Review ■

Computer-based Approaches to Patient Education:
A Review of the Literature

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Abstract All articles indexed in MEDLINE or CINAHL, related to the use of computer technology in patient education, and published in peer-reviewed journals between 1971 and 1998 were selected for review. Sixty-six articles, including 21 research-based reports, were identified.

Forty-five percent of the studies were related to the management of chronic disease. Thirteen studies described an improvement in knowledge scores or clinical outcomes when computer-based patient education was compared with traditional instruction. Additional articles examined patients' computer experience, socioeconomic status, race, and gender and found no significant differences when compared with program outcomes. Sixteen of the 21 research-based studies had effect sizes greater than 0.5, indicating a significant change in the described outcome when the study subjects participated in computer-based patient education.

The findings from this review support computer-based education as an effective strategy for transfer of knowledge and skill development for patients. The limited number of research studies (N = 21) points to the need for additional research. Recommendations for new studies include cost–benefit analysis and the impact of these new technologies on health outcomes over time.

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Ongoing changes in health care, which include legislated reimbursement for educational interventions, are increasing the attention placed on patient education. Patient education has emerged as an important component of many health promotion and disease management programs. Responding to increased pressure to provide more informed and interactive information resources to patients at less cost, patient educators are beginning to realize the benefits of using computer technology to support the health care learning process. The findings presented in this paper suggest that the use of technology to improve patients' knowledge and to involve them in health care decisions leads to better health outcomes. The purpose of this article is to explore the evolution of computer technology in health care education and, in particular, to examine the application of technology in the process of knowledge transfer and skill development necessary for self-health promotion and disease self-management. A systematic review of the published literature on the development and use of computer-based patient education is followed by a discussion of the application of research findings to practice.

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Methods

Two primary health care resources, MEDLINE and CINAHL, were selected to review the current literature. A listing of articles related to the use of computer technology in patient education was obtained from both health care databases. The search strategy included exploding subject heading terms "computer" and "informatics" and the heading "patient education." The results from these searches were combined to identify relevant literature in the areas of patient education and informatics, and patient education and computer/computer technology. Common key words identified were "patient education," "consumer informatics," "consumer health information," "patient informatics," "health promotion," "computers," "com-

puter-assisted instruction,'' ''computer technology,'' ''computer education,'' ''multimedia,'' ''technology,'' ''software,'' ''world wide web,'' ''Internet,'' and ''telemedicine.'' In addition, the American Medical Informatics Association symposium proceedings and related journals, including *Computers in Nursing, Artificial Intelligence in Medicine, Journal of the American Medical Informatics Association,* and *MD Computing*, were reviewed to reduce under-ascertainment. A reexamination and cross-checking of the bibliographies of relevant articles were also performed. The initial results comprised 420 titles and included articles from 1971 to 1998.

Study Selection

Research in the field of informatics incorporates the study of information systems that are in various stages of development. Usability studies, as well as early evaluation studies, may not employ the same methods as impact studies.[1] While randomized trials have the most robust design, limiting this review to randomized trials would have eliminated the preliminary studies that provide information crucial to program developers. Because of the wide variation in research design and reporting, a formal meta-analysis of this body of research proved difficult. Likewise, developing a numeric scoring criterion for inclusion was also difficult, because traditional methods for inclusion scoring would exclude many articles.

Initially, the author excluded articles that were not relevant to the topic; these articles generally addressed clinical technologies or represented the combined key words ''patient education'' and ''technology'' (e.g., central venous catheter care), or ''patient education'' and ''data analysis software.'' In addition, articles that addressed professional education or dental patient education were not included. All identified articles that reported on the development and implementation of computer-based patient education and appeared in peer-reviewed journals between 1971 and 1998 were included in this review. Sixty-six articles met these broad inclusion criteria. Of these articles, a subset of 21 research-based reports focusing on evaluation of computer-based patient education and providing documentation of significant findings were identified. The remaining 45 articles were primarily descriptive or anecdotal in nature and are included in the narrative.

