

Technology-Based Interventions for Asthma—Can They Help Decrease Health Disparities?



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Asthma is a condition that has consistently demonstrated significant health outcome inequalities for minority populations. One approach used for care of patients with asthma is the incorporation of technology for behavioral modification, symptom monitoring, education, and/or treatment decision making. Whether such technological interventions can improve the care of black and inner-city patients is unknown. We reviewed all randomized controlled trial technological interventions from 2000 to 2015 performed in minority populations. A total of 16 articles met inclusion and exclusion criteria; all but 1 was performed in a childhood or adolescent age group. The interventions used MPEG audio layer-3 players, text messaging, computer/Web-based systems, video games, and interactive voice response. Many used tailored content and/or a specific behavior theory. Although the interventions were based on technology, most required additional special staffing. Subject user satisfaction was positive, and improvements were noted in asthma knowledge, medication adherence, asthma symptoms, and quality of life. Unfortunately, health care utilization (emergency department visits and/or hospitalizations) was typically not improved by the interventions. Although no single intervention modality was vastly superior, the computer-based interventions appeared to have the most positive results. In summary, technology-based interventions have a high level of user satisfaction among minority and urban/low-income individuals with asthma, and can improve asthma outcomes. Further large-scale studies are needed to assess whether such interventions can decrease health disparities in asthma. © 2016 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2016;4:1135–42)

Key words: Asthma; Health disparities; Technology; Computers; Inner-city; Text messages; Cellular phones

Asthma is a chronic inflammatory disease of the lungs, and also a health condition with significant income and racial inequalities in outcomes. Although the overall prevalence of asthma

in the United States is 8.0%, this rate is significantly higher (10.3%) among non-Hispanic blacks.¹ Furthermore, the black-white asthma disease severity and control disparity is even wider. For example, the hospital discharge rate for asthma was 8.7 per 10,000 for whites, whereas it was 29.9 for blacks; mortality rates were 8.4 per million for whites and 25.9 per million for blacks.² Many factors may explain such disparities including both environmental and underlying genetic influences. Urban areas, which often have a predominance of black patients, are heavily concentrated with risk factors associated with asthma such as air pollution,³ cockroaches,⁴ dust mites,⁵ poor diet,⁶ poverty,⁷ stress,⁸ and violence.⁹ Compared with whites, blacks visit an asthma specialist less often, and use an inhaled corticosteroid for persistent asthma less frequently.^{7,10–12}

Although no single intervention may be able to address all factors associated with asthma health disparities, a novel approach is the use of technology. Technological interventions have the ability to assist in the delivery of behavioral, monitoring, educational, and shared decision-making activities. Examples include the use of computer programs, short message service text messaging, Internet Web sites, social media groups, and MPEG audio layer-3 (MP3) players. Although technology-based interventions are innovative, the medical community has questioned whether these could be effective in reducing asthma morbidity in communities of color with high need, but low access. In this article, we summarize published reports on technology-based interventions that have been evaluated in black and urban/low-income individuals with asthma.

METHODS

To complete this narrative review, PubMed, OVID, PsychInfo, and CINAHL searches were conducted for abstracts published between January 2000 and October 2015. The databases were searched using a combination of the text word “asthma” and one of the following text words: “technology base,” “computers,” “cellular phones,” “outcomes,” “texting,” “urban populations,” and “inner city.” Other combination words such as “social media” and “apps” did not yield successful searches. Abstracts that were not written in English and did not pertain to human subjects were excluded. The resulting abstracts went through a tiered elimination system and were excluded if they fell in any of the following categories: not related to asthma outcomes, not technology-based, not a randomized controlled trial (RCT), not a minority population, or not conducted in the United States. Also excluded were systematic reviews. The remaining abstracts were considered as candidate articles, and their full texts were examined by 2 investigators (C.L.M.J. and A.B.). The inclusion criteria were focused on minority and inner-city populations containing patients of all ages. Sixteen articles met inclusion and exclusion criteria for this review, and described 13 unique interventions (Figure 1).

