ASTHMA IN CHILDREN: A CHRONIC CONDITION REQUIRING A MULTI-FACETED APPROACH

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Abstract

Background
Asthma is a serious chronic disease with physical, academic, and economic consequences that affected more than 7 million children in 2010. The physical consequences of asthma are estimated to have caused more than 1,700 childhood deaths between 2002 and 2007. One of the ways to reduce the impact of asthma is to avoid triggers—including exercise, allergens, viral infections, excitement/stress, and environmental triggers such as air pollution, allergens, and cold weather—that exacerbate asthma symptoms. Unfortunately, many children are regularly exposed to potential triggers, which can have a negative impact on their health and well-being.

Asthma also negatively impacts school attendance and school performance. Children with asthma are more likely to be absent when compared to their non-asthmatic peers, with more than 10.5 million missed days of school due to asthma in 2008. Furthermore, pediatric asthma costs the United States about $27 billion every year, largely due to health care expenditures. In 2007, children experienced nearly 151,000 hospitalizations; 640,000 emergency department (ED) visits; and 6.7 million doctor visits that were asthma-related. While the impact of asthma is significant, affected children can manage the disease with proper medical care and by avoiding potential triggers. The Centers for Disease Control and Prevention (CDC) has reported that teaching people how to independently manage asthma is one of the most important aspects of controlling this disease. Proper asthma management education can reduce the number of asthma-related deaths, hospitalizations, emergency room visits, and missed days of school.

A focus on children is important because this population is at a higher risk for poor asthma management, due in part to the disconnect that occurs between children and the adults supporting their asthma management. Properly managed asthma in children leads to improved health outcomes, contributing to decreased economic costs and improved quality of life. Technology provides an inexpensive, accessible conduit for educational programs; and with children’s increased access to technology both in and out school, there is a valuable opportunity to incorporate these resources in asthma interventions, management, and education for this population. This paper aims to review the literature on asthma management programs for children, highlight successful interventions incorporating the use of technology, and discuss policies to aid in improved asthma management. We will also provide recommendations for asthma management programs, future research, and policy development.

Methods
A systematic review examining asthma management programs/policies that targeted school-age children was conducted. The terms “best/practices,” “asthma,” “school,” “education,” “interventions,” “public/policy,” and “children/pediatric” were entered into the PubMed database. Inclusion criteria for search results were: 1) topic, i.e., articles that addressed best practice for asthma management, and 2) population, i.e., interventions targeted toward children or adolescents. Our search yielded 2,381 articles meeting inclusion criteria. We then excluded articles that 1) were written in a language other than
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English, 2) provided only vague descriptions of interventions, 3) focused primarily on chronic obstructive pulmonary disease (COPD) and other non-asthma respiratory diseases, and/or 4) did not characterize results. Using the exclusion criteria, our results narrowed to 44 articles.

Results
This review demonstrates that asthma management programs, which reportedly led to significant improvements in the targeted health-related outcomes, incorporated one or more of the components recommended by the National Heart, Lung, and Blood Institute (NHLBI) Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma. The NHLBI states that effective asthma management requires 1) measures of assessment and monitoring of asthma severity and controls, 2) education supporting a partnership in asthma care, 3) control of environmental factors affecting asthma, and 4) pharmacologic therapy. Based on the articles reviewed, this paper demonstrates the possibility for innovative programs, particularly those using technology, to be used in schools. The results suggest that the NHLBI components as well as innovation should be considered critical to developing a successful asthma management program targeting children.

Discussion
Proper asthma management results in improved health outcomes for asthmatic children, leading to decreased absenteeism from school, decreased economic costs, and an improved quality of life. However, proper management requires multiple components addressing various aspects of this disease. This includes measures of assessment and monitoring of asthma severity and controls, education supporting a partnership in asthma care, control of environmental factors affecting asthma, and pharmacologic therapy. While interventions incorporating one or two of these components may still report positive outcomes, long-term sustainable effects are still a concern. Multi-faceted asthma management programs could encourage long-term use and improved health outcomes. Schools, in particular, provide a valuable opportunity to incorporate programs targeting school-age children because they allow families, school staff, clinicians, and school nurses to work together to manage asthma. The use of technology, such as Web-based education and monitoring, provides additional opportunity to develop programs that incorporate all of the NHLBI recommended components. Furthermore, policies that support multi-faceted asthma management, interventions, and education for children are crucial to improving management of asthma.
Introduction

Asthma is a serious chronic disease with many physical, academic, and economic consequences that impacted more than 7 million children in 2010. Asthmatic children face significant physical consequences affecting their quality of life, such as sleep disturbance and asthma attacks. These attacks range in severity from mild to life-threatening, and are estimated to have caused more than 1,700 childhood deaths between 2002 and 2007.

Children experience varying levels of asthma-related physical effects, the severity of which is influenced by other physiological and environmental factors. For example, overweight and obese children have an increased risk for asthma and more severe asthma symptoms. Furthermore, triggers such as air pollution, exercise, allergens, cold weather, viral infections, excitement/stress, and tobacco smoke present a major concern for those diagnosed with asthma. Triggers exacerbate asthma symptoms leading to an increased need for short-acting beta agonists (SABAs), which are typically used as “rescue” medication. Unfortunately, many children with asthma frequently encounter triggers on a daily basis; almost one-third of asthmatic children are exposed to a smoker in the house, and more than one-half are exposed to furry pets at home. Regular exposure to asthma triggers such as these can have a significant impact on a child’s health and overall well-being. Young children are at an increased risk for experiencing the negative health effects of asthma, since asthma exacerbations are common during early childhood and may lead to progressive loss of lung functions. Furthermore, this population has an increased likelihood to experience more episodic disease patterns, which are not typically addressed by diagnostic asthma questionnaires that focus mainly on the chronic disease aspects. This presents a concern regarding asthma management, as insufficient understanding of the disease may lead to mismanagement of an individual’s asthma.

