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Effective and Sustainable Multimedia Education for Children With Asthma: A Randomized Controlled Trial

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Traditional asthma education has been found to be time-consuming and limited in terms of availability. Our goal was to improve asthma care by meeting special needs of children with asthma and by building on their skills in using new technologies. Multimedia asthma education occurred through the viewing of short, animated vignettes on an exam room computer. Evaluation of 228 children showed significant improvement in days of asthma symptoms ($p < .01$), in emergency room visits ($p < .05$), in school days missed ($p < .05$), and in days of activity limitation from baseline to the year-end follow-up ($p < .05$). Effective multimedia education, if integrated into pediatric practice to supplement existing asthma care, can improve clinical outcomes.

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Asthma is the most common chronic disorder of childhood, accounting for 14.7 million lost days of school annually, and is the third-ranking cause of hospitalizations among those younger than 15 years of age (Centers for Disease Control, 2005a). There are nearly 8.6 million asthmatic children in the United States (American Lung Association, 2001). In 1998 3.8 million children had an asthma episode; there were 5.8 million outpatient visits, 867,000 emergency department visits, and more than 89,000 hospitalizations (Centers for Disease Control, 2005b). In addition to the physical and emotional burden of asthma on children and families, it is an expensive chronic disease, with billions of dollars spent on asthma-related health care each year (Gergen, Mullally, & Evans, 1988; Gottlieb, Beiser, & O'Conner, 1995; Lozano, Fishman, Vonkorff, & Hecht, 1997; Weiss, Sullivan, & Lyttle, 2000; Wise, 2004).

Special skills are required to control and manage asthma, that is, avoidance of asthma triggers, correctly taking the prescribed control medicine, early assessment and timely reporting of signs and symptoms, timely rescue treatment, and seeking urgent care when necessary. Patient and caregiver education, as recommended by the National Asthma Guidelines (National Asthma Education and Prevention Program, 1997), has been recognized as an important component of quality asthma care. Despite reported increase in patients' and caregivers' knowledge of asthma (Hindi-Alexander & Cropp, 1984) and health outcomes by others (Evans et al., 1999), patient education programs are often ineffective in improving adherence behaviors such as compliance with medication taking (Colland et al., 2004; Garrett, Fenwick, Taylor, Mitchel, & Rea, 1994), reduction in school absences (Hilton, Sibbald, Anderson, & Freeling, 1986), and asthma self-management behavior attribution (Shegog et al., 2001).

Due to commitment of a large amount of financial and human resources to traditional forms of patient education, resource-conserving educational methods such as camps and group education have been used but are hampered by the limitation of one-time delivery, nonindividualized information, and limited reach. Assessment of learner comprehension is rarely a component of these approaches. Furthermore, due to the "washout" effect of learning, patient education needs to be frequently refreshed and reinforced (Hughes, Mcloed, Garner, & Goldman, 1991). New methods of patient education are needed that can overcome these barriers while complementing clinical approaches to care.

The unique features of computer-based multimedia education have been employed to overcome the limitations of traditional education methods. Computerized educational interventions in a variety of health conditions have reported positive health outcomes (Krishna, Balas, Spencer, Griffin, & Boren, 1997). Programs such as IMPACT© (Interactive Multimedia Program for Asthma Control and Tracking) provide unique capabilities of multiple tutorial sessions, interactivity, tracking of learner comprehension and progress, symptom monitoring, and personalization of information to the specific needs of a child with asthma (Adsit, 1996; Kahn, 1993; Skinner, Siegfried, Kegler, & Strecher, 1993).

Multimedia programs can simulate real-life situations and teach decision-making skills to patients and caregivers, provide feedback and reinforcement, and enhance patient and provider communication by involving children in their own care (McPherson, Glazebrook, & Smyth, 2001).

At the time of IMPACT's development in 1998, reference to only one multimedia computer program, Asthma Command, was found in published literature (Rubin, Bauman, & Lauby, 1989). Other asthma education computer programs have been developed in the intervening years (Bartholomew et al., 2000; Homer et al., 2000; McPherson, Forster, Glazebrook, & Smyth, 2002; Yawn et al., 2000). A recent pilot study of a multimedia program called Asthma Files assessed children's knowledge of asthma triggers (McPherson et al., 2002). IMPACT differs in that the previously mentioned programs teach about asthma through a game children play.