The studies were divided into three broad categories —learning interventions, history taking and interviewing, and online connections and support—which were derived by the author from an analysis of the content and outcomes of the reviewed articles and are supported by an earlier review by Krishna et al.[2] Since the focus of this article is learning interventions, this category was further organized by type of outcome measure and by the special population characteristics that were examined or targeted by the learning intervention:

Outcome measure:
- Knowledge transfer/health behaviors
- Skill development/decision support

Special population:
- Physical or cognitive disabilities
- Age—e.g., child or elderly
- Low socioeconomic status
- Low literacy

Although this approach follows a liberal inclusion criterion, it provides a more comprehensive review of this body of literature.

Results

Content Focus

Of the 66 articles represented in this review, the majority were about diabetes education or management programs (n = 18, 28 percent),[3–20] six were related to cancer education,[21–26] and three each represented cardiovascular disease,[27–29] asthma,[30–32] urology/dialysis,[33–35] and spinal cord injuries.[36–38] Programs for alcohol education,[39,40] medication instruction,[41,42] psychiatric diagnosis,[42,43] primary care,[44,45] and arthritis[46,47] were represented by two articles each. Six additional articles described programs related to brain injury,[48] ophthalmology,[49] back pain,[50] the common cold,[51] endoscopy education,[52] and prenatal care.[53]

Participant Characteristics

In most cases the program participants were adults (n = 41, 79 percent). Four programs were designed specifically for elderly patients,[15,35,41,46] four were designed for adolescents,[8,12,54,55] and six were for younger children.[3,6,25,32,33,49]

Additional Areas of Focus

Seven articles presented the use of Internet-based approaches to patient education[17,19,26,56,57,58,68]; these were frequently reports of research on the development of Web-based information-delivery strategies, online patient support, or the application of patient education and decision support in an online learning environment. Nine additional articles examined computerized history taking and interviewing,[43,44,54,55,59,60–63] one

provided a review of previous research,[2] and the remaining three addressed general issues related to computer-based patient education.[64,65,67]

Learning Interventions

In the 21 articles identified as research-based, the computer-based delivery strategies that were employed ranged from simple tutorials to Internet applications. Interactive video or CD-ROM programs were most often utilized (n = 17). Most studies occurred in the clinical environment, although three studies described the use of patient education technology in the outpatient waiting room environment.[4,48,49,53] Many of the research-based programs used the keyboard as an input device. However, three programs utilized touch-screen kiosk technology,[21,48,53] three used modified keyboards,[20,35,61] one used a mouse,[5] and one used a remote device.[29] Two research programs were video games.[3,32] Table 1 provides study design and significant findings for the reported research. Of the 21 studies presented, 14 represent randomized trials, whereas the remaining studies are convenience samples more representative of early evaluation studies.

Effect sizes (ESs) were computed for reported outcomes when sufficient data existed. The ES is represented as Cohen's D and was calculated according to the procedures described by Wolf.[66] Effects equal to or greater than 0.5 (moderate) were considered significant.[66] For the 21 research-based articles, 27 ES values were reported, since the studies were too disparate to summarize into a single estimate of effect. The ESs ranged from 0.21 to 1.91, with 17 effects (63 percent) above the 0.5 level. Thus, patients participating in the 17 studies with ES values greater than or equal to 0.5 had a significant change in the described outcome when they participated in computer-based patient education.

The reviewed literature supports the use of health care information technology in patient education. As an educational tool the computer provides a number of advantages, including ''just-in-time'' availability, a private learning environment, and immediate reinforcement of the learning that has occurred. Other advantages described in the literature include support for the decision-making process, potential for individualization of information presented, and the ability to simulate life experiences.*

Many of the research studies presented information to patients and evaluated changes in their knowledge and health care behavior outcomes. Ten authors reported that computer-based learning programs were popular and effective in delivering information and that patients were generally able to use them without difficulty.† Eight studies demonstrated an improvement in knowledge scores when computer-based patient education was compared with traditional instruction.‡ Five other studies documented significant knowledge gains for patients in both the computer-based patient education and traditional education groups.[3,8,16,30,42]