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Abbreviations used

IVR- interactive voice response

MP3- MPEG audio layer-3

RCT- randomized controlled trial

Each article was assessed for the demographic characteristics of the study population (total subjects, age, and ethnicity) and percent retention. We also identified the specific type of electronic format used, number of sessions, and whether each intervention was a pilot study, theory-based, had tailored content, or required special staffing. To assess intervention efficacy, we focused on the following outcomes: health care utilization (emergency department visits, hospitalizations, urgent care visits), medication adherence, quality of life, asthma knowledge, *functional status* (defined as factors related to asthma control, including symptom-days/nights, days of restricted activity, school days missed, and days of changed plans), and positive participant feedback. The following categories of interventions were identified and are described below: MP3, short message service text messaging, computer/Web-based, and other (video games, interactive voice response [IVR], and Health Buddy).

RESULTS**MP3**

Young adults and adolescents frequently listen to music through audio portable media players, frequently referred to as MP3 players. A national survey performed by the Kaiser Family Foundation found that 76% of teenagers used an iPod or MP3 player.¹³ MP3 players may also play a role in improving health and health-related behaviors. For example, studies have been performed using MP3 players to screen for sleep apnea,¹⁴ to deliver positive messages to ventilated patients in the intensive care unit,⁹ and to improve adherence with human immunodeficiency virus medications.¹⁵ In asthma care, 2 randomized controlled pilot studies have been performed among black/Hispanic populations. Both were performed in teenage populations, and both by the same author using 2 interventions, and conducted among 2 cohorts of patients.

In the first pilot, Mosnaim et al¹⁶ randomized 28 inner-city black adolescents with asthma to receive (1) celebrity asthma messages or (2) general health messages (control group) between music tracks on an MP3 player. The celebrity asthma messages were delivered by black athletes and musicians in an attempt to reduce the stigma associated with having this chronic disease. At 12 weeks, there was a statistically significant increase in asthma knowledge (assessed by the ZAP Asthma knowledge test) among the celebrity asthma message group than among the control group. No other outcomes were evaluated.

More recently, Mosnaim et al¹⁷ randomized 68 inner-city black and/or Hispanic adolescents with asthma to an intervention that consisted of weekly peer support groups augmented by MP3 messages that promoted medication adherence, or a control group.¹⁷ The messages were developed and recorded by the adolescents themselves, and each participant recorded 2 to 4 messages gleaned from discussions at the weekly peer support meetings. These messages were set to music, and randomly played between favorite music tracks on an MP3 device provided to participants. At 10 weeks, there was no difference in adherence or asthma knowledge between the intervention and control groups. No further outcomes were measured.

Text messaging

According to the Pew Research Center, as of October 2014, 90% of American adults own a cellular phone and 81% of these adults use the phone for text messaging.¹⁸ Blacks are as likely or more likely to have a cell phone compared with those of other races.¹⁸ There is also data that patients with asthma are interested in using text messaging as a platform to improve asthma care. A study from 2011 by Baptist et al¹⁹ assessed the electronic preferences (email, text messaging, and social media) of patients with asthma between the ages of 12 and 40 years. Specific items investigated included overall use, interest in receiving asthma information, and interest in communicating with a health care provider about asthma through each of the electronic media modalities. Of the 145 participants included in the study, 20.1% were black and 60% were female. Among all participants, text messaging was the most commonly used electronic media, with 82.5% of the respondents stating they text at least once a week. There was also significant enthusiasm for the use of text messaging to receive asthma information; among those aged 18 to 29 years, 50% stated they would be interested in doing so. Text messaging has been used successfully for blacks as an adjunct treatment for obesity²⁰ and to increase physical activity²¹; however, this method was unsuccessful in improving outcomes of glaucoma treatment,²² nor was it able to increase vaccination rates.²³

Two pilot RCTs were identified that examined the use of text messaging among racially/ethnically diverse populations with asthma. In 2012, Seid et al²⁴ performed an RCT of 26