Development and evaluation of IMPACT makes a significant contribution to this body of literature as it sets precedence for effective multimedia asthma education in a clinical setting. A randomized controlled trial design, the gold standard in evidence-based medicine, was used to evaluate the program. We formulated the following hypotheses (H):

H1. There will be a significant difference between control and intervention groups in increase in asthma knowledge among children with asthma and their caregivers.
H2. There will be a significant improvement in health outcomes, quality of life, functional disability, and reduction in health care resource utilization between visits among children with asthma.
H3. There will be a significant difference between control and intervention group children in improvement in health outcomes, quality of life, and functional disability and in reduction in health care resource utilization among children with asthma.
H4. There will be a significant improvement in lung function of children in the intervention group than those in the control group, as measured by spirometry.
H5. Interactive multimedia asthma education will be acceptable to children and caregivers.

Results for H1, H2, and H3 were presented in an earlier publication (Krishna et al., 2003). Therefore, we only briefly describe them here. Detailed analysis and findings for H4 and H5 and additional information are presented here.

METHODS

A two-group pre–post randomized controlled study was designed to evaluate the efficacy of the multimedia asthma education program, IMPACT. Measurements

were to be taken at three visits over a 12-month period: baseline, 3 months, and 12 months.

Participants

Patients and their caregivers were selected for the study if a child had been given a confirmed diagnosis of asthma by a pulmonologist, the child was younger than 18 years of age, and child and caregiver were willing to sign a consent form. To make later implementation to the real-world environments as easy as possible, all children were invited to participate regardless of their asthma severity level and no child was excluded due to physical disability.

The pediatric pulmonary clinic at the University of Missouri sees about 1,000 children a year, with 2,500 scheduled visits. Approximately 15% of the children are non-White. Children are often referred to the clinic by their primary care providers. An attrition rate of 10% was observed with 246 of 1,000 children seen at the clinic enrolled into the study, and data were analyzed on an "intention-to-treat" basis for 228 participants who participated in at least one follow-up visit. Altogether 18 children (7%) dropped out (reasons cited were lack of time, 2; routine follow-up interval was too great (1 year); change in diagnosis of asthma, 1; other complications, 1; travel time too long, 1; technical difficulty while using the program, 1; and did not complete first-visit forms even after signing the consent form, 11). Of the dropouts, 12 were boys, 7 were in the 0 to 6 age groups, and 10 were from control groups. Except for two teenagers who gave schoolwork as the reason for withdrawing, explicit requests to drop out came from parents. Only one child was excluded by researchers due to change in diagnosis. All dropouts had mild asthma.

Control group—Standard care. The control group received standard care provided to all asthma patients attending the Pediatric Pulmonary Clinic at the University of Missouri–Columbia Health Care Clinics. This care was based on Expert Guidelines (NAEPP, 1997) and included asthma education by verbal instructions, demonstration of technique, and printed asthma information fact sheets to take home. Printed asthma education fact sheets were part of a series titled Caring for Kids with Asthma© (Children's Hospital, 1997) developed to provide information to all first-time patients who are diagnosed with asthma at the Pediatric Pulmonary and Allergy Clinic. Information in these fact sheets covers disease-specific information about asthma such as the pathophysiology of disease, asthma prevention and control measures, triggers, medicines, and various inhalers. Information sheets were illustrated by a graphic artist who used more than 80 sketches and drawings to present the material in an interesting and easy-to-understand format. These two-sided fact sheets have basic information on the front written at a second-grade reading level and "notes to parents" on the back,

written at the sixth-grade level. The asthma education materials were authored and approved by a multidisciplinary team of professionals from pediatric pulmonary medicine, respiratory therapy, pharmacy, nursing, and child life and educational media specialists. Materials were field-tested among family members and caregivers who completed a questionnaire.

