Effects of a Comprehensive School-Based Asthma Program on Symptoms, Parent Management, Grades, and Absenteeism*

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Study objective: **This study assessed the impact of a comprehensive school-based asthma program on symptoms, grades, and school absences in children, and parents' asthma management practices.**
Design: **Randomized controlled trial.**
Setting: **Fourteen elementary schools in low-income neighborhoods in Detroit, MI.**
Participants: **Eight hundred thirty-five children with asthma in grades 2 through 5 and their parents.**
Intervention: **The intervention entailed six components for children, their parents, classmates, and school personnel to encourage and enable disease management.**
Measurements and results: **Parents completed telephone interviews and the schools provided data at baseline and 24 months after intervention. At follow-up, treatment children with persistent disease had significant declines in both daytime (14% fewer, $p < 0.0001$) and nighttime (14% fewer, $p < 0.0001$) symptoms. Among children with both mild intermittent and persistent disease, those in the treatment group had 17% fewer daytime symptoms ($p < 0.0001$) but 40% more nighttime symptoms. Treatment children had higher grades for science ($p < 0.02$) but not reading, mathematics, or physical education. No differences in school absences for all causes between groups were noted in school records. However, parents of treatment group children reported fewer absences attributable to asthma in the previous 3 months (34% fewer, $p < 0.0001$) and 12 months (8% fewer, $p < 0.05$). Parents of treatment children had higher scores (2.19 greater, $p = 0.02$) on an asthma management index. The program may have stimulated attention to symptoms at night by parents of children with mild intermittent disease. Overall, the intervention provided significant benefits, particularly for children with persistent asthma.**
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Key words: asthma; childhood asthma; morbidity; randomized controlled trial; school-based education; school performance; urban children

Abbreviations: DPS = Detroit Public Schools; PE = physical education

The worrisome data on the prevalence of asthma among children has led to focus on the schools as a point of intervention for asthma control.[1] On average, 6 to 8% of American children have asthma[2]; however, in asthma hot spots, for example, low income, urban, minority neighborhoods in Detroit, New York City, and other major cities, rates > 20% have been reported.[3–5] The randomized controlled trial reported here evaluated a comprehensive asthma program introduced into elementary schools in high asthma prevalence areas in Detroit, MI. This article presents data testing the assumptions that the program would reduce symptoms, improve school grades, and reduce school absences among children with asthma in intervention schools compared to those in control schools. It was also anticipated that parents of treatment children would engage in more asthma management activities than control subjects.

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Materials and Methods

Sample and Research Design

Fourteen elementary schools comprising the former Area D of the Detroit School System participated in the study. These schools are located in communities that are 94% African American and for which > 40% of study children met federal guidelines for poverty according to the 1990 census. Schools faced many problems during the study period, including district reorganization and significant budget reductions. No school-based health services were available at participating elementary school sites at the time of program start-up. Parents of all children in grades 2 to 5 (n = 6,351) were provided a survey form designed to identify asthma cases, and 4,576 parents returned the survey with sufficient data for analysis. Based on responses, 1,217 children were identified for participation in the randomized trial.

The survey procedures used to identify children with asthma have been discussed in detail elsewhere.[3] For participation in the study reported here, enrollment criteria were as follows: (1) a physician's diagnosis of asthma and active symptoms, or a diagnosis and received a prescription for asthma medications in the previous year; and (2) no physician's diagnosis, but reported presence of three or more of seven asthma symptoms in the past year, or reported either of two exercise-related asthma symptoms with frequency of three times or more, in the past year.

Of 1,217 children fitting these initial criteria, parents or caretakers of 835 agreed to participate and provided useable baseline data. Two years later, 674 parents provided follow-up data. The University of Michigan Institutional Review Board approved all consent procedures. Reasons for not participating were primarily that the family moved, could not be contacted after several attempts, or believed the child did not have asthma. Schools were randomly assigned by use of a random number table to receive the program (seven schools and 416 children) or to be assigned to a wait list control group (seven schools and 419 children). The program was offered in control schools subsequent to final data collection. Schools were the unit of randomization, and children were the unit for data analysis.

Intervention

The comprehensive program comprised education for children with asthma to enhance their disease management skills and a series of components aimed at those in the social environment who might enable him or her to manage better. The program elements, were as follows: (1) "Open Airways for Schools"[6] disease management training for children adapted to local needs (for example, related to smoking among elementary school-aged children[7]), which included handouts and homework assignments involving parents; (2) "Environmental Detective," two classroom sessions for classmates to enhance their understanding of factors that may influence respiratory health in general, and to help them develop empathy for children with asthma in particular; (3) orientation to asthma and control strategies for school principals and counselors; (4) briefings and building walk-throughs for custodial personnel regarding potential environmental triggers to asthma symptoms and practical means of remediation; (5) school fairs for children and their caretakers, including asthma care question-and-answer sessions for the adults; (6) written communication on behalf of the family with the child's clinician providing information about the school program, encouraging completion of an asthma action plan for the child, and requesting provision of a copy to the school.

All elements of the program were