SUPPLEMENT ARTICLE

Effectiveness of Educational and Behavioral Asthma Interventions

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ABSTRACT

In this article we discuss studies of individualized and community-based interventions for control of asthma in children. We posit that successful programs share 8 common characteristics: (1) recognition of the multiple factors affecting childhood asthma; (2) careful assessment of participants’ risk factors and needs; (3) tailoring of program elements to address participants’ risk factors and needs; (4) consideration of both physical and social environments; (5) use of sound learning and change theories; (6) family involvement; (7) focus on children with the most serious disease; and (8) selection of delivery venues at which learning can be optimized. Challenges for moving practice and research forward also are presented. *Pediatrics* 2009;123:S185–S192

THE PARADOX of asthma is that, although our understanding of its pathophysiological features and the therapies available for treating the disease have increased significantly over the past 2 decades, the prevalence of asthma, the health care use associated with it, and the disruptions it causes to family and community life have not decreased substantially.\textsuperscript{1} These facts suggest a need for interventions that enable individuals, families, communities, and health care providers to manage asthma and its consequences effectively.

Asthma control requires the attention and involvement of a wide range of stakeholders. Figure 1 depicts the patient at the center of effective disease management efforts and illustrates the relative levels of influence of people and institutions that can help the patient. Within the circle closest to the person with asthma is the family, which must provide extensive support, especially for children. Next are the clinicians and health care institutions whose expertise and services are required to guide the child and the family in their control efforts. Then comes the school (or the workplace, in the case of an adult), where optimal support and understanding are needed. Community organizations, agencies, and individuals must be aware of the prevalence of asthma in the community and the ways in which they can provide services and assistance to reduce the disease burden that families face. Appropriate environmental and other policies (eg, enabling children to carry medicines at school) are needed to ensure consistent, affordable, effective, system-wide, ameliorative actions that assist families in managing the condition.

Significant advances have been made in recent years in the design of programs to enhance asthma management by patients and to improve the helping capacity of those within the patient’s circles of influence. The challenge for both medicine and public health is how to mount proven programs that can address the needs of individual patients while reaching large numbers of people. This article provides examples of studies of programs that either target individual children with asthma or are designed to offer assistance in community venues such as schools, which provide opportunities for reaching maximal numbers of children.

The use of proven asthma programs is not as widespread as the evidence warrants or as we would wish. In many settings, either proven interventions are in limited use or the interventions in use have no clear-cut evidence of success. The studies presented here are examples of carefully conducted research that has increased our understanding of intervention effectiveness and has enabled identification of the type of programs that warrant broader use. We begin by describing selected asthma intervention programs; then we identify the elements common to successful programs that should be considered in program design and implementation, and we make recommendations for moving research and practice forward.

EVIDENCE FOR AND CHALLENGES IN INDIVIDUALIZING ASTHMA INTERVENTIONS

One of the most interesting recent trends in science and medicine has been the increasing attention to variability in responses, that is, recognition that not all patients are equally responsive to a given treatment. Although physicians have long been aware that this is the case, only recently has science progressed to the level that “designer” drugs can be formulated with properties uniquely effective for individual patients or groups of patients. Genetic characteristics
and other risk factors associated with the disease or the patient are now influencing medication and treatment selection. For some time, we have observed this same phenomenon in educational and behavioral intervention research: some interventions are quite effective for some people in some situations but are seemingly useless for other people or in other situations. The different responses to interventions are a function of the characteristics of those undergoing the intervention and the intervention itself. Although this is true in general, it is even more true for interventions that target asthma, in large part because of the many diverse factors that influence the development or exacerbation of asthma.