Intervention group—Standard care plus interactive multimedia. The intervention group participants were provided with standard care, including verbal instruction and asthma fact sheets, plus the interactive multimedia asthma education during routine clinic visits. The Web-enabled asthma education program IMPACT was designed and produced by the Advanced Technology Center at the University of Missouri–Columbia. It consists of 44 vignettes (cartoons) covering the basic pathophysiology of asthma, triggers of asthma, quick-relief and control medicines, and strategies to control and manage asthma. Each vignette presents one central concept followed by one or more questions to assess asthma knowledge or management skills. Two cartoon children (a girl and a boy) and "Mr. O2," a fictional character, guide the user through the program using both children and adult voices to narrate the IMPACT vignettes. The program ends with a game to identify asthma triggers in and around one's home.

The IMPACT program was designed on a computer-assisted instruction model to keep track of the learners' progress. Each time a learner logs into the tutorial, the session begins with remedial instruction for vignettes previously viewed but not comprehended (learner previously viewed material but provided an incorrect answer). To handle the problem of washout, the tutorial presents again any vignette completed more than 6 months previously. All 44 vignettes can be viewed in a little over 1 hr in a single sitting; however, several shorter sessions are appropriate for most learners. Use of multimedia (color, audio, and animation) make it possible to convey concepts readily, so reading level was less important in the instruction. The IMPACT program is interactive and provides immediate feedback to the user about whether a question was answered correctly or incorrectly. A unique feature of the program is its ability to track mastered concepts. At the end of the session, printed report documents measure mastery and the severity of asthma symptoms and medications used, according to the child's input.

Theories used in the development of IMPACT included the theory of learning and retention (Dale, 1969), self-care deficit (Orem, 2001), and behavior change (Bandura, 1982). According to Edgar Dale's Cone of Learning, passive methods of learning lead to a maximum of 50% content retention whereas interactive learning methods provide up to 90% retention of the content. Interactive multimedia gets the user actively involved with the program, leading to the likelihood of better learning and retention. The Self-Care Deficit Nursing Theory (Orem, 2001) provides a listing of health care demands that when applied to a particular illness condition provides a framework for the identification of actions that must be

taken to regulate the particular condition. Once the regulatory actions were known, a model of self-regulation was used to elucidate critical knowledge and behaviors for self-appraisal, symptom-reporting, taking actions to mitigate symptoms, and planning to improve future control.

Procedures

The study was approved by the Institutional Review Board of the University of Missouri–Columbia. Both the pilot, which was completed January 20 and 21, 1999, and the full-scale trial were conducted at the University of Missouri Health Care Pediatric Pulmonary Clinic. Participants for the study were enrolled between February and October 1999. Following the consent from the participating children and caregivers, the medical record number was used to randomize to one of two groups: the standard care group and the standard care plus interactive multimedia education group. Groups were further subdivided in a 0 to 6-year-old group and a 7- to 17-year-old group from an operational point of view and to match the age group of Juniper's self-administered PAQLQ (Juniper et al., 1996a). Children in the 7- to 17-year-old group were to complete the survey forms along with their caregivers, whereas for children 6 and under, only caregivers were to complete the forms. During the initial visit, demographic data were collected. Other surveys were administered at baseline, 3 months, and 12 months.

All participants received standard care that included printed asthma education materials, 30 to 45 min of verbal instructions and technique demonstration from a nurse practitioner during the initial visit, and shorter sessions during subsequent visits. In addition, the intervention group children along with their caregivers used the multimedia program while waiting in the consulting room to visit with a provider or undergo a clinic procedure. An identification number and a password were provided for confidential program access. Users were shown how to log in, navigate, and exit the system. Caregiver and child watched the program together, but they were requested to fill out the forms independently. Younger children could seek help with reading of the questions if they did not understand, but not with answering them.

Measures and Instruments

To test the previously stated hypotheses, the following measures were assessed: knowledge of asthma, asthma symptoms and medicine use, quality of life, functional disability, and asthma-related health care resource utilization. Except for the two quality of life questionnaires, all instruments were developed by the authors and were not validated independently.

Demographics. Demographic data were obtained using Study Participant Enrollment forms for patients and caregivers. All caregivers completed this form. In addition, children in the 7- to 17-year-old group also completed one.