In addition to the physical consequences of asthma, it also negatively impacts school attendance and school performance. For example, asthmatic students are more likely to be absent when compared to their non-asthmatic peers, with more than 10.5 million days of school missed due to asthma in 2008. Even when asthmatic students are able to attend school, many still face difficulties: 40% of children with disabling asthma reported a limitation in their ability to engage in school activities. This decreased school attendance and participation likely contributes to decreased school performance among asthmatic students, and children with persistent asthma are at a particular risk compared to those with mild intermittent asthma. One study demonstrated an increased likelihood for these children to score below “Nearing Proficient” on the Missouri Assessment Program (MAP), a standardized test administered throughout Missouri schools to test performance on math, social studies, communication arts, and science.

Asthma also has a significant economic impact, costing the United States about $27 billion every year. Much of this cost is due to health care expenditures: in 2007, children experienced nearly 151,000 hospitalizations; 640,000 emergency department (ED) visits; and 6.7 million doctor visits that were asthma-related.
The impact of asthma is significant, and while there is no cure, affected children can manage the disease with proper medical care and by avoiding potential triggers. The Centers for Disease Control and Prevention (CDC) has reported that teaching people how to independently manage asthma is one of the most important aspects of controlling this disease. In fact, many pediatric hospitalizations may be avoided if parents and children were better educated about avoiding known disease triggers. However, proper asthma education also involves educating children on what their triggers are; often, there is only a modest correlation between self-reported triggers and true, objective allergy test results. This discrepancy can be detrimental to asthma patients, who cannot successfully avoid triggers if the triggers are being misidentified. However, properly educating children through programs supporting proper trigger identification can prevent asthma symptoms arising solely from the fear and anxiety of perceived trigger exposure (for some, even the perception of an asthma trigger can elicit bronchoconstriction). Furthermore, asthma management education can reduce the number of asthma-related deaths, hospitalizations, emergency room visits, and missed days of school.

Asthma education programs targeting children and adolescents address many of the physical consequences of asthma and have the potential to improve health outcomes within this population. Successful programs have reported improved lung function, decreased the number of days with restricted activity, and increased feelings of self-control. A focus on children is important because this population is at a higher risk for poor asthma management. This is partly due to the disconnect that occurs between children and the adults supporting their asthma management; adherence to childhood asthma treatment is frequently poor, and parents often overestimate the amount of drug being utilized. This is not surprising since many young children—20% of 7-year-olds and 50% of 11-year-olds—are often left to take asthma treatment unsupervised, leading to poor inhaler-use technique. This is concerning because non-adherence and poor practices of treatment regimens contribute to roughly half of patients’ poor asthma control. Proper asthma management is not the only area where reports from parents and their children differed. A University of Washington study also found discrepancies in sleep quality reports for asthmatic children. Parent-child reports were significantly different across all symptoms and sleep parameters for children with asthma, with parents reporting better sleep with fewer awakenings and symptoms than their children. Addressing these discrepancies and concerns through asthma management education targeting children has the potential to significantly improve the consequences of asthma. Children who are able to properly manage their asthma show improved health outcomes, contributing to decreased economic costs and an improved quality of life.

Children’s increased access to technology both in and out of school provides a valuable opportunity to incorporate technology in asthma interventions, management, and education for this population. Over the last several years, the number of children in the United States with access to computer technology has significantly increased. Many children have access to different types of technology outside of school, and a growing number of parents are providing their children with access to computers at home: surveys of 14 elementary schools found that approximately 80% of students and parents have access...
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to the Internet at home.\textsuperscript{49,50} Student access to technology extends into the classroom as
well, and is even more prevalent in the school environment: as of fall 2002, 99% of schools
in America had access to the Internet.\textsuperscript{51} Furthermore, use of educational technology is high,
as 75% of elementary teachers reported that either they or their students used computers
during school instructional time.\textsuperscript{52} With so many children able to access technology, there
is much potential for using technology to provide asthma management tools and education
to children on a large scale.

This paper aims to review the literature on asthma management programs for children,
highlighting the successful interventions incorporating the use of technology; and to
discuss implications and recommendations for asthma management programs, future
research, and policy development.

Methods

We performed a systematic literature examining asthma management programs and
policies that targeted school-age children. The terms “best/practices,” “asthma,” “school,”
“education,” “interventions,” “public/policy,” and “children/pediatric” were entered into the
PubMed database. Inclusion criteria for search results were: 1) topic, i.e., articles that
addressed best practice for asthma management, and 2) population, i.e., interventions
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English, 2) provided only vague descriptions of interventions, 3) focused primarily on
chronic obstructive pulmonary disease (COPD) and other non-asthma respiratory diseases,
and/or 4) did not characterize results. Using the exclusion criteria, our results narrowed to
44 articles. The flow diagram below (Figure 1) depicts the literature search results.

Results

Key factors of asthma management
for the Diagnosis and Management of Asthma} stated that effective asthma management
requires 1) measures of assessment and monitoring of asthma severity and controls, 2)
education supporting a partnership in asthma care, 3) control of environmental factors
affecting asthma, and 4) pharmacologic therapy.\textsuperscript{53}

The first component—assessment measures and monitoring—encourages observations of
an individual's respiratory symptoms, sleep disturbance, medication use, and activity
limitation.\textsuperscript{54} These observations can be recorded through the use of routine self-
assessments (Figures 2 and 3) that can then be brought to clinical appointments for
monitoring and feedback from medical professions.\textsuperscript{55} The second component—education
supporting a partnership in asthma care—involves teaching children self-management
skills and increasing the number of educational opportunities in the clinic or doctor’s
office, during ED visits, and in school-setting interventions.\textsuperscript{56} There are many resources
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available to support this partnership in asthma care, including the development of an asthma action plan distributed during physician and/or ED visits (Figure 4 and 5). The third component—control of environmental factors affecting asthma—requires first utilizing medical testing to properly assess allergens and then supporting the avoidance of trigger exposure whenever possible. The fourth component—pharmacologic therapy—encourages asthma patients who seek consistent control of persistent asthma to use long-term control medication on a daily basis, to utilize spacers for all metered dose inhalers, and to use SABAs sparingly.