In one of the most ambitious explorations of the factors influencing asthma, the National Institute of Allergy and Infectious Diseases (NIAID) inner-city asthma studies evaluated thousands of children across the United States and investigated the factors associated with asthma morbidity. In the initial studies to identify factors related to asthma symptoms and exacerbations, the investigators were somewhat surprised to find that no single factor accounted for the high prevalence of asthma and the increased asthma rates among inner-city children. To the contrary, a myriad of factors were found to be important. For some children, asthma morbidity was related to problems accessing care. The asthma symptoms of other children were strongly related to psychosocial problems and stress in the family, which seemed to interfere with appropriate asthma management. Still other children were highly allergic to cockroach and other allergen exposures, which greatly increased rates of asthma hospitalizations and symptoms. Among other children, especially those without strong allergic responses, nitrogen dioxide exposure, primarily from unvented gas stoves, was significantly related to asthma symptoms. After 15 years of these inner-city asthma studies, the most striking finding was that the multitude of factors varied dramatically from one child to the next.

The realization that so many factors were contribut-
undergo the intervention and there is adequate impact, then the net effectiveness of these more-global efforts could be greater on a population-wide basis. If the individualized approach is to be most effective, then the technology and packaging of the intervention materials and the method of implementation must be optimized, and we must learn how to expand such interventions to reach larger numbers of children without losing effect.

EFFECTIVENESS OF COMMUNITY-BASED INTERVENTIONS FOR CHILDREN

Outreach

In asthma, 4 types of community interventions have been examined: (1) interventions that provide outreach to patients in their homes from clinicians and other health care providers; (2) home-based computer programs; (3) school-based programs; and (4) coalitions and partnerships. The great majority of interventions reaching out to patients and families in their homes have involved the deployment of community health workers. It is this facet of outreach that has received the most attention in rigorous evaluations. These community health worker efforts have had 2 primary goals, that is, to provide asthma self-management education to children and their family members and to assist the family in modifying the home environment, sometimes by providing equipment (eg, bed coverings or pest-control materials) to support the modifications.

Table 1 summarizes the designs of randomized, clinical trials that assessed the outcomes of outreach activities and were exemplar studies that used accepted methods and included a control or comparison group. Six carefully conducted evaluations involving reasonable numbers of children provided evidence. Williams et al8 found positive outcomes associated with community health worker visits to the homes of children with asthma to assist the family in improving the home environment by making changes designed to reduce the presence of asthma symptom triggers. They found that this intervention resulted in significant decreases in dust mite allergen levels in the home and improved daily functioning (as evidenced by fewer symptoms and days of restricted activity) for children who had been classified as having severe asthma.9,10 Krieger et al10 examined 2 levels of efforts of community health workers. The high-intensity level included assisting families with home environment modifications, providing needed materials, and providing asthma education. The low-intensity level involved fewer visits and education regarding asthma and environmental control. For both levels of intervention, children subsequently reported a higher quality of life and less use of urgent care for asthma episodes.

Evans et al6 assessed a program involving social workers trained in asthma control who developed tailored education for the child and family, designed to provide optimal support for the social, behavioral, and cultural factors involved in asthma management. They found that subsequently the children experienced fewer days with asthma symptoms and fewer hospitalizations and these effects were most significant for children with severe disease. Carter et al11 compared 3 types of community health worker interventions, ranging from very intensive efforts to prevent or to reduce the effects of environmental triggers (including the use of recommended preventive measures and materials and comprehensive asthma education) to brief and less frequent visits. The children who received the most-active intervention had fewer urgent care visits and slight reductions in the levels of allergens of all types (eg, mite, dander, and cockroach) in the home, with the greatest decrease in mite allergen levels. Morgan et al12 conducted an environmental intervention in the homes of inner-city children with asthma and found that a tailored intervention directed at the risks for each individual family led to significant reductions in asthma symptoms. The reductions in symptoms were strongly related to reductions in levels of cockroach allergen, the predominant trigger among inner-city children with asthma. Brown et al12 evaluated the “Wee Wheezers” program, a comprehensive asthma education intervention delivered in the homes of children <7 years of age. Positive results were found for children <3 years of age, who experienced fewer days with asthma symptoms, and for their parents, whose asthma-related quality of life improved.