Knowledge of asthma. Knowledge was measured using a multichoice 60-item questionnaire. In the absence of a validated asthma knowledge instrument, a 60-item test was developed for use in this study to cover what children and caregivers need to know about asthma and its self-management. Questions following each vignette cover the information presented. Scenarios are designed to assess the application of concepts to self-management and decision-making skills in simulated real-life situations. Of 11 scenarios, 2 cover trigger avoidance and 9 cover making a correct decision about taking the control or quick-relief medicine, recognizing early signs and symptoms and taking an appropriate action, or communicating with the asthma care team. The reliability and validity of the instrument were not independently evaluated.

Asthma symptoms and medicine use. Questions to measure asthma symptoms (five items), medicine use (four items), and asthma-related health care resource utilization (four items) were part of the form, Asthma Summary Since Last Visit, completed at baseline as well as at the two follow-up visits.

Asthma-related health outcomes. Health outcome variables measured included number of reported days with asthma symptoms such as chest tightness, shortness of breath, wheezing, coughing, and asthma exacerbations or flare-ups; days of quick-relief medicine use; days of activity limitation; nights of disturbed sleep; and quality of life. All except quality of life were part of the form titled Asthma Summary Since Last Week.

Health care resource utilization. Resource utilization was measured by the reported number of unscheduled physician visits, emergency room visits, hospitalizations, and total number of hospital days for all asthma hospitalizations on the Asthma Summary questionnaire.

School absences. Number of reported school days absent due to asthma was a measure of functional disability and was included on the Asthma Summary Since Last Visit questionnaire.

Quality of life. Children's and caregivers' quality of life were assessed through the Pediatric Asthma Quality of Life Questionnaire (PAQLQ; Juniper et al., 1996a) and Caregiver's Quality of Life Questionnaire (PACQLQ; Juniper et al., 1996b). The two instruments use 7-point Likert- type scales and were developed and validated by Juniper and colleagues at McMaster University, Canada, among fifty-two 7- to 17-year-old children and their primary caregivers. In those studies, the PACQLQ was able to detect quality of life changes in those caregivers who changed ($p < .001$) and to differentiate these from those who were stable ($p < .0001$). The PAQLQ was able to detect quality of life changes in those patients who altered their health status ($p < .001$) and to differentiate these patients from

those who did not ($p < .0001$). The PACQLQ and PAQLQ were found reproducible in participants who remained stable with Intra Class Correlations = 0.84 and .95, respectively.

Lung function. Pulmonary function of children 5 years and older was assessed by recording four values, Forced expiratory volume in 1 sec (FEV_1) and forced expiratory flow 75% of predicted (FEF75%) before and after bronchodilator (albuterol) treatment.

Acceptability of interactive multimedia. To find out if the program was acceptable to children and caregivers who used the program, a 4-point Likert scale questionnaire ranging from 1 (*very easy*) to 4 (*very difficult*) was administered during the third visit to those who had completed the program 50% or more. The questionnaire asked six questions: How easy was it, how interesting was it, how enjoyable was it, how easy was it to navigate, their preferred method of learning about asthma, and if they would use it again.

RESULTS

Data Analytic Plan

A sample-size calculation determined that 100 children in each of the two groups would have 80% power to detect an effect size of .40 using a two-group *t* test with a .05 two-sided significance level. Between-visit differences were used to determine changes and the direction of change in each of the variables. A Cochran–Mantel–Haenszel nonparametric test (Mantel & Haenszel, 1959) was used to determine significance of difference between control and intervention groups, controlling for baseline knowledge scores through stratified analysis.