The effect of knowledge acquisition on clinical outcomes was evaluated by several authors. Clark et al.[27] found that patients with hyperlipidemia who received computer-based, diet-mediated counseling were just as likely to succeed in reducing plasma lipid levels as were those who received diet counseling from a dietician; however, the computer system was useful in identifying those patients who needed additional help. Four other researchers also found that clinical outcomes were improved in both the treatment and control groups,[3,8,12,16] whereas eight authors reported that knowledge presented by computer-based patient education methods resulted in improved clinical outcomes when compared with traditional patient education methods.[14,19,20,30–32,34,46] ''Diabeto,'' an application for diet self-monitoring for patients with non-insulin-dependent diabetes,[19] was found to significantly improve their dietetic knowledge and dietary habits. Osman et al.[31] found that computer-generated booklets distributed to adult patients with asthma resulted in decreased hospital admissions. Huss et al.[30] developed a program that was designed to be an adjunct to the traditional education provided to patients with atopic asthma. For these patients, repeated instruction by use of computers resulted in more changed behavior than did single-session traditional instruction. Reis and Wrestler[51] found that the use of a computer program to educate patients about interventions for the common cold reduced the time of health care visits. In addition, patients in their study reported that the computer-assisted instruction program could save time and money, was a best use of resources, and was a reliable and accurate source of information.

Most studies were of short duration, with only five extending a year or more.[9,12,14,19,33] Turnin et al.[19] found that the impact of ''Diabeto'' was long-lasting on the dietary habits of persons with diabetes, and Evans et al.[33] found that improved knowledge scores remained significant when subjects were retested six months later.

*References 3, 10, 22, 24, 30, 31, 34, 48–50, 53, 54, 64, 65.

†References 4, 5, 21, 27, 30, 40, 42, 43, 47, 53.

‡References 15, 19, 20, 25, 32, 33, 46, 47.

Technology has been used successfully to support skill development and patient decision making. Shepperd et al.[45] found that a touch-screen interactive video program was useful in helping patients with hypertension and benign prostatic hypertrophy make health care choices. Nishimoto et al.[13] developed a computer-based patient education program to teach clients skills needed to use the Novo-Pen insulin delivery device. In this study, computer-based patient education supported active participation in the learning process and reduced the time required for learning by as much as 40 percent, thereby allowing the diabetes care provider more time for individualized instruction.

Lehmann[11] proposed that information technology could assist in the transfer of knowledge and expertise from diabetes centers to the patients themselves. The results of his study found that a computer-based diabetes management system could effectively provide a means to store blood glucose levels and suggest the next meal or insulin injection. Five other investigators provided evidence to support the use of computer-based decision support technologies in diabetes management.[9,12,14,16,18] Peters et al.[16] however, noted that, compared with diabetes educators, the computer-based decision-support program evaluated in their study did not provide additional significant gains in blood glucose control or a reduced incidence of hypoglycemia. In three of these studies, the investigators found that the use of the computer-based systems decreased over time and that once patients were comfortable with the skill being learned, the perceived advantages of these learning systems diminished.[9,12,14]

Special Populations

Strategies to ensure the success of patient education programs involve more than the delivery of information. Information must be delivered in a way that is accessible and meaningful for the learner. Virtual reality and CD-ROM instruction programs have been developed to accommodate persons with both physical and cognitive disabilities. Researchers in three studies concluded that these programs provide patients with opportunities for enhanced social interaction, diminished feelings of isolation, and improved self-esteem.[36–38] In these studies, most patients were able to use these virtual learning environments to acquire knowledge and skills that could be transferred to the real world. Four patient education programs made use of modified input devices that could be adapted to individual needs.[35,36,61] These modified input devices were used successfully in independent studies by groups of elderly patients, psychiatric patients, and patients with spinal cord injuries.[37] Madoff et al.[42] noted that psychiatric patients were also comfortable using standard input devices, including touch-screen monitors and keyboards.