These intervention results are promising and suggest that providing active assistance in the home to families (particularly those whose child has more serious disease) can produce benefits. Two issues, however, must be considered when the use of this type of program is being

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<th>Authors</th>
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<th>Outcomes</th>
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<tr>
<td>Williams et al (2006)</td>
<td>410</td>
<td>Modification of environment</td>
<td>Reduction in dust mites; improved functioning among children with most-severe asthma</td>
</tr>
<tr>
<td>Krieger et al (2005)</td>
<td>274</td>
<td>High- vs low-intensity environmental control and education</td>
<td>Improved quality of life; less urgent care</td>
</tr>
<tr>
<td>Evans et al (1999)</td>
<td>1033</td>
<td>Social workers individualized education for family</td>
<td>Fewer sick days; fewer hospitalizations; greatest effect on children with severe asthma</td>
</tr>
<tr>
<td>Carter et al (2001)</td>
<td>104</td>
<td>Assistance with home prevention (3 groups)</td>
<td>Reduction in acute visits with active intervention; slight reduction in allergen presence; decrease in mite allergen levels</td>
</tr>
<tr>
<td>Brown et al (2002)</td>
<td>95</td>
<td>“Wee Wheezers” (&lt;7 y of age) at home</td>
<td>Fewer symptom days for younger children only; better quality of life for parents of younger children</td>
</tr>
<tr>
<td>Morgan et al (2004)</td>
<td>937</td>
<td>Environmental control and education</td>
<td>Reductions in allergen exposures and symptoms</td>
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assessed. First, in virtually all of the available studies of home-directed environmental control, the effects of environmental changes were not distinguished from the effects of more-general asthma education. We do not know whether the environmental modifications or the asthma education accounted for the observed outcomes. Second, environmental modifications can be costly; whether they are borne by the program or by the family, the expenses associated with bedding covers, allergen control measures, and improvements in indoor air quality are significant. More research is needed to move from overall intervention studies to studies that consider the relative effects of various control activities.

Computer Programs for Home Use

Most computer programs for use by children with asthma in their homes have centered on involving the children in games and problem-solving. Although a number of computer-based interventions have been described in the literature, including some used in clinics or doctors’ offices or as part of a larger asthma education program, few rigorous evaluations of home-based programs have been undertaken. Table 2 presents findings for 3 of the most carefully assessed programs. In 2 of the studies, 1 by Huss et al13 evaluating an asthma game and 1 by Homer et al14 comparing computer-assisted asthma management action plans versus written ones, no significant results were observed. A smaller study by Shegog et al15 found that computer-delivered self-management education used at home enhanced children’s sense of self-efficacy.

Although 3 studies cannot provide a definitive understanding of the use of computers at home to improve asthma management and outcomes, they do indicate that, to date, the success of that type of intervention has been limited. Two observations can be made, however. First, these studies primarily tested children’s knowledge levels, and the relationship of knowledge to subsequent behavior has been shown to be tenuous in most areas of health. Second, many children in communities with the greatest problems with asthma do not have computers, which makes it difficult for them to access this type of intervention.

In a novel approach to computerized educational programs directed at physicians, Kattan et al16 collected inner-city children’s asthma symptom and medication use information every 2 months, through telephone interviews, and used an automated computer program that provided this information to the child’s primary care physician along with guideline-based treatment recommendations. The computerized algorithm analyzed each child’s current level of symptoms, health care utilization, and medication use and, on the basis of National Asthma Education and Prevention Program guidelines, recommended increased treatment, decreased treatment, or no change. Children whose primary care physicians received these computerized letters had more follow-up care visits, received increased treatment more rapidly when warranted, and had fewer emergency department visits.

School-Based Interventions

A number of investigators have evaluated school-based interventions, which are thought to be a very useful way to reach large numbers of children and to involve those who are not currently or consistently seen within the health care system. Most school-based programs have focused on children’s efforts to self-manage and have been conducted with or without the availability of school-based health services. Table 3 presents the results of 6 randomized trials of school-based asthma programs; each program provided a different type of intervention.

