings; expert systems can consistently include many factors, search large databases, create easily modifiable action plans, and are available 24–7/365
Arrange—5	Persistence in making follow-up contacts	Lack of personal touch	Consistent follow-up and repeated contacts not often feasible by nonreimbursed staff

[a]Ratings are of potential for multimedia DSME within each 5 As area. 1 = little potential; 5 = great potential.

RE-AIM issues. To date, multimedia DSME approaches have probably made their largest contribution in terms of enhancing *reach*.[14,15,49] Many patients will not or cannot take the time to attend multiple, in-person DSME sessions, whereas IM approaches can be available continuously. Properly designed IM approaches seem able not only to attract more participants than in-person DSME but also to reach older adults, as well as those with little prior computer experience or low levels of health literacy.

Although research on IM DSME interventions has been positive, it is too early to draw definitive conclusions about their *effectiveness*. Future research should expand the range of settings, staff, and IM modalities; directly compare multimedia DSME to in-person approaches; and determine the amount of health care team contact necessary to produce the most cost-effective results.[55] A particular challenge and opportunity will be to develop and evaluate interventions that can engage and assist subgroups who have been underserved or experience health disparities in both care and outcomes. These potential target groups include racial and ethnic minorities, persons of lower socioeconomic status (SES), those with limited health literacy and numeracy, older adults, and those in rural areas and low-resource and low social capital environments.

There has been less DSME research on *adoption* than on other RE-AIM elements. Clearly, multimedia approaches need to fit into clinic routines (or other settings) to be widely adopted. Physicians appear most likely to adopt programs in which patient IM interactions are conducted at locations outside their offices. In such cases, it is hypothesized that the amount and integration of feedback into primary care may be a primary determinant of long-term success. Perhaps the emergence of the medical home movement will provide an opportunity for IM to demonstrate capacity to achieve medical home goals such as enhanced patient-centered care and more frequent and consistent follow-up.

Implementation rates have generally been high for brief DSME multimodality programs. In longer, web-based programs, patient engagement tends to decrease over time but may be enhanced by electronic peer or health coach support. Identifying methods to keep users engaged over time should be a high priority.

Individual-level *maintenance* of multimodality DSME effects has been variable. Some programs have found good maintenance effects, whereas others have reported substantial relapse. Priority areas for future research are setting-level maintenance or sustainability and investigation of factors that determine whether organizations continue, drop, or modify IM programs over time.

CONCLUSIONS

IM programs have produced at least moderate improvements in self-management behaviors and diabetes control. Studies that have targeted and evaluated programs to enhance reach have reported encouraging participation rates. These results should not be overgeneralized, however. Different media may produce different outcomes or interact with patient or setting characteristics. There have been no studies of the relationship between treatment outcomes and number of media components used, degree of interactivity, or level of integration with primary care. Research is needed to evaluate the effects of combining different technologies (e.g., websites, IVR calls, and health care team e-mail prompts). In particular, studies are needed of innovative IM components to enhance maintenance. A realist review approach[56] to help determine what IM interventions are most cost-effective for what patient subgroups, for what particular outcomes, and under what setting and delivery conditions is especially recommended to advance the field.

The single greatest need at present is for cost-effectiveness data. One of the great promises of IM approaches is that after initial development, they should be inexpensive to deliver or "scale up" (depending on the amount of staff contact required). They should prove very scalable in that the incremental costs of delivering the same IM program to additional participants should be minimal. This hypothesis needs to be empirically tested rather than assumed correct, however, as there can be unanticipated costs of maintaining websites, updating content, moderating online discussion groups, and answering participant questions.

It is hoped that IM can facilitate achievement of the Institute of Medicine vision[57] of health care that is safe, affordable, equitable, timely, effective, and patient centered. We need to learn from experiences with medical devices and procedures, however, to document that DSME programs intended to improve care and increase patient autonomy and self-management actually do so and do not produce unintended negative consequences. The fundamental question for future IM research is what approaches are most cost-effective for producing which outcomes—and how generalizable are results across various patient, staff, setting, modality, and delivery characteristics.

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