Our review of asthma management studies targeting children found that interventions reporting significant improvements in the targeted health-related outcomes often utilized one or more of these components. We highlight some of these interventions below and discuss relevant policies geared toward improving asthma management.

Interventions incorporating measures of assessment and monitoring
The following interventions focused on incorporating measures of assessment and monitoring of asthma severity and controls in order to improve asthma-related health outcomes among children. The Blue Angel for Asthma Kids program is an intervention that aimed to monitor daily asthmatic symptoms, provide information for an action plan, and enhance compliance of daily asthma control among children ages 6-12. This Internet-based asthma intervention incorporated the use of Internet-based diary cards for symptom recording, a diary record for peak expiratory flow rate (PEFR), symptomatic support information, action plan suggestions, and telecommunication technologies for uploading and retrieving storage data for personal and physician use. These tools could also be used to assist medical doctors in diagnosing and treating asthma. Results showed that the program did improve PEFRs, adherence to medication, knowledge of self-management, and quality of life of caregivers, although daily participation in program declined over time.

Another study targeting inner-city children ages 8-16 examined the effectiveness of Health Buddy—a device that connects to a home phone in order to present asthma-related questions and information while recording a child’s response—in enhancing children’s self-management skills and reducing adverse asthma outcomes. During the 90-day study, a standard asthma diary was compared to Health Buddy. A nurse coordinator connected to the devices via the Internet sent daily questions regarding asthma symptoms, peak flow readings, medication and health services utilization, functional status, and educational trivia. Using the phone buttons, individuals were then able to provide answers that were processed and sent to a secure website for the nurse coordinator to view. Immediate feedback was provided based off the answers given. While both the standard asthma diary and Health Buddy reported a decrease in asthma symptoms and in peak flow severity readings at the 6 and 12 week marks, the Health Buddy program reported more significant outcomes overall. In addition, Health Buddy participants were significantly less likely to experience activity limitation during the trial, to report severe peak flow readings, and to make urgent calls to the hospital. There were also significant improvements in self-care behaviors, including the use of asthma medication without reminders. While 77% of all participants used their tracking system for 3 days a week or more, this level of adherence
was recorded more in the Health Buddy group (89% of 66 children) than in the asthma diary group (65% of 68 children). While both groups declined in compliance rates over time, rates declined faster at earlier stages of the intervention for the asthma diary group. These results suggest that Health Buddy can be more effective in self-management skills and asthma outcomes than an asthma diary.

These interventions highlight the use of technology to assist with asthma-related assessment and monitoring among children. Technology increases opportunities for recording and sharing symptoms with caretakers, as well as receiving prompt feedback and information from health care professionals.

**Interventions incorporating education for a partnership in asthma care**

The following interventions focused on the use of education to support a partnership in asthma care between children with asthma and their adult caregivers. In a study done by the University of Wisconsin, researchers conducted an eHealth intervention targeting both asthmatic children and their caregiver or parent with two different components. The first component, targeting children, provided asthma education in a game and audio format, and social support via a peer discussion group. Each child was also assigned an asthma case manager who had access to the child’s well-being assessments on the eHealth program. The second component targeted the caregivers or parents of asthmatic children, and included online asthma education along with a peer discussion group. Parents were also provided the email of their child’s case manager, who would call them once a month to assess and discuss asthma management (Figure 6). This eHealth intervention resulted in improved asthma control according to the Asthma Control Questionnaire (ACQ), but did not significantly improve medication adherence. Social support in particular was shown to have a significant positive effect on asthma control.

Another study focused on supporting a partnership in asthma care aimed to identify an effective approach to asthma education for children and their caregivers. Children visiting the ED were assigned to either 1) a control group who followed usual care recommendations from the patient’s primary care physician or 2) an intervention group who participated in an interactive, small-group education program. This education program was directed toward the parents of children ages 3-6, both the parents and children for the 7-11 age group, and children ages 12-16. Each program, led by a nurse educator and a respiratory therapist team, consisted of a group of 6-8 participating families. The small groups met for about 1.5 hours a week for four weeks, addressing different asthma management topics such as medication and triggers (Figure 7). This provided parents and children an opportunity to discuss asthma management, as well as to share their own successes and failures. Results showed that children in the intervention group made significantly fewer ED visits and reduced their likelihood of requiring emergency care by 38%. Furthermore, they required fewer courses of oral corticosteroids and reported significant improvements in their quality of life.

Another intervention aimed to improve asthma care management for asthmatic children between the ages 5-12. Over the course of a year, nurses carried out a telephone intervention with parents that consisted of five stages: precontemplation, contemplation,
preparation, action, and maintenance (Figure 8). Training for coaching focused on reducing the nurses’ natural tendency to impose their own solutions on participants’ problems, worked to increase the conversations’ focus toward eliciting the parents’ own reasons and readiness for change, as well as the parents’ own ideas on how to implement changes. Call frequency was dependent upon parent behavior and asthma control, with 54% of participants receiving a total of 4-8 calls. Results showed that coaching was effective in promoting self-management behaviors in parents of children with asthma, and coached parents indicated an improvement in their child’s asthma-related quality of life and a reduction in their child’s asthma impairment. The most progress occurred when nurses used an up-to-date asthma action plan (AAP) to manage asthma, while less progress occurred in developing a collaborative partnership between the nurse and child’s pediatrician.