Evans et al17 provided comprehensive asthma self-management education for children in low-income, minority, elementary schools; subsequently, children in the treatment schools experienced significantly fewer

### Table 2: Randomized Trials of Interventions Using Computer Programs at Home

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<th>Intervention</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>Huss et al13 (2003)</td>
<td>101</td>
<td>Asthma game</td>
<td>No significant results observed</td>
</tr>
<tr>
<td>Shegog et al15 (2001)</td>
<td>76</td>
<td>Self-management education</td>
<td>Increased self-efficacy</td>
</tr>
<tr>
<td>Homer et al14 (2000)</td>
<td>137</td>
<td>Asthma management through computer-assisted instructions vs written instructions</td>
<td>No significant results observed</td>
</tr>
<tr>
<td>Kattan et al16 (2006)</td>
<td>937</td>
<td>Feedback on child’s clinical status to primary care physician</td>
<td>Increase in follow-up care; reduction in acute care visits</td>
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### Table 3: Randomized Trials of School-Based Programs

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<tr>
<th>Authors</th>
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<th>Intervention</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>Evans et al17 (1987)</td>
<td>239</td>
<td>Self-management</td>
<td>Reductions in symptoms and emergency department visits; better grades</td>
</tr>
<tr>
<td>Shah et al20 (2001)</td>
<td>272</td>
<td>Peer education on asthma management</td>
<td>Improved quality of life and reduction in absenteeism</td>
</tr>
<tr>
<td>Guo et al21 (2005)</td>
<td>273</td>
<td>School-based asthma clinic</td>
<td>Reductions in hospital and emergency department visits and care costs</td>
</tr>
<tr>
<td>Tinkelman and Schwartz18 (2004)</td>
<td>41</td>
<td>Asthma self-management education</td>
<td>Reductions in missed school days, unscheduled doctor visits, and symptoms</td>
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<tr>
<td>Halterman et al19 (2004)</td>
<td>180</td>
<td>Asthma medications provided at school</td>
<td>Reductions in missed school days and symptoms</td>
</tr>
<tr>
<td>Clark et al22 (2004)</td>
<td>835</td>
<td>Comprehensive management education</td>
<td>Reductions in symptoms in persistent group; better grades; fewer missed school days</td>
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asthma symptoms, had fewer emergency department visits, and had better grades in school, compared with control subjects. In a smaller study, Tinkelman and Schwartz also found positive results for school-based asthma education, that is, the children had fewer asthma symptoms, less absenteeism, and fewer unscheduled doctor visits. Clark et al. assessed a comprehensive, school-based program that provided education to students with asthma and to their classmates, to engender more school-wide support for the children with asthma. The program also included education and orientation for school principals, counselors, and building personnel and involvement of relevant community organizations. Children with persistent disease in the treatment group experienced a significant reduction of symptoms, better grades, and fewer missed school days. In their assessment of a peer education program for high school students in which older students taught younger ones about asthma control through a range of classroom and assembly events, Shah et al. found less absenteeism attributable to asthma and higher levels of asthma quality of life in the treatment schools.

Guo et al. assessed school-based asthma clinics with services provided by nurses trained in asthma management. They found that children in the schools with clinics had significantly fewer hospital and emergency department visits attributable to asthma and associated costs were less. Halterman et al. evaluated a program providing asthma medicines at school, including both antiinflammatory and bronchodilator therapies. They found that children in the treatment schools had fewer asthma symptoms and less absenteeism.

A number of observations can be made about the potential for school-based programs. These interventions are difficult to provide in schools with limited resources. For such schools, which are usually in low-income and minority communities (ie, the communities experiencing the greatest burden of asthma), the school systems may be reorganized frequently in efforts to enhance students’ academic performance. It may be difficult for school personnel and program providers to implement asthma interventions in the presence of many competing priorities. However, 5 of the 6 programs described here produced outcomes of great interest to school leaders (improved grades or reduced absenteeism), and these results may generate interest in implementing school-based programs.