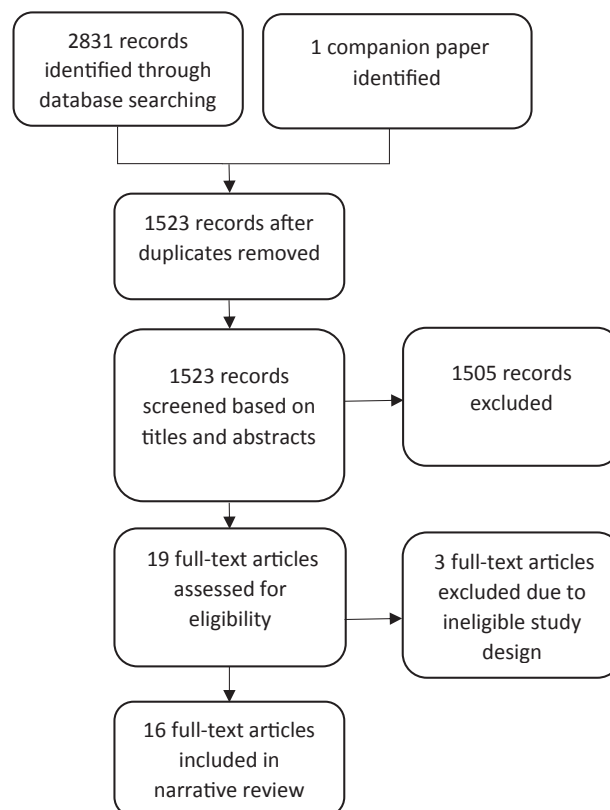


FIGURE 1. Selection of studies for narrative review.

low-income adolescents (77% black), with the intervention group receiving standard asthma education, motivational interviewing, self-management education, and text messages over a 1-month period.²⁴ The text messages were reminder and motivational messages selected by the participants. Participants were given a cell phone if they did not have one. The MI component of the intervention consisted of 2 in-person sessions with over 1-hour combined instruction. Control group participants received standard asthma education, and were given a cell phone if they did not have one. At the end of the trial, 16% of the intervention participants had withdrawn. The intervention was found to be feasible and acceptable by the participants, and at 2 months postintervention, quality-of-life scores were significantly improved compared with those in the control group. Although the intervention group did have a greater improvement in asthma symptoms compared with the control group, the results were not significant.

A second RCT was performed by Britto et al²⁵ in 2012. This pilot study was conducted among 23 black youths aged 12 to 22 years. The intervention consisted of text messages that the participants created themselves, and was delivered on a schedule of the participant's choosing. The primary outcome (assessed at 1, 2, and 3 months after enrollment) was the acceptability and usability of the system, and a secondary end point was asthma control. At the end of the trial, most of the intervention participants gave the intervention high scores for usefulness and acceptability. However, there was no difference in asthma control scores between the 2 groups.

Computer and web-based

Around much longer than short message service and MP3 players, computer-based asthma interventions began appearing in the literature around the year 2000.²⁶⁻²⁹ The underlying basis for computer-based programs was perhaps a combination of capitalizing on the overwhelmingly favorite pastime of youth and an emerging market destined to be larger than cinema and music.³⁰ An interactive multimedia asthma education program delivered by computer could be an effective method for responding to the complexities of asthma management due to individual-level disease characteristics and environmental sensitivities, and the time commitment from a health educator or nurse to provide the ongoing training and education needed to support patient and family.³¹ Several computer-based trials among minority populations appeared in the literature between 2000 and 2015.

One of the earliest computer-based programs was conducted by Homer et al²⁷ in 2000. This team evaluated a computer program that used simulated daily events emphasizing monitoring, allergen identification, use of medications, and use of health services and maintenance of normal activity.²⁷ Delivered as a game, participants could help a superhero manage his asthma by making decisions about taking rescue medication for acute symptoms, preventive medications on a regular basis, and consulting physicians for advice. Children reported to the clinic to access the program, which was uploaded onto the clinic computer. A pioneering study, participant satisfaction was relatively high and children as young as 8 years were able to master the skills necessary to operate the game after some coaching. However, the intervention was clinic-based with limited accessibility, and children commented on educational videos that "interfered" with the gaming aspects of the program. Improvements were observed in asthma knowledge.