One study evaluated the effectiveness of a space adventure-themed computer game—*Air Academy: The Quest for Airtopia*—in improving asthma knowledge. The six-week study targeted 87 fourth-grade students in three different classes, with one class serving as the control group. The intervention group played *Air Academy* for 20 minutes three times a week. The game covers the topics of asthma triggers, medications, symptoms, and maintenance, and includes videos and a “mission debriefing” stressing the importance of proper communication and dialogue between parents, students, nurses, and physicians. Children in the intervention group gained significantly more asthma knowledge, which was retained over a four-week period. In addition, three participants were subsequently diagnosed with asthma after discussing symptoms with their parents.

The Interactive Multimedia Program for Asthma Control and Tracking (IMPACT) program was another study that aimed to improve asthma management among children through the use of computer-based asthma education. Children would complete the program, which involved a series of animated lessons, during regular appointments at a clinic. The lessons were about a minute in length and focused on the principles of asthma self-management, including 1) instructional and educational aspects of asthma control, 2) real-life scenarios and decisions about asthma prevention behavior, and 3) teaching exercises aimed at helping children learn how to accurately describe their symptom and medication use. The IMPACT program tracked the educational progress of each child, recorded symptom levels, and documented medication use. Results showed an increase in asthma knowledge, increased asthma control, and a reduced burden of asthma.

Education supporting a partnership in asthma care is commonly incorporated into asthma management programs, and involves teaching children self-management skills as well as increasing the number of educational opportunities in clinics, schools, etc. An important aspect of this component is supporting collaboration between a child and their adult caretakers. While barriers such as distance can make collaboration between children, parents, caretakers, and health care providers difficult, technology could eliminate this a major concern.

*Interventions incorporating proper control of environmental factors*

The following interventions evaluate the effect of proper control of environmental factors
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on asthma-related health outcomes in children. One example is from East Carolina University, which implemented the Eastern Carolina Asthma Prevention Program (ECAPP), an intervention targeting low-income, minority children in rural North Carolina.\textsuperscript{101} The ECAPP aimed to reduce self-reported asthma symptoms, improve breathing tests, and decrease the number of asthma-related ED visits.\textsuperscript{102} The program began with an environmental health professional conducting an indoor environmental assessment of asthma triggers.\textsuperscript{103} The intervention group then received environmental products to assist in the cleaning and maintenance of the child’s home environment, asthma education for participants and their caregivers, and follow-up calls every two weeks.\textsuperscript{104} Results showed that the intervention groups’ self-reported asthma symptoms decreased by 58%, rescue medicine use decreased by 76%, controller medicine use increased by 12%, and asthma-related ED visits decreased by 75%.\textsuperscript{105} However, due to the small sample size and multi-level dimensions of the intervention, the exact impact of the environmental changes cannot be measured.

Another study examined the effects of a secret agent themed game, \textit{The Asthma Files}, on 31 asthmatic participants ages 7-14.\textsuperscript{106} The intervention aimed to increase knowledge of common environmental triggers and improve trigger identification through games and puzzles.\textsuperscript{107} Participants were invited to enter their asthma symptoms—including peak flow and triggers—which were then used to generate a personalized asthma action plan.\textsuperscript{108} Results demonstrated initial knowledge of asthma triggers among participants was low, and game exposure significantly increased trigger awareness.\textsuperscript{109} \textit{The Asthma Files} could be an additional tool to support asthma education regarding asthma trigger knowledge and identification.

Studies have been performed to evaluate the types and frequency of efforts by families to control environmental factors, and how their actions align with the current NHLBI asthma guidelines.\textsuperscript{110} The University of Michigan piloted a telephone-based survey conducted with a random, nationwide sample involving 896 asthmatic children ages 2-12.\textsuperscript{111} Interviews were conducted with caregivers of affected children to ask about their child’s asthma triggers and actions taken to rid the home of these triggers, as well as to collect information about demographics and health care utilization.\textsuperscript{112} Some of the common triggers that were reported included plants, animals, dust, seasonal changes, and smoke (Figures 9 and 10).\textsuperscript{113} Furthermore, 81% of respondents reported taking at least one action to address environmental triggers; 42% of these actions were consistent with NHLBI guidelines, while 51% of actions had a neutral effect.\textsuperscript{114}

Control of environmental factors, which can exacerbate asthma symptoms, is an important component of proper asthma management. However, controlling each of the environments to which children are exposed can be difficult. Focusing on locations where children spend a majority of their time, such as in schools and at home, can decrease asthma symptoms, increase the use of controller medicine, and decrease the use of rescue medication.

\textit{Interventions addressing the use of pharmacologic therapy}

The following interventions address the use of pharmacologic therapy to improve health
outcomes among asthmatic children. One study conducted within the New York City public school system evaluated how health information technology and rescue medication order forms could be used to improve asthma care for students. This intervention consisted of using preprinted rescue medication order forms and using the Automated Student Health Record (ASHR) application to monitor care. The ASHR application was used to create daily asthma reports, and generated a list of students with asthma, according to severity of disease. This allowed nurses to easily identify students with poorly controlled asthma and conveniently access and evaluate their treatment plan. Furthermore, students that needed medication services were required to use a standardized Medication Administration Form (MAF) (Figure 1). The results of this study showed that the MAF preprinted rescue medication order led to improvements in subscribing medications and standardization of care.

Asthma medication may also play a role in asthma-related hospitalizations. Asthma symptoms can result in hospitalizations for affected children, with readmission rates between 15% and 30%. One study followed children who were hospitalized for asthma for one year, or until they were readmitted. Adult caregivers were provided a 134-question survey in order to evaluate their asthma knowledge, the child’s medication adherence, trigger exposures, financial strain, predictors of asthma severity and self-efficacy—or the belief in one’s ability to achieve a desired result—regarding their ability to control their child’s asthma. Increased asthma knowledge among caregivers and non-adherence to medication was correlated with a greater risk of readmission. While it is unclear why an increase in asthma knowledge resulted in a greater risk of readmission, it is evident that adherence to medication is an important aspect of proper asthma management.

Interventions incorporating multiple key components
The following interventions incorporated multiple key components of effective asthma management, including measures of assessment and monitoring of asthma severity and controls, education supporting a partnership in asthma care, control of environmental factors affecting asthma, and/or pharmacologic therapy.