Computer-based education has been shown to be effective for persons across the age continuum. Health care education for younger children is difficult in part because of their limited attention spans. School-age children with chronic diseases, from kindergarten through high-school age, responded positively to this form of patient education.[3,6,8,25,32,49] For the children who participated in these studies, computer-based patient education was effective in changing their health care behavior and health outcomes, including improved knowledge and communication with parents and care providers and a reduction in urgent medical care.[3,6,8,25,32,33,49]

At the opposite end of the age continuum, elderly clients with very little prior computer experience have successfully learned computer-based information about health management and disease-related self-care, and they have reported satisfaction with computer-based learning technologies.[15,35,41,46] Ogozalek[15] compared leaflets, text-based computer-assisted instruction, and interactive video as means to convey medication instructions. She found that patients with no prior computer experience were able to accomplish learning tasks significantly better when using interactive video. Patients' visual deficits were reported to be a problem for some participants in the computer-based group, pointing to the need to design age-sensitive educational material to accommodate the sensory deficits that occur with aging.[15]

Four studies considered patients' social and personal characteristics. Rural patients and patients from low socioeconomic backgrounds responded well to computer-based interventions.[39,40,53,62] Five studies explored patients' context of computer use, level of experience, and gender. In those studies no significant differences were identified when these variables were compared with the program outcomes.[26,30,42,47,51] Ogozalek[15] did, however, note that female subjects preferred the multimedia approach of interactive video to text-based computer programs, and Liao et al.[28] found that an interactive video program designed to assist patients in making treatment choices caused increased anxiety among subjects from diverse ethnic groups.

Patients with low literacy skills appear to benefit from the individualized pace of instruction and the non-threatening learning that occur with a computer-based learning program. Pernotto et al.[52] developed an interactive videodisk program to provide prepro-

Table 1 ■

Research Reported in the Literature

	No. in Study	Length of Study	Study Design	Age Group	Disease or Event, and Intervention	Findings Significant for Experimental Group ($P < 0.05$), Including Effect Sizes (ES)	Findings Significant for All Study Participants*
Fisher et al., 1977[34]	99	3 wk	Volunteer sample, random group assignment	Adults 18–25 yr	*Urine collection* Three groups: CAI, text or human instruction	More uniform skill performance, decreased bacterial count (ES 0.33), and decreased procedure problems	
Millstein & Irwin, 1983[54]	108	5 mo	Randomized (three groups)	Adolescents 14–20 yr	*Sexual history* Interview, self-administered questionnaire, or computerized assessment	Satisfaction with survey (ES 0.43)	
Wetstone et al., 1985[47]	36	34 day	Randomized (two groups stratified by education level)	Adults: avg age 50.9 yr	*Rheumatoid arthritis* CAI or traditional instruction	Improved knowledge, improved self-care (joint protection and rest) and hope, improved outlook, and decreased fatalism	Improved self-reported compliance
Rubin et al., 1986[32]	65	1 yr	Randomized (two groups)	Children 7–12 yr	*Asthma* Educational game or entertainment game	Improved disease management, health related behaviors (ES 0.72), and knowledge (ES 0.98)	
Wise et al., 1986[20]	174	4–6 mo	Randomized (stratified by year and month of birth)	Adults 23–72 yr	*Diabetes* CAI (two different interventions) or traditional instruction	Improved knowledge (IDDM group ES 0.41, NIDDM group ES 0.69) and decreased HgbA1 (ES 0.74)	
Rippey et al., 1987[46]	72	Pre- and post-test	Convenience	Elderly 52–88 yr	*Arthritis* CAI	Improved knowledge (ES 0.94) and self-care behaviors (joint rest ES 0.53, heat ES 0.49, relaxation ES 0.64 and exercise ES 0.37)	
Leirer et al., 1988[41]	16	14 day	Randomized cross-over	Adults: "elderly"	*Medication recall* CAI or traditional training	Decreased nonadherence (ES 1.14)	
Marrero et al., 1989[12]	57	4 mo	Randomized (two groups stratified by age and sex)	Adolescents 10–18 yr	*Diabetes* One group used glucose meter with data storage; the other used text logs to record glucose values	Increase in self-reported understanding of treatment, increased perceived importance of testing, improved quality of interaction with physician	Improved HgbA1c
Horan et al., 1990[8]	20	15 wk	Randomized (two groups)†	Adolescents 12–19 yr	*Diabetes* CAI plus data management or print material	Improved pre-lunch and pre-dinner blood glucose results	Improved HgbA1c and knowledge