In 2003, Huss et al²⁶ reported on a randomized trial of 148 "inner-city" children, aged 7 to 12 years, to evaluate a computer-assisted instructional game on asthma symptoms (eg, coughing, wheezing, shortness of breath, and nighttime awakenings) over a 12-week period. The program consisted of 2 games (The Magic School Bus and Wee Willie Wheezie), and focused on improving home allergen avoidance. Change in asthma symptoms, the primary study outcome, was measured by the Pediatric Asthma Quality of Life Questionnaire.^{32,33} The program was provided to enrolled children during a home visit in which they were given a prescribed amount of time to participate. Unfortunately, no change in asthma symptoms, quality of life, or asthma knowledge was noted.

The largest trial of computer-based interventions was conducted by Bartholomew et al²⁹ in 2006 in which 946 urban children were randomized to receive a multilevel intervention, Watch, Discover, Think and Act, comprising training videos for parents and teachers and a multimedia compact disc read only-memory designed to be accessed via physician offices and clinics. A successful pilot was conducted in 2000 with 171 children using the same program.²⁹ This program included case-finding of children with asthma, linking families with clinicians to develop an action plan for asthma, use of the computer game, and a school environment intervention. The game was one of the first to introduce the concept of tailoring the intervention to user and disease characteristics. Results showed significant improvements in child asthma knowledge, self-efficacy, self-management skills, and health care utilization, but not in health status, school attendance, or school performance.

The above computer-based interventions ushered in a new era of asthma interventions in which a multimedia platform allowed intervention components to be tailored to user beliefs and attitudes as well as disease characteristics, while continuing to incorporate behavioral theory. Although Homer et al²⁷ mentioned education theory, Huss et al²⁶ and Bartholomew et al²⁸ incorporated additional theories, such as the social cognitive theory and the Proceed-Precede model. All programs required access to the computer through a provider (clinic or home visit) or special staffing for participant training/access.²⁶⁻²⁹

More recently, an asthma management program was reported in the literature in which computer-tailoring was used to deliver theory-based messages to urban teens aged 15 to 19 years.³⁴ The program was made available to adolescents in the school setting through school computers. Significant self-reported outcomes included symptom days, functional status, and health care utilization. In addition to tailoring on disease characteristics, the Puff City program illustrated the potential for more deeply tailored health messages based on personal characteristics and attitudes, such as depression, rebelliousness, and lack of motivation.³⁵⁻³⁷

Other technological devices evaluated for asthma care

Video games. Video game consoles are a long-time popular source of entertainment in American households, especially among youth. A recent survey found that 51% of the households in the United States have a video game console.³⁸ Because of their popularity, video games in the past have been used as a medium to deliver health education on topics including diabetes,^{39,40} cancer,⁴¹ autism,⁴² and asthma.⁴³

TABLE I. Summary of technology-based interventions for asthma evaluated in urban and/or ethnic study samples: Intervention characteristics