Replication of proven programs does not occur as frequently as it might. The large voluntary associations that once were very active in providing asthma education in schools now are less involved in program provision. Continuous sponsorship for school-based programs is especially needed in districts with few resources to spare. Finally, the high cost of providing clinical services and school-based provision of medicines is an important consideration.

Community Coalitions and Partnerships
Currently, there are >200 asthma coalitions in the United States and countless others around the world. These community-based partnerships focus on bringing disparate groups together to advocate and to provide models for system and policy changes that can enhance the ability of individuals, families, and communities to control asthma. Evaluations of these efforts generally have used the following logic: eventually improved health status of children with asthma results from supportive health system-wide changes and community-wide policies that support family management efforts. Table 4 provides examples of studies of asthma coalitions. Some of the characteristics of community-wide collaborations suggest that they are a promising means of asthma control; for example, they tend to be ecological in their approach to improving community and clinical systems and considering the influences of both social and physical environments. They attend to the epidemiological features of asthma in a given area and generally tailor changes in light of group prevalence. They promote changes in the range of settings where children with asthma live and seek services.

Kreger et al. evaluated 11 asthma coalitions across the state of California and found that they had success in educating and advocating for changes related to housing rights, public awareness of asthma, school environmental assessments, outdoor air quality, and asthma action plans in schools throughout the community. Fisher et al. evaluated a neighborhood asthma coalition in St Louis and found a significant decrease in acute care rates for asthma among families with high levels of participation in coalition activities. Assessing 7 asthma coalitions across the United States, Clark et al. found that these partnerships achieved several system and policy changes. Two established community-wide patient registries. Two developed agreements for deploying care coordinators among community hospitals and clinics. Four established the routine integration of community health workers into the clinical care teams in community hospitals. Six provided ongoing community-wide

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<tr>
<td>Kreger et al. (2005)</td>
<td>11 coalitions across California</td>
<td>Community education regarding housing rights; public education regarding asthma; school environmental assessments; advocacy for air quality; asthma action plans in schools throughout community</td>
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<tr>
<td>Fisher et al. (2004)</td>
<td>Neighborhood asthma coalition</td>
<td>Reduction in acute care rates among high-level participants</td>
</tr>
<tr>
<td>Clark et al. (2006)</td>
<td>7 asthma coalitions across the United States</td>
<td>Community-wide patient registries; care coordinators among hospitals and clinics; integration of community health workers into clinic care teams; community-wide education for clinicians; environmental control policy changes</td>
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education for practicing physicians. One changed community policies related to diesel emission control and traffic patterns near residential areas.

Observers have noted that, although community coalitions and partnerships can be effective, they require high-level skills related not only to effective asthma policies and regulations but also to the processes needed to enable diverse stakeholders to work together effectively to bring about change. Such efforts take time to produce results, although, once they are established, coalitions can broaden their interests to other health problems and take advantage of the collective wisdom, experience, and contacts of members to address other needed changes.

There have been few studies of the actual health outcomes for children in relation to coalition efforts and the changes they achieve in asthma-related policies and health care systems. Such studies are needed, especially those that can produce population-wide outcome data. In addition, coalitions have not found extensive support for their work, beyond a few foundations that have committed significant resources for limited periods of time. With a few notable exceptions, institutionalizing the work of asthma coalitions and partnerships is a challenge yet to be overcome.

In summary, a few good models of interventions to enhance asthma outcomes for children are available for use in health care systems, through outreach by community health workers, school-based programs, and community coalitions/partnerships. Continuing challenges related to these community-based programs are widespread dissemination of effective models, sustainability and institutionalization of successful programs, development of new approaches using innovative technologies, and studies to document program outcomes (particularly population studies).