A 12-week study was conducted to evaluate an asthma management intervention for students and their adult network members in two California middle schools. Participants were randomized into one of two groups: Group 1 was provided with six weekly group-based skills trainings for the students followed by six weekly, targeted newsletters for their caregivers (Figure 12). In contrast, Group 2 was provided with the group-based skills training only. The weekly training for students of both groups included homework assignments and an asthma checklist. Homework assignments were activities focused on increasing asthma management and knowledge, such as explaining asthma to someone, monitoring and recording peak flow, and examining the home environment for triggers. In addition, students would complete the asthma checklists by recording their symptoms, activity limitations, and medication use. Caregiver newsletters provided asthma information, such as how to maintain a proper home environment for children at risk. This study reported positive results while incorporating all four recommended components of the NHLBI report. In both groups, adults reported an improved quality of life and access to asthma care resources among adolescents. Self-efficacy also increased
significantly among Group 1 adults. Furthermore, adults in Group 2—who did not receive a newsletter—reported that their children took more responsibility for their asthma care. This may be an unintended consequence of an adolescent-only intervention, which may communicate to adults that they can assume less responsibility for asthma management.

One study aimed to connect potentially asthmatic children and their parents with health care providers through the use of videos, and to improve asthma management through the use of the Watch, Discover, Think, and Act game. Initially, 21,000 students across 60 low-income schools in Texas were surveyed, and students with a probable asthma diagnosis were contacted. Of those contacted, 982 students agreed to participate in the study. Parents were then sent videos, in both English and Spanish, demonstrating how to initiate communication with a physician and develop an asthma action plan. In addition, students were sent a CD-ROM of the Watch, Discover, Think, and Act game, which was developed through collaboration between Texas Children’s Hospital and The University of Texas Health Science Center. The game, which aims to provide asthma self-management skills training, features 18 real-world and 4 castle scenarios in which children can practice self-regulatory skills and review asthma-related tutorials. Results demonstrated an increase in asthma-related knowledge, daily self-management, self-management of at-home episodes, and self-efficacy among participants. However, the study reported a failure to create a meaningful connection between patients and health care providers.

The Community Asthma Initiative (CAI) is a program that worked to enhance the model of care for children who have previously been seen in the ED due to asthma. This program used a comprehensive approach to improve patients’ number of asthma-symptom-free days and reduce their number of ED visits. The CAI improved traditional asthma care by providing nurse case management, home visits from a nurse or community health worker, asthma education, and environmental assessments and remediation. This program incorporated multiple components of the NHLBI report, and saw a significant reduction in asthma ED visits, hospitalizations, limitation of physical activity, missed school, and parent/guardian missed days of work at 6 and 12 months of follow-up. Feedback from participants showed that home visits were particularly important, because they allowed health professionals to provide in-home asthma education and address social and environmental obstacles to proper asthma control.

Asthma management programs incorporating multiple key components not only address the child’s asthma-related knowledge, but also their perceived ability to utilize that knowledge on a daily basis (self-efficacy). Furthermore, by involving adult caretakers and addressing potential environmental concerns, the scope of influence broadens and there is an increased likelihood that the child and/or their has the knowledge, ability, and the confidence necessary for proper asthma management. These factors, in addition to proper pharmacologic therapy, are crucial to success. This is evident through multifaceted programs reporting many positive effects such as improved self-efficacy, knowledge, and management. These results are then correlated with improved health outcomes such as decreased ED visits, hospitalizations, and missed days of school.
Discussion

Conclusions
Proper asthma management results in improved health outcomes for asthmatic children, leading to decreased absenteeism, decreased economic costs, and an improved quality of life.\textsuperscript{146} However, proper management requires multiple components addressing various aspects of this disease. This includes measures of assessment and monitoring of asthma severity and controls, education supporting a partnership in asthma care, control of environmental factors affecting asthma, and pharmacologic therapy.\textsuperscript{147} For example, incorporation of a single component such as education into an asthma program is not enough to manage this disease; it is also important that children—with the support of their caretakers—adhere to their medication schedule.\textsuperscript{148}

While interventions incorporating one or two of these components may still report positive outcomes, long-term sustainable effects are still a concern.\textsuperscript{149,150} Multifaceted asthma management programs, however, could encourage long-term use and improved health outcomes. Schools in particular provide a valuable opportunity to incorporate programs targeting school-age children. They allow for families, school staff, clinicians, and school nurses to work together to manage asthma. Additional opportunities for developing effective asthma management programs within schools include increasing the size of school health teams, providing children with educational services, expanding school asthma care services, and training school staff to recognize, respond to, and provide information about attacks.\textsuperscript{151}

The use of technology provides an opportunity to develop programs, both within and outside schools, that incorporate all of the NHLBI recommended components. Web-based programs allow for immediate and secure assessment and monitoring of asthma severity, which can then be quickly shared with members of the child’s care team, further supporting a partnership in asthma care. Web-based education, including games, allow for age-appropriate asthma management information to be easily distributed to a large number of children.

Future research and policy recommendations
More research should be conducted regarding pharmacologic therapy to ensure it is properly incorporated into asthma management programs. For example, one study done by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) researched the drug labeling of asthma medication for young children.\textsuperscript{152} The NICHD found that more information is needed to assist clinicians in the treatment of younger children considering the large burden of asthma in early childhood.\textsuperscript{153} Age-specific drug formulations and outcome measures designed for young children could be important in reducing the risk of asthma exacerbations within this demographic.\textsuperscript{154} Additional research could improve health outcomes within this population and encourage proper asthma management.