Author, year	Demographic characteristics				Session information			Content delivery and specifics				
	N	Retained (%)	Age (y)	Race	Trial period	No. of sessions	Pilot?	Theory-based?	Content tailored?	Special staffing?	Content delivery	Positive participant feedback?
Bartholomew 2000 ²⁸	171	77.8	6-17	Hispanic: 45.9% AA: 49.6% Other: 4.6%	Mean = 7.9 mo (range, 4-15 mo)	Varies	No	Yes	Yes	Yes	CD-ROM	Yes
Bartholomew 2006 ²⁹	946	53.2	Grade 1-4; mean age = 7.7 y	AA: 45% Hispanic: 51% White: 3% Other: 1%	1 y	Varies	No	Yes	Yes	Yes	Computer game (software)	NR
Homer 2000 ²⁷	137	77	3-12	Black: 60.5% Hispanic: 5.3% Other: 34.2%	1 y	3 visits	No	Yes	No	Yes	Computer software at clinic	Yes
Huss 2003 ²⁶	148	68	7-12	Non-Hispanic black: 78.2% Non-Hispanic white: 20.8% Other: 1%	18 wk	3 visits	No	Yes	No	Yes	Computer software	Yes
Joseph 2007 ³⁴	314	87	15-19	AA: 98%	4 wk minimum	4 online sessions + baseline	No	Yes	Yes	No*	Web-based Laptop/ computer	NR
Joseph 2013, ³⁷ Guglani 2012, ³⁵ 2013 ³⁶	422	90	15-19	AA: 98%	4 online sessions > 7 d apart + 6-mo booster	4 online sessions + baseline and booster	No	Yes	Yes	No*	Web-based Laptop/ computer	NR
Mosnaim 2008 ¹⁶	28	82.1	10-18	AA: 100%	14 wk	Varies	Yes	No	Yes	Yes	MP3 Media hub programmed	NR
Mosnaim 2013 ¹⁷	68	72.1	11-16	Black/AA: 85.2% Mixed AA: 1.5% Other: 13.3	10 wk	Varies	No	Yes	Yes	Yes	MP3 iPod Shuffle	NR
Britto 2012 ²⁵	23	83	13-18	Black: 84% White: 16%	3 mo	Varies	Yes	No	Yes	No	Phone capable of SMS	Yes
Seid 2012 ²⁴	28	93	Mean age = 15.1	AA: 76.9% White: 11.5% Other: 11.5%	2 in-person sessions; 1 mo of SMS messages	Varies	Yes	Yes	Yes	Yes	SMS; 70% given cell phone	Yes

Guendelman 2002, ⁴⁷ 2004 ⁴⁸	134	91	Mean age = 12.0 (treatment); 12.2 (control)	AA: 76.1% White: 9.7% Other: 14.1%	12 wk	Use device daily	No	No	No	Yes	Home-based device transmits to case manager via Web site	Yes
Shames 2004 ⁴⁴	119	77	Mean age = 8.1 (treatment); 8.0 (control)	Hispanic: 57.5% AA: 21.9% Other: 19.4%	52 wk	Assessed at 8, 32, and 52 wk	No	Not evident	No	ACM board— certified allergist	Super Nintendo console	NR
Bender 2010 ⁴⁶	50	NR	Adults (18-65)	White: 58% Hispanic: 18% AA: 20% Asian: 4%	10 wk	2-3 calls	No	Yes	Yes	No	IVR software; telephony card; other software	NR

AA, African American; ACM, Asthma case manager; CD-ROM, compact disc read only-memory; NR, not reported; SMS, short message service.
*Option of seeing an Asthma Referral Counselor, however, not necessary for intervention delivery.

An RCT was carried out by Shames et al⁴⁴ in 2004 among a population of urban, low-income children—the control group received their usual care, and the intervention group received an asthma video game delivered through the Super Nintendo Entertainment System. One hundred nineteen children who were diagnosed with moderate to severe asthma were randomized. The intervention group received detailed disease management, which included the asthma health education video game, whereas the control group received usual care. The children were asked to record their asthma symptoms, peak flow, and other asthma health indicators in an asthma diary in conjunction to playing the video game. The intervention group saw significant improvements in their functional status and quality of life. There was no difference between the groups for health care utilization.

Interactive voice response. Interactive voice response (IVR) has been a popular way to deliver health education. Because IVR is a system that is set up at a call center, all the participant needs is a telephone that has a touch tone keypad. This can be applicable to home telephones or cell phones. In the past, studies have shown success in using IVR. Disease management in patients with acute coronary syndrome has found that the IVR intervention can be successful.⁴⁵

In 2010, Bender et al⁴⁶ randomized a diverse population of 50 adults with asthma, ages 18 to 65 years, to receive an IVR intervention. The intervention group received 2 automated calls through an IVR that lasted less than 5 minutes. In the calls, the system would ask questions about their asthma symptoms, deliver health education messages, and remind the participants to refill their inhaled corticosteroid prescriptions. The participants were able to respond using their touch tone key pad. The control group received no calls. Each group was given either an electronic tracking device on their inhaler or a canister that was weighed at the end of the study. The intervention group showed a statistically significant improvement in medication utilization, but there were no improvements in health care utilization, functional status, and quality of life.