COMMON FEATURES OF SUCCESSFUL INTERVENTIONS
The successful interventions discussed here share some common characteristics. These characteristics might have been evident to greater or lesser degrees according to the program goals and setting; however, they seem to be important considerations for both practitioners and researchers in choosing or developing interventions. These common characteristics of success include (1) recognizing the multiple factors that influence childhood asthma and its control, (2) carefully assessing the participants’ risk factors and needs in achieving asthma control, (3) tailoring program elements to the individual to the greatest extent possible, (4) basing interventions on sound principles of learning and change, (5) considering both the physical and social environments, (6) involving significant family members in intervention activities, (7) focusing on children with the most serious disease, and (8) selecting a venue where learning can be optimized (eg, schools, where large numbers of children can be affected).

There are, of course, limitations to this overview of asthma interventions and common features of success. The primary limitation is related to the source material available for assessment of success. One inherent flaw in any consideration of the evidence base for interventions is the usual failure of null-result studies to be published. As a result of this positive study bias, we likely have a skewed perspective of how often similar strategies (or different strategies) have been tried and failed. To put it another way, how often have elements of programs apparently associated with efficacy been present in interventions without positive outcomes? As with pharmaceutical studies, the research community should assess efficacy and effectiveness on the basis of all studies performed, not only those for which results have been published. Our state of knowledge is imperfect, and we need to refine our understanding of effective practices on the basis of the complete set of studies actually undertaken.

CHALLENGES TO MOVING RESEARCH AND PRACTICE FORWARD
As we look forward, it is important, and somewhat provocative, to consider whether all positive outcomes should be considered of equal value when asthma interventions are being compared. Is an intervention that results in a 6-month decrease in urgent care visits more clinically significant than one that produces a 12-month decrease in symptoms but no reduction in emergency department use? How important is improved parent quality of life if a child’s disease outcomes do not change? What does it mean when some asthma outcome measures improve but other measures remain unchanged, as typically occurs? Understandably, different stakeholders value the range of asthma outcomes differently. Payers may be more concerned with costly asthma outcomes and therefore are more willing to invest in programs with an evidence base of reduced urgent care utilization, whereas school districts may be more sensitive to lost school days. Evaluating intervention effectiveness or outcome value is, and will continue to be, dependent on the context and perspective of the observer.

As noted, different interventions produce different outcomes. However, some programs with overwhelming results continue to appear in the literature; a salient example is interventions that change knowledge but not behavior. These types of interventions might not have included one of the key success factors noted above, that is, using sound principles of learning. Perhaps the time has come to set a standard for asthma interventions. Many controlled trials of intervention programs have demonstrated reductions in children’s symptoms and the need for fewer urgent health care services. We may have come to a point where we will accept nothing less than symptom reduction and improvement in health care use as the markers of intervention success.

Increasingly there is widespread recognition, even among bench scientists, that the social, behavioral, and policy elements of asthma control are crucial. This recognition has developed in part because the important basic science and clinical advancements in asthma therapies in the past decade have produced no concomitant change in asthma burden for many popula-
ctions of children. However, these elements have been the least examined in rigorous research, in large part because of the lack of funding and concerted effort among research sponsors. We have reached the time when a serious shift in funding priorities is needed to make significant advances in asthma control.

The interventions outlined in this article demonstrate that desired levels of asthma control are achievable; however, in many ways the field of practice keeps reinventing the wheel by using homegrown interventions that have not been evaluated in a rigorous manner. In part, the problem results from a failure to disseminate effective interventions widely and to adapt them for local use without losing their ability to produce change. The time has come to place greater emphasis on replication and dissemination of research that enables us to understand how to translate effective programs into practice and how to scale successful interventions for widespread use.

Although some plateauing of asthma prevalence was noted in the recent data from the Centers for Disease Control and Prevention, 2 factors are important to note. First, asthma is still at an unacceptable level of prevalence. Second, the plateauing has not occurred in the low-income and minority communities that experience the greatest burden of disease. After a decade-long effort to control the condition with better therapies, we seem to be experiencing a type of “asthma fatigue.” Our efforts at reducing the prevalence and burden of this disease must become more sophisticated in the ways described in this article, including targeting of the social, behavioral, and policy-linked factors that have received less attention in research. To achieve better control over a disease that continues to affect far too many children, we need to reinvigorate our efforts as practitioners and researchers.

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