There are numerous opportunities for developing policies that support multifaceted asthma management, interventions, and education for children. For example, policies that
encourage information sharing between primary care physicians and school nurses would allow for more comprehensive care of affected students. Health care specialists, such as clinicians and school nurses, can also provide expert guidance to school boards during policy development. Additionally, there are opportunities for implementing policies that support the control of environmental asthma triggers. For example, the rate of asthma cases and exacerbations caused by traffic-related pollution could be decreased with the implementation of policies that discourage developers from building homes near busy roadways. Policies incorporated into the school environment could also have a significant impact on health, especially considering the amount of time students spend in this environment. These policies should focus on reducing exposure to the pollutants, such as bus fumes, to which children are exposed. Additional opportunities for developing policy include creating standards for building new schools that minimize common environmental triggers. Decreasing levels of and exposure to asthma triggers would then result in improved health outcomes for asthmatic children.

Asthma is a serious health concern for millions of children across the country, and while it is not curable, multifaceted asthma management programs and policies have the potential to improve asthma management within this vulnerable population. However, programs and policies should consider each aspect of a child’s environment—school, home, parents, etc.—in order to encourage proper education and management of this disease. Advancements in technology, especially within schools, continue to provide opportunities for positively impacting asthmatic children and their families throughout the United States.
Appendix

Figure 1. Literature search results

![Diagram showing literature search results]

**Total article search results**

2,381

**Narrowed article search results**

44

Figure 2. Validated instruments for assessment and monitoring of asthma

![Table of validated instruments]

<table>
<thead>
<tr>
<th>Instrument</th>
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<tr>
<td>Asthma Control Questionnaire (Juniper et al. 1999b)</td>
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<tr>
<td>Asthma Therapy Assessment Questionnaire (Vollmer et al. 1999) (See below.)</td>
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<tr>
<td>Asthma Control Test (Nathan et al. 2004) (See below.)</td>
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<tr>
<td>Asthma Control score (Boulet et al. 2002)</td>
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**Asthma Therapy Assessment Questionnaire** (ATAQ)

1. In the past 4 weeks did you miss any work, school, or normal daily activities because of your asthma? (1 point for YES)
2. In the past 4 weeks, did you wake up at night because of your asthma? (1 point for YES)
3. Do you believe your asthma was well controlled in the past 4 weeks? (1 point for NO)
4. Do you use an inhaler for quick relief from asthma symptoms? If yes, what is the highest number of puffs in 1 day you took of this inhaler? (1 point for more than 15)

Total Points: 0-4, with more points indicating more control problems

Source: Adapted and reprinted with permission from Merck and Co., Inc. Copyright © 1997, 1998, 1999 Merck and Co., Inc. All Rights Reserved.
Figure 3. Sample patient self-assessment sheet for follow-up visits\textsuperscript{161}
Figure 4. Asthma action plan

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Figure 5. Alternate asthma action plan

Figure 6. Parents’ home page of the Comprehensive Health Enhancement Support System (CHESS)
Asthma in Children: A Chronic Condition Requiring a Multi-Faceted Approach

**Figure 7. Intervention documents used**

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Content</th>
</tr>
</thead>
</table>
| 1       | What is asthma?                | Basic epidemiology and pathophysiology  
• Chronic disease  
• “Sensitive” airways  
• Inflammation vs. bronchospasm  
• Causes of asthma vs. myths  
Goals of management  
• Introduction to steps in achieving control  
Warning signs of an acute episode of asthma  
• Common symptoms  
• Early warning signs                                                                 |
| 2       | Asthma triggers and avoidance  | Common asthma triggers  
• Trigger definition  
• How to identify triggers  
• Common triggers (smoke, allergens, viral infections, irritants, exercise, emotions, weather, medicines)  
Avoidance and control strategies  
• Trigger actions (identify, avoid, control)  
• Consideration of different environments (home, school, friends)  
Using an asthma diary                                                                 |
| 3       | Asthma medications             | Types of medications, correct use of medications  
• Goals of medications  
• How do different medications work (what they do, how fast they do it)  
• Side effects  
Demonstration and evaluation of inhaled delivery device technique  
Use of an asthma action plan  
• What is an action plan (sample plans and how to use)  
• How to work with your physician to develop and use a plan                                                                 |
| 4       | Asthma self-management         | Definition of self-management  
Review of steps to achieve asthma control  
Use of peak flow meters  
Importance of partnering with your doctor  
Ways to keep learning about asthma  
Asthma scenarios with problem solving  
Final questions                                                                 |
**Figure 8. Coaching strategies by stage**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Coaching Strategies</th>
</tr>
</thead>
</table>
| Precontemplation | • Assess knowledge, attitudes, and beliefs about desired asthma care behavior.  
                   • Create supportive climate for change by accepting present decision not to change now.  
                   • Extend availability to assist in the future if the decision is made to engage in desired asthma.  
                   • Present low-key information based on existing asthma care knowledge to inspire thinking about change.  
                   • Introduce the idea of a strong personal motivator, something a person wants badly enough to make the effort to change.  
                   • If the parent seems overwhelmed, help elicit barriers getting in the way of parent performing the desired asthma care behavior. |
| Contemplation    | • Discuss the motivation to perform the desired asthma care behavior.  
                   • Assist in identifying benefits of performing the desired asthma care behavior.  
                   • Focus on most meaningful personal benefit for the parent and/or child.  
                   • Assist in identifying barriers to performing the desired asthma care behavior.  
                   • Help discover possible solutions for each barrier.  
                   • Suggest small, achievable steps to making a change. |
| Preparation      | • Discuss successes and failures with earlier attempts to perform desired asthma care behavior.  
                   • Assist in developing achievable short-term and long-term goals related to performing the desired asthma care behavior.  
                   • Stress the importance of choosing a goal for which there is a high degree of confidence.  
                   • Plan follow up to track success with the goal and support change.  
                   • Recommend eliciting support from family and friends for attempting to perform the desired asthma care behavior. |
| Action           | • Offer praise and recognition for performing the desired asthma care behavior.  
                   • Emphasize benefits to performing the desired asthma care behavior.  
                   • Check on goals consistently.  
                   • Recommend journaling of successes/failures in performing the desired asthma care behavior.  
                   • Reinforce self-confidence.  
                   • Put parent in a role model situation for demonstrating an effective asthma care behavior.  
                   • Discuss potential for relapse and coping strategies.  
                   • Strategize how to handle challenging situations as a relapse prevention plan. |
Maintenance

- Offer praise and recognition for performing the desired asthma care behavior.
- Listen to success story related to performing the desired asthma care behavior.
- Encourage sharing of story with others.
- Discuss staying motivated to perform the desired asthma care behavior.
- Discuss potential for relapse and coping strategies.
- Look to the future. Assist in identifying potential barriers to performing the desired asthma care behavior and possible solutions.