Demographic characteristics of the two groups were comparable at baseline. Control and intervention children were not significantly different for boys (33% vs. 32%), girls (20% vs. 15%), Whites (45% vs. 41%), African Americans (4% vs. 4%), others (4% vs. 2%), elementary education and below (31% vs. 25%), junior high (19% vs. 20%), and high school (3% vs. 3%), respectively. At enrollment time, use of a computer at least one day per week was reported by 38% of 7- to 17-year-old children, and Internet access from home was reported by 18% only. At baseline, caregiver demographics of the two groups were the following, respectively: women (54% vs. 46%), White (47% vs. 43%), African American (3% vs. 4%), high school (27% vs. 28%), some college (20% vs. 17%), full- or part-time employment (39% vs. 35%), homemaker or student (14% vs. 12%), computer use 1 or more days per week (34% vs. 33%), and Internet access from home (21% vs. 18%).

Asthma knowledge. First, we hypothesized that there would be a significant increase in asthma knowledge between visits among all participants. Analysis using student's *t* tests indicated a statistically significant increase in knowledge of asthma at 3 months and 12 months, respectively, among all caregivers and children ($p < .01$). Increase in knowledge scores was greatest among 7- to 17-year-old children with asthma. Second, we hypothesized that there would be a significant difference between control and intervention groups in increase in asthma knowledge. Compared to the control groups, all three intervention subgroups had a significantly greater increase in asthma knowledge scores ($p < .01$).

Health outcomes, resource utilization, and quality of life. We hypothesized that there would be significant improvement between visits in health outcomes, resource utilization, functional disability, and quality of life measures among intervention-group participants. Results revealed a significantly greater decrease among intervention-group children in school days missed and of activity limitation ($p < .01$).

We further hypothesized that there would be a significant difference between control and intervention group children in improvement in health outcomes, quality of life, functional disability, and in reduction in health care resource utilization among children with asthma. A significant difference between groups was found for rate of decrease in the days with asthma symptoms and number of emergency room visits ($p < .01$). No significant difference was found for other outcomes, utilization variables, or caregivers or children's quality of life ($p > .05$).

Lung function. All children capable of performing spirometry, usually 5 years and older, performed the procedure every time they had a scheduled visit. A respiratory therapist assisted them with the spirometry, and results were recorded by a computer. To compare the groups for lung function, the values of FEV_1 and FEF75% before and after bronchodilator treatment were compared. A positive difference between visits was considered improvement in airways. The Wilcoxon rank sum test was used to compare groups at baseline and also at year-end. No significant differences between the control group and the intervention group were found in lung function as measured by FEV_1 and FEF75% at 12 months ($p > .05$; Table 1).

Acceptability of interactive multimedia. It was hypothesized that multimedia intervention would be acceptable to users of the asthma education program. Three groups—children 7 to 17 years, caregivers of children 0 to 6 years, and caregivers of children 7 to 17 years—were compared using analyses of variance. The three groups were significantly different in program being interesting, $F(2, 58) = 3.98$, $p < .05$; program being enjoyable, $F(2, 58) = 18.58$, $p < .01$; and ease of navigation, $F(2, 55) = 5.67$, $p < .01$. However, there was no difference among groups in ease of use, computer as the preferred method of obtaining asthma information, and

TABLE 1
Lung Function as Measured by Spirometry

		Baseline		*12 Months*	
Group	*Variable*	*M*	*SD*	*M*	*SD*
Control[a]	FEV_1 before	94.63	17.32	94.44	18.41
	FEV_1 after	97.53	16.46	94.97	18.60
	FEF 75% before	67.43	31.55	67.27	26.33
	FEF 75% after	75.00	36.83	73.70	29.97
Intervention[b]	FEV_1 before	95.20	15.19	92.11	16.27
	FEV_1 after	99.10	16.45	94.72	20.05
	FEF 75% before	68.93	27.40	67.74	22.81
	FEF 75% after	74.88	27.53	73.72	26.04

Note. FEV = forced expiratory volume.
[a]Baseline, $n = 68$; 12 months, $n = 41$. [b]Baseline, $n = 59$; 12 months, $n = 35$.

whether they will use it again ($p > .05$). A post hoc analysis using the Tukey test revealed that, for program as interesting, children significantly differed from caregivers of younger children ($p < .05$) but not from caregivers of older children. Regarding the program as enjoyable and ease of navigation, children were significantly different from both groups of caregivers ($p < .05$). Compared to caregivers, a smaller percentage of intervention children, 93% of who were between the ages of 9 and 14 years, found the program interesting (54% vs. 78% and 91%), enjoyable (50% vs. 67% and 91%), and would use it again (62% vs. 67% and 86%). A subgroup analysis of preadolescent children and adolescents showed no significant differences between the two age subgroups, but a smaller percentage of adolescents compared to the preadolescents found the program interesting (Table 2).