Huss et al., 1991[30]	52	12 wk	Randomized (two groups)	Adults 18–75 yr	*Atopic asthma* CAI or CAI and traditional instruction	Improved adherence to therapy between CAI and traditional instruction (ES 0.64)	
Peters et al., 1991[16]	42	32 day	Randomized (two groups)	Adults 22–45 yr	*Diabetes* CAI and traditional support for therapy decisions	Decreased insulin required (ES 0.35)	Improved HgbA1c, decreased hypoglycemia
Turnin et al., 1992[19]	105	1 yr	Randomized (two groups crossover)	Adults 42–47 yr	*Diabetes* Access to a distributed learning system	Improved knowledge (ES 1.91), decreased fat intake (ES 0.48), decreased HgbA1 (ES 0.80)	
Ogozalek, 1993[15]	64	Pre- and post-test	Selection criteria unclear	Elderly 65–75 yr	*Medication information* Leaflets, text-based computer, or IVD	Improved knowledge score with computer and IVD (ES 0.41) and between computer and IVD (ES 1.3)	Improved knowledge with text-based computer
Meyerhoff et al., 1994[14]	24	3 yr	Volunteers (three groups), length-of-time meter used	Adults 17–50 yr	*Diabetes* Glucose meter with data storage	Improved HgbA1c (ES 1.12)	
Osman et al., 1994[31]	801	1 yr	Randomized (two groups)	Adults 48–51 yr	*Asthma* Treatment group received computer-generated books	Decreased hospital admission (ES 0.85)	
Liao et al., 1996[28]	68	Pre- and post-test	Volunteers (pilot study)	Adults: avg age 61 yr	*Coronary artery disease* IVD	Increased confidence in treatment choices	
Madoff et al., 1996[42]	42 + 13 from pilot	3 mo	Randomized (two groups)	Adults: avg age 35 yr	*Psychiatric patients* CAI or traditional instruction	Medication knowledge (ES 1.54)	Improved knowledge retention and medication compliance
Petersen, 1996[25]	15	Pre- and post-test	Convenience	Children 9–16 yr	*Oncology blood counts* CAI	Improved knowledge (ES 1.78)	
Brown et al., 1997[3]	59	6 mo	Randomized (two groups)	Children 8–16 yr	*Diabetes* Educational game or entertainment game	Communication with parents about diabetes (ES 0.21), self-care rating scale (ES 0.37)	Improved HgbA1c and knowledge
Clark et al., 1997[27]	814	12 wk	Randomized (two groups)	Adults: ''middle age''	*Hyperlipidemia* CAI or traditional instruction	Decreased plasma cholesterol (ES 0.58)	Decreased self-report of consumption of dietary fat and cholesterol
Evans et al., 1998[33]	43	18 mo	Convenience sample	Children 8–10 yr	*Nocturnal enuresis* CAI pre- and post-test	Improved knowledge score	

NOTE: CAI indicates computer-assisted instruction; IVD, interactive video disk; IDDM, insulin-dependent diabetes mellitus; NIDDM, non-insulin-dependent diabetes mellitus.

*No between-group differences.

†Groups matched for age, sex, race, HgbA1c, and diabetes knowledge.

cedure education for patients who would be undergoing endoscopy, colonoscopy, or polypectomy. The intention of the program was to support the informed consent process. After each segment of the program was viewed by the patient, questions were asked that validated the patient's understanding of the presented material. The program was designed for use with low-literacy patients. The use of graphics and audio made the program easier to understand for persons with limited reading ability. In a separate study, Liao et al.[28] found that for patients with ischemic heart disease, those who were less well educated benefited most from an interactive video program.