Health Buddy. Health education interventions have been delivered through the telephone (ie, IVR), but the Health Buddy System intervention by Guendelman et al^{47,48} was unique in its structure. In a study, Guendelman et al randomized 136 inner-city children with persistent asthma between the ages of 8 and 16 years. The intervention group was to use the Health Buddy System, which was a device attached to their home phone. The device presented information and questions on its screen. A nurse coordinator would send daily queries about their asthma symptoms and trivia through the device. Participants, using 1 of 4 buttons on the device, answered the queries, which were transmitted back to a data processing center. Health Buddy would give tailored responses, praise, or encouragement to the participant on the basis of their answers. The control group recorded their symptoms in an asthma diary. The intervention group demonstrated improvements in quality of life and medication adherence, though no change in health care utilization was noted.

DISCUSSION

In 2009, Clark et al⁴⁹ reviewed publications on existing asthma interventions, and noted 8 characteristics of successful interventions: recognition of the multifaceted nature of asthma

TABLE II. Summary of technology-based interventions for asthma evaluated in urban and/or ethnic study samples: Outcomes

First author, year	Outcomes				
	Health care utilization	Functional status	QOL	Medication adherence	Asthma knowledge
Bartholomew 2000 ²⁸	Yes	Yes	NR*	NR	Yes
Bartholomew 2006 ²⁹	No	No	NR	NR	Yes
Homer 2000 ²⁷	No	No	NR	NR	Yes
Huss 2003 ²⁶	NR	No	No	NR	No
Joseph 2007 ³⁴	Yes	Yes	No	No	NR
Joseph 2013 ³⁷ ; Guglani 2012, ³⁵ 2013 ³⁶	No	Yes	No†	Yes‡	NR
Mosnaim 2008 ¹⁶	NR	NR	NR	NR	Yes
Mosnaim 2013 ¹⁷	NR	NR	NR	No	No
Britto 2012 ²⁵	NR	No	NR	NR	NR
Seid 2012 ²⁴	NR	No	Yes	NR	NR
Guendelman 2002, ⁴⁷ 2004 ⁴⁸	No§	Yes	NR	Yes	NR
Shames 2004 ⁴⁴	No	No¶	Yes	NR	Yes#
Bender 2010 ⁴⁶	NR	No	No	Yes	NR

NR, Not reported.

*Reduced "total symptoms" among mild asthma only; $P < .05$ for hospitalizations in children <12 y.† $P = .01$ for emotional domain among depressed only.³⁵‡Medication adherence improved in depressed children with controller medication at baseline.³⁶

§Fewer urgent calls for treatment vs control group.

||Treatment group more likely to take medication without reminder.

¶ $P < .05$ for clinical outcomes in subgroup analyses.# $P < .05$ for parental asthma knowledge.

management for patients, assessments of the needs and risks of each patient, tailoring of program elements to those needs and risks, accounting for both the physical and social context of disease management, the use of sound learning and behavioral change theories, family involvement, targeting those with severe disease, and the offer of various venues through which the intervention could be delivered and optimized.⁴⁹ Technology-based interventions have the potential to address most of these characteristics. We have conducted a literature review to identify technology-based asthma interventions that have been evaluated using an RCT and have the objective of reducing health disparities in asthma by targeting black and Hispanic/Latino patients with asthma (Table I). Our results indicate important issues and implications for the patient, provider, and health system to consider.

Implications for patients

The technology-based programs outlined in this review were developed on the basis of a need for asthma interventions that were innovative. Patients are busier than ever and the literature suggests that patients are amenable to accessing medical education through a home computer or the Internet.^{50,51} Of the studies reviewed here, participant feedback was uniformly positive when such information was obtained. Technology-based interventions were delivered through various channels (including Web-based, MP3, and Super Nintendo console) and formats that can be manipulated to appeal to different age groups or demographic characteristics. Likewise, intervention content can be "tailored" to deliver appropriate, personalized content to each individual user.