DISCUSSION

This study contributes to a growing body of research that demonstrates the utility of multimedia education in clinical care. Many asthma education programs using multimedia such as Asthma Control (Homer et al., 2000), Air Academy: The Quest for Airtopia (Yawn et al., 2000), and Asthma Files (which is still under development; McPherson et al., 2002), report an increase in children's asthma-related knowledge. Watch, Discover, Think, and Act, also a computer game, showed improvement in knowledge and also in some health outcomes of children in a study by Bartholomew et al. (2000). Yawn et al. assessed no health outcomes, and a study by Homer et al. did not show any significant differences between groups in any of the health measures. Our study uses a nongaming approach to

TABLE 2
Acceptance of Interactive Multimedia: Children 7 to 17 Years

	Under 12 Years[a]		*12 Years and Older*[b]	
Questions	*n*	%	*n*	%
Very/somewhat easy	7	100	15	94
Very/somewhat interesting	5	71	7	44
Very/somewhat enjoyable	5	71	6	38
Very/somewhat easy to navigate	5	71	13	81
Favorite method–computer	6	86	15	94
Will use IMPACT© again	6	86	11	69

Note. IMPACT = Interactive Multimedia Program for Asthma Control and Tracking.
[a]$n = 7$. [b]$n = 16$.

asthma self-management education and disease monitoring that integrates the learning activity into the routine workflow of a busy specialty clinic. Our focus was on presenting information in a straightforward manner in simple-to-understand language from which both children and caregivers can benefit. The demonstrated power of multimedia education to affect additional knowledge gains and clinical improvements in a setting where asthma education was a longstanding priority was encouraging. The additional, unexpected finding of reduced doses of inhaled corticosteroids while maintaining the lung function that they entered the study with among the intervention group at the third visit accentuates the significance of clinical improvements (Krishna et al., 2003).

The fact that the study did not involve additional sessions or home use of the program so as not to put those without computer access at a disadvantage is an important consideration for assessing effectiveness and sustainability of an intervention in clinical settings. Participants used IMPACT in the exam room, in between the nurse, medical student, respiratory therapist, and physician interactions, using it for an average of 15 to 30 min during each visit. After an initial 5-min lesson on how to log in and navigate, little staff time was required for the intervention. Lack of experience with computers did not pose any noticeable barriers to program use. The format of the program facilitated efficiency in utilization of patient and family time and coordination of instruction with the delivery of other services. Because most vignettes took only 1 min to watch, learning could occur in small increments between other clinic activities. Unlike a videotape, vignettes "wait" for learner response before proceeding and can be replayed with the click of a button. This particular departure from traditional instructional approaches is well suited for clinical settings where several relatively brief waiting periods could be filled on demand with learning opportunities (Guendelman, Meade, Benson, Chen, & Samuels, 2002; Porter, Cai, Gribbons, Goldmann, & Kohane, 2004).

A number of benefits afforded by the software could have contributed to increased knowledge gains and improved clinical outcomes. Manual skills involved in asthma self-care, such as inhalation of medications and performance of peak flow maneuvers, are intrinsically clearer when presented by animation (McPherson et al., 2001). Information presented through multimedia would have a clear advantage for a learner with a low reading level. Other activities and simulations that were incorporated into the software probably improved communication with clinicians and thus contributed to improved clinical outcomes. IMPACT included specific exercises to improve participants' ability to identify and describe their asthma symptoms. This is consistent with the theory of self-regulation that points to the critical role of self-appraisal, action taking, and communication by the individual with asthma (Clark, Gong, & Kaciroti, 2001). Because asthma guidelines are largely based on evaluation of an individual's symptom pattern, it is likely that improved assessment and description on the child's or parent's part led to more appropriate care and better outcomes.