Figure 9. General categories and frequency of reported environmental triggers\(^\text{167}\)

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Frequency</th>
<th>Examples of Parent Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants</td>
<td>307 (34%)</td>
<td>Trees, grass, weeds, hay, ragweed leaves</td>
</tr>
<tr>
<td>Animals</td>
<td>274 (31%)</td>
<td>Cats, dogs, other pet dander, horses, birds, feathers</td>
</tr>
<tr>
<td>Dust</td>
<td>261 (29%)</td>
<td>Dust, dust mites, stuffed animals, dust from vacuuming</td>
</tr>
<tr>
<td>Weather/Change of season</td>
<td>242 (27%)</td>
<td>Humidity, cold air, dry weather, heat, rainy weather, fog</td>
</tr>
<tr>
<td>Smoke</td>
<td>215 (24%)</td>
<td>Cigarette smoke, tobacco</td>
</tr>
<tr>
<td>Mold</td>
<td>160 (18%)</td>
<td>Mold, mildew, fungus</td>
</tr>
<tr>
<td>Acute illness</td>
<td>142 (16%)</td>
<td>Colds, viruses, respiratory infections, sinus drainage</td>
</tr>
<tr>
<td>Chemicals/odors</td>
<td>72 (10%)</td>
<td>Perfume, scented candles, paint, car fumes, house cleaners</td>
</tr>
<tr>
<td>Specific foods</td>
<td>87 (9%)</td>
<td>Popcorn, nuts, dairy, milk, soy, peanuts</td>
</tr>
<tr>
<td>Activity</td>
<td>66 (7%)</td>
<td>Too much activity, overexertion, sports</td>
</tr>
<tr>
<td>Air quality</td>
<td>28 (3%)</td>
<td>Bad air quality, smog, lack of fresh air</td>
</tr>
<tr>
<td>Emotions</td>
<td>9 (1%)</td>
<td>Getting upset, crying, stress, anxiety, being scared</td>
</tr>
<tr>
<td>Medications</td>
<td>8 (0.9%)</td>
<td>Penicillin, sulfa drugs, erythromycin</td>
</tr>
<tr>
<td>Cockroaches</td>
<td>6 (0.6%)</td>
<td>Cockroaches, roaches</td>
</tr>
<tr>
<td>Fabric</td>
<td>3 (0.3%)</td>
<td>Cotton, wool</td>
</tr>
<tr>
<td>Menstrual cycle</td>
<td>2 (0.2%)</td>
<td>First day of period</td>
</tr>
</tbody>
</table>
Figure 10. Five most common types of actions to address environmental triggers

<table>
<thead>
<tr>
<th>Action described by parent</th>
<th>Overall frequency, n (%)</th>
<th>Percentage of these children who had trigger for which action was recommended or reasonable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchasing special air filters</td>
<td>224 (25%)</td>
<td>157/224 (70%)</td>
</tr>
<tr>
<td>Reducing child’s exposure to dust</td>
<td>201 (22%)</td>
<td>81/201 (40%)</td>
</tr>
<tr>
<td>Using specialized vacuum for cleaning</td>
<td>150 (17%)</td>
<td>53/150 (35%)</td>
</tr>
<tr>
<td>Purchasing special bedding (e.g., mattress covers)</td>
<td>139 (16%)</td>
<td>67/139 (48%)</td>
</tr>
<tr>
<td>Increasing cleaning of house in general</td>
<td>113 (13%)</td>
<td>69/113 (61%)</td>
</tr>
<tr>
<td>Reducing exposure to animals</td>
<td>96 (11%)</td>
<td>58/96 (60%)</td>
</tr>
</tbody>
</table>
### Figure II. NYC Department of Education health forms

#### ASThma Medication Administration Form - Office of School Health

**Authorization for Administration of Medication to Students for School Year 2014-2015**

<table>
<thead>
<tr>
<th>Student Last Name</th>
<th>First Name</th>
<th>Middle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Date of Birth**

- MM/DD/YYYY

**School (include name, number, address and borough)**

- 

**DOB**

- 

**Grade**

- 

**Class**

- 

**Sex**

- Male

- Female

**Birth Certificate**

- 

**Allergies**

- 

**Diagnosis**

- Asthma

**Select Asthma Severity**

- Intermittent

- Mild Persistent

- Moderate Persistent

- Severe Persistent

**NAEPP guidelines recommend inhaled corticosteroids (ICS) for persistent asthma.**

**Select in School Asthma Medications**

- rescue Meds

- ICS meds

**Meds**

- Beclomethasone (Vanceril®) 0.025 mg HFA

- Fluticasone (Flovent®) 25 mcg HFA

- Mometasone (Pr.za 500®) 50 mcg HFA

**Select all options that are appropriate**

- student may carry medication & self-administer

- student may carry medication & self-administer

- student to self-administer with supervision

- student to self-administer personal MDI on school trips & after-school programs

**Instructions for partial or full improvement or absence**

- if improved, but not enough to return to class, call parent.

- if significant respiratory distress periods:

  - call 911

  - notify parent and PPD.

  - may provide additional puffs as needed until EMS arrives.