Many of the technology-based interventions reviewed were successful in achieving improved outcomes in patients, including functional status, symptoms, asthma knowledge, and medication adherence. However, few interventions were able to reduce

emergency department visits. In fact, only computer/Web-based interventions successfully reduced health care utilization in some of the trials analyzed. Of note, no intervention or trial was universally successful across all domains.

Implications for physicians

Technology-based programs represent an extension of the provider or health educator, while using theory-based methods to motivate behavior change. Nine of the 13 interventions featured mentioned theoretical underpinnings, and overall, these appeared more successful (Table II). Sustained adherence and improved outcomes, however, are unlikely to continue without the support and partnership of a health care provider. Finding ways to incorporate technology into coordinated health care will be essential if these interventions are to be effective. In this day of mobile devices, however, dissemination is entirely feasible. These programs could be an adjunct to provider care delivered at a clinic visit. Although some programs may reflect an area of expertise that a primary care physician or specialist may not yet have (eg, motivational interviewing), the provider-patient partnership will still likely be important for reinforcement, shared decision making, and assigning treatment regimens. This concept of using the interventions in conjunction with primary or specialty care was not touched upon in some of the studies reviewed.

Intersecting the physician and the health care system is cost. Costs to acquire technology may be too high for solo practitioners, and none of the studies reviewed included a cost/cost-effectiveness analysis (one study included the cost associated with the asthma counselor). In addition, the possibility of integration of these interventions with electronic medical records remains to be explored, as does the promise of using patient portals in asthma management.

Implications for health care systems

This review uniquely shows how changes and progress in the culture of technology have driven similar changes in asthma interventions. The translation of research findings into practical programs that can be used by providers and health care systems remains challenging, and unfortunately, the process of development, evaluation, and dissemination (which can take up to 17 years) is often too slow for today's rapidly changing technology.⁵² As such, tech-driven asthma interventions would have to change or update rapidly to incorporate the trends of each new wave, or risk becoming obsolete by the time the evaluation is completed. For example, the Health Buddy System mentioned above uses a home telephone landline. Landlines are rapidly becoming obsolete, as currently 51.7% of the households do not regularly use one.⁵³ In addition, although cell phone and tablet use continue to expand, MP3 and game console use has remained flat or declined.⁵⁴

Weaknesses still apparent in these technological advances include accessibility, feasibility, requirement for special staffing, and efficacy. To reach most individuals with uncontrolled asthma, interventions should be available in homes, schools, emergency departments, and community sites. Related to accessibility is the feasibility of delivering the intervention on a large scale. To be cost-effective and scalable, interventions may need to be delivered on the basis of equipment or devices youth already own. Despite a lag in uptake of technology and social media in 1995, current data show that blacks and Latino/a communities make use of mobile devices more or as much as do their white counterparts.^{55,56} Important for intervention adoption by health care systems is minimal oversight and manipulation needed by program staff. Special staffing (eg, nurses and asthma counselor) was needed, or recommended, for all except the IVR and text messaging interventions. This need for staff oversight may limit uptake and add cost to health care organizations.

Staffing is also relevant because the literature shows that social factors may play a crucial role in the effectiveness of even enticing and progressive interventions. For example, frequent emergency department visitors are characterized by few resources to support self-management. More investigations of how social determinants may influence intervention uptake are also needed.

In summary, technology-based interventions can be delivered through various channels, have high levels of user satisfaction, and have the potential for high fidelity while delivering theory-based tailored content. The interventions reviewed here have the potential to help black and Latino patients as results have shown successful improvement of asthma symptoms, functional status, quality of life, and medication adherence in these populations. However, barriers to dissemination, cost, the need for special staffing, and the ability to address social determinants remain as important impediments to use by physicians and health care systems. Further studies are required to fully evaluate the potential of these interventions to decrease asthma health disparities.

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