Some limitations of the study are noted here. Because the study was conducted in one pediatric specialty clinic serving primarily rural, White children, results may not apply to other populations with different sociodemographic characteristics such as inner-city populations or those of other cultures. A 1-week recall period for the quality of life instrument may not adequately reflect the variable asthma-related quality of life over several months. The knowledge instrument was not validated prior to its use in this study. Also, the version of the program used in this study does not track which vignettes were accessed and how often; it would be helpful to have this information. Another limitation to note is that not all children entering the study returned to the clinic to complete the follow-up visits. This may have occurred for various reasons, such as children returning to their primary care providers or having their asthma under control due to mild asthmatics. This study did not try to contact such participants to solicit a visit or to gather additional information. These limitations should be considered when implementing this program in other clinical practices or using it in other environments.

IMPLICATIONS FOR FUTURE RESEARCH

Evaluation of IMPACT has demonstrated encouraging results and operational feasibility in one pediatric pulmonary clinic population. Future research should be done at primary care clinics, community clinics, and schools for inner-city populations and various cultural groups. Research should also be conducted in different parts of the United States and perhaps of the world to see if the program is as beneficial as it was in one clinic. Program acceptance data were provided by a small subset of children and caregivers and may not adequately reflect the opinions of all the users. Data from a larger group of users should be collected to

assess the acceptance of the program. The multimedia design aspect such as using cartoon characters and simultaneous use of text and audio may have limited appeal to teenagers. Multimedia programs should be modified for different age groups of children and a separate one designed for caregivers. These versions should be evaluated in the target populations.

The presence of caregivers introduced a complex variable. For school-age children, it was not possible to distinguish between clinical improvements resulting from learning on the part of a child from improvements related to the caregivers' knowledge gains. It is unclear to what extent parent and child learning are synergistic. Very young children were unable to use the program. Their caregivers who demonstrated knowledge gain and behavior changes were likely responsible for observed clinical outcome improvements for very young children in the intervention group. Further research is needed to understand the interaction between parent and child effects.

IMPLICATIONS FOR PRACTICE

Asthma education must be integrated into patient's routine care (CAMP, 1998). There are many barriers that make it challenging to provide asthma education in clinical settings. Lack of resources, time, and expertise to provide education; lack of patient–provider communication; failure to assess asthma knowledge and competency of asthma management skills; difficulty in monitoring and facilitating behavior change; and lack of reimbursement for delivering education are just a few. Multimedia technology can be utilized for overcoming some of these barriers by supplementing care (McPherson et al., 2001).

Health care providers could prescribe specific vignettes (on triggers, medicines, or inhaler technique) depending on a child's need. For example, if a child was having asthma attacks because he or she was not avoiding certain triggers or was not in compliance with the prescribed medicines, he or she could be asked to review the vignettes on triggers or medicines only. Children or their caregivers might be encouraged to complete the prescribed vignettes in the clinic, home, school, community center, or a library where the Web-based program could be accessed. Patients can also generate a printout of their educational progress and symptom report to take to their next clinic visit, enhancing patient–provider communication, although program design makes it possible to review learner records regardless of where the learning took place. Clinicians interested in using the program will need to see which format works best in their clinical environment. The IMPACT program is currently in use at the University of Missouri Health Care Pediatric Pulmonary Clinic. A majority of children at this clinic, 6 to 12 years of age with persistent asthma, use the program. However, most children currently also receive a CD to take home and complete the lessons off-site.

It is important that successful interventions are translated into clinical practice to benefit patients and their families who bear the greatest burden of asthma in children. It takes 17 years to translate 14% of original research into clinical practice (Balas & Boren, 2000). Results of this study demonstrate that in this age of technology it is possible to incorporate multimedia education into a busy clinical practice to supplement standard care in asthma management (Krishna et al., 2003). Web-based programs are readily updated and managed with minimal distribution costs. Computer-based multimedia approaches coupled with interactivity and Web-based secure individual records supports incremental learning over time and across settings. Disparities in asthma services could be reduced through widespread availability of this type of high quality, evidence-based instructional media in hospitals, clinics, schools, libraries, pharmacies, and other community settings.

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