**IM & IV Medications**

- Beclomethasone (Vanceril®) 0.025 mg HFA

- Fluticasone (Flovent®) 25 mcg HFA

- Mometasone (Pr.za 500®) 50 mcg HFA

**Select all options that are appropriate**

- student may carry medication & self-administer

- student may carry medication & self-administer

- store medication in medical room & student to self-administer with supervision

- student to self-administer on school trips & after-school programs

**Other asthma medication**

- Prevention/Control:

- 

**Route**

- 

**Select all options that are appropriate**

- student may carry medication & self-administer

- student may carry medication & self-administer

- store medication in medical room & student to self-administer with supervision

- student to self-administer on school trips & after-school programs

**HOME medications (include over the counter)**

- 

**Health Care Provider**

- 

**Signature**

- 

**CDC and AAP strongly recommend annual influenza vaccination for all children diagnosed with asthma.**

*Confidential information should not be sent by e-mail.*

Item 414
Asthma in Children: A Chronic Condition Requiring a Multi-Faceted Approach

### ASTHMA

**MEDICATION ADMINISTRATION FORM - OFFICE OF SCHOOL HEALTH**

**Authorization for Administration of Medication to Students for School Year 2014-2015**

<table>
<thead>
<tr>
<th>Student Last Name</th>
<th>First Name</th>
<th>M</th>
<th>Date of birth</th>
<th>School</th>
</tr>
</thead>
</table>

**PARENT/GUARDIAN’S CONSENT AND AUTHORIZATION**

I hereby authorize the storage and administration of medication, as well as the storage and use of necessary equipment to administer the medication, in accordance with the instructions of my child’s physician. I understand that I must provide the school with the medication and equipment necessary to administer medication, including non-steroidal inhalers. Medication is to be provided in a properly labeled container from the pharmacy (another such container should be obtained by me for my child’s use outside of school); the label on the prescription medication must include the name of the student, same and telephone number of the pharmacy, licensed prescriber’s name, date and number of refills, name of medication, dosage, frequency of administration, route of administration and other directions. Over-the-counter medications and drug samples must be in the manufacturer’s original container, with the student’s name affixed to that container. I understand that if I provide an asthma inhaler, it must be supplied in its original and UNOPENED medication box. I further understand that I must immediately advise the principal and/or his/her designee(s) especially the school nurse of any change in the prescription or instructions stated above.

I understand that no student will be allowed to carry or self-administer controlled substances.

I understand that this Authorization is valid until the earlier of (1) June 25, 2015; (2) the student attending a New York City Department of Education (the “Department”) sponsored summer enrichment program; (3) the close of the school year, i.e., the last scheduled school day of the calendar year. The above authorization may be extended through August 31 if the student is attending a New York City Department of Education (the “Department”) sponsored summer enrichment program. I understand that if the student is attending a Department sponsored summer enrichment program, the Department will provide the proper documentation of eligibility, and that the student will be instructed by the Department to bring the Authorization Form to the school in which the student is enrolled. I understand that the Department will provide the proper documentation of eligibility, and that the student will be instructed by the Department to bring the Authorization Form to the school in which the student is enrolled.

**ST. ADMINISTRATION OF MEDICATION**

I hereby authorize the Department to provide the services requested, but, rather, my request, consent and authorization for such services. It is determined that these services are necessary, a Student Accommodation Plan may be also necessary and will be completed by the school.

I hereby authorize the Department, DOHMH and their employees and agents, to contact, consult with and obtain any further information they may deem appropriate relating to my child’s medical condition, medication and/or treatment, from any health care provider and/or pharmacist that has provided medical or health services to my child.

I further authorize the Department, DOHMH and their employees and agents, to contact, consult with and obtain any further information they may deem appropriate relating to my child’s medical condition, medication and/or treatment, from any health care provider and/or pharmacist that has provided medical or health services to my child.

**Parent/Guardian’s Signature**

**Date Signed** __/__/____

**Parent/Guardian’s Address**

**Telephone Numbers:**

- **Daytime ( )-_______**
- **Home ( )-_______**
- **Cell Phone ( )-_______**

**Parent/Guardian e-mail address**

**Alternate Emergency Contact’s Name**

**Contact Telephone Number** ( )-_______

**Received by Name**

**Date** __/__/____

**Reviewed by Name**

**Date** __/__/____

**Services provided by:**

- **Nurse**
- **DOHMH Public Health Advisor**
- **School Based Health Center**
- **DOE School Staff**

**Signature and Title** (RN OR MD):

*Confidential Information should not be sent by e-mail.*
**Figure 12. Group session and newsletter topics**

<table>
<thead>
<tr>
<th>Group Session Topics</th>
<th>Newsletter Content</th>
<th>Evaluation Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What is asthma and how did I get it?</td>
<td>• Introduction to the program</td>
<td>• Responsibility for care (RC)</td>
</tr>
<tr>
<td>• Holler. Stop. Six-pack. Chill: signs and symptoms of an attack and knowing how to respond</td>
<td>• What is asthma, including from a perspective of an adolescent</td>
<td>• Outcome expectancies (OE)</td>
</tr>
<tr>
<td>• How do medicines prevent attacks?</td>
<td>• Preventing attacks by identifying triggers and using a peak flow meter</td>
<td>• Self-efficacy through managing and preventing attacks (SE)</td>
</tr>
<tr>
<td>• Stopping asthma before it stops you: action planning and using a peak flow meter</td>
<td>• Controlling attacks via medication management</td>
<td>• SE</td>
</tr>
<tr>
<td>• How can I avoid triggers and asthma attacks?</td>
<td>• Improving communication with others</td>
<td>• SE</td>
</tr>
<tr>
<td>• Getting the help you need: how to talk to parents, friends, doctors, and school personnel</td>
<td>• Maintaining changes through reinforcement</td>
<td>• OE, RC, impact of illness on family</td>
</tr>
</tbody>
</table>
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108 Ibid.
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AAFA, “Child Care.”


Gustafson et al., “The Effects.”

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