History Taking and Interviewing

Research that supported the benefits of computer-based interviewing systems was first reported in the literature in 1971.[60,62] A 1973 report by Griest et al.[43] noted that the computer could be used successfully for "interviews" with psychiatric patients and that the patients were more comfortable revealing personal information in this way. More recent studies by Millstein and Irwin[54] and by Paperny[55] found that adolescents preferred the computer as a way of providing assessment data. These researchers reported that the teens in their studies readily interacted with the automated education system, thus providing a solution to the problem of obtaining information about personally sensitive issues and breaking down barriers to the delivery of health messages. Three additional studies have reported on the development and implementation of technology-based health interview programs.[44,59,63] These programs were designed to deliver both customized interviews and individualized patient information. In these studies, users reported satisfaction with the system, and researchers concluded that these systems encouraged patients to think about their health and enhanced their readiness to interact with care providers.[44,59,63]

Online Connections and Support

The advent of widespread Internet access made the application of patient education in a global learning environment a reality. Current literature includes references to the development of programs that are meant to provide information in the context of an online social network of health care providers as well as fellow patients. Access to these online learning environments is provided to patients in their homes[17,19,23,56–58] or in public libraries.[68] The following studies describe these applications and provide data to support their usefulness in effecting positive health care outcomes: "Diabeto,"[19] a program described previously, is delivered using "Minitel," the French national videotext network. Patients have access to decision support, electronic mail, and an information component. Patients reported liking the home access, and they especially liked the individualized interaction and the fact that it was free. "Computerlink"[57] was developed to provide access to support for caregivers of patients with Alzheimer disease. Initial research results indicated that the online approach was successful in promoting collaboration with members of the health team and providing access to information. A later study expanded this format to include caregivers of persons with AIDS. This group used the system even more than did the caregivers of patients with Alzheimer disease and found that access to private support and consultation was particularly valuable.[56]

The Computerized Health Enhancement Support System (CHESS)[58] was developed as an online interactive computer-based system to provide information, referral, and support for patients. Target populations for CHESS included adult children of alcoholics, patients with HIV, patients with breast cancer, and victims of sexual assault. Research and usage statistics revealed that the system was found to be most useful for patients with HIV and patients with breast cancer.[58] In a study of 96 parents of children with leukemia, Tetzlaff[26] found that parents were enthusiastic about the use of online education in supporting the care that their children were receiving at home. An additional finding of this study supports customizing information to gender, educational level, and stages of disease. In four of the five Internet-based studies described in this paper, the most often used resources were related to support.[26,56–58] When decision support was available, it was used least often.[56–58] Tetzlaff[26] further noted that interactive video was preferred to text.

Patient–Provider Relationships

Twelve studies explored the relationship between patients and care providers when computer-based strategies had been implemented. Three studies noted that computer-based patient education supports the communication that occurs between patient and provider.[10,12,13] Other researchers indicated that patient–educator contact is an important factor in ensuring patient motivation and the involvement needed to facilitate lifestyle changes.[7,9,10,16,30,48,65] Tetzlaff[26] examined electronic communication and educational interventions for parents of children with leukemia and found that parents preferred live interaction with patient educators for some types of communication.

Discussion

In a number of studies, the use of computer-based education had a positive impact on clinical outcomes, knowledge acquisition, self-care management, and skill development. Few authors report untoward outcomes resulting from the application of computer-based patient education in the clinical setting. The following discussion will summarize the related literature and the unfavorable, favorable, and inconclusive findings in an effort to provide a balanced review.

As the focus of health care delivery environments moves toward health promotion and the management of chronic disease, it appears that computer-based patient education will have a greater role in supporting patients' understanding of their personal disease management plan. The literature reviewed in this report supports the conclusion that computer-based patient education has the potential to blend with and strengthen the established health care learning environment. Because the broad potential of this new information resource is only now beginning to be tapped, it is important that educators understand how these technologies can best support the practice of health care education.

It is likely that a number of patient education systems that could contribute to this body of knowledge were not included in this review. In addition, a number of worthwhile systems that are used as information resources were not included because no evaluation studies were identified that describe their use as electronic learning interventions. A good example is the National Cancer Institute's PDQ system, which provides up-to-date cancer information to lay persons over the Internet.

While every effort was made to conduct a comprehensive, systematic, and thorough review, the author acknowledges that the positive effects of computer-based patient education reported in this review may have been exaggerated by publication bias. It is also suggested that the participation of additional reviewers in this systematic review might have reduced the selection bias that is possible with single-author review.

Technology is providing innovative ways for patients to extend their world. Online communication offers new avenues for making crucial connections between patients and health care providers, and online support groups expand the team approach to include other patients facing similar health challenges. Patients who are dealing with disabling conditions are able to use technology to "virtually" participate in activities that would otherwise not be possible. The social integration and sharing of knowledge that occurs through these new connections may increase involvement in learning and expand patients' understanding of their medical conditions.

Research related to the role of technology in the delivery of information and the acquisition of knowledge raises some important issues. In 17 of 21 research reports, patients who participated in computer-based patient education experienced significant changes in the desired outcomes. These studies supported the positive impact that computer-based patient education has on knowledge acquisition and the communication that occurs between patient and provider. Several researchers noted that their studies produced no difference in knowledge acquisition when computer-based education was compared with traditional patient education. These authors concluded that if computer-assisted instruction can deliver some information as well as could patient educators, then it may serve to support the educational process where no educator exists. Although patients may benefit from computer-assisted instruction when no educator is available, being able to reproduce information is not equivalent to understanding and being able to apply new knowledge. It is important to understand how the patient is processing the information and translating this understanding into action. No studies emerged as a result of this literature review that explored the value of the form that the interaction takes. The focus has been on the message and not the messenger. If we can evaluate the best way to deliver the message, then we will better understand how to use technology to its fullest advantage as a health care learning resource and also know when it is most appropriate to rely on the human interaction that occurs between patients and providers.

Patients bring varied experience and learning preferences to the educational environment. To best meet their individual learning needs, patients need opportunities to learn in ways that work for them. At various points during the learning processes, patients need opportunities to reflect on what they have learned and what they still need to know. Computer-based technologies that customize the assessment and education intervention processes should support this important educational concept. To individualize patient education materials, developers must consider the unique needs of the target audience to include culture, age, race, gender, and social issues and physical and psychological or cognitive disabilities. The studies reviewed in this report suggest that the unique needs of special patient groups do not appear to have

a negative impact on the effectiveness of computer-augmented learning. However, the number of published studies that examined these important personal characteristics was small, pointing to the need for further investigation into ways to best address diverse patient needs across the health care continuum.[28,30,42,47,51]

Conclusions

Although the research reviewed in this report indicates that patient education technologies consistently provided positive outcomes, there are several important areas requiring further study. Exploration of these areas would strengthen the arguments that call for an increased application of these tools. The areas in which the deficits in research-supported knowledge occurred are: 1) impact of the methodologies on long-term health care outcomes; 2) interaction between race, culture, and mode of learning; 3) interaction of age and learning styles; 4) impact of mode of knowledge acquisition and the patient's ability to solve health care problems; 5) patients' retention of knowledge over time; 6) cost–benefit analysis and cost-effectiveness; 7) consequences of providing information without the opportunity to validate comprehension, understanding, and ability to integrate the information.

The most outstanding research deficits occur in the area of evaluation of the long-term outcomes of computer-based patient education. All but five of the research studies reviewed in this report focused on knowledge acquisition, skill development, and clinical outcomes over short intervals. Information related to the retention of knowledge over extended periods will be crucial in determining the cost–benefit ratio of these technologies. Although it appears that computer-based education is an effective and efficient way to teach skills and provide information to the patient, it is not clear whether it is valuable when information must be regularly updated or when skills require ongoing remediation. If knowledge acquisition diminishes over time, the overall value of computer-based education would be greatly reduced, thus adding support to the need for customized information that is flexible enough to adapt to the dynamic nature of patients' ongoing information needs and changes in their personal health and social circumstances. To capitalize on the advantages of new learning technologies, we need to broaden our understanding of how people learn best using technology and examine the impact of this knowledge on health care outcomes over time. This can only be accomplished through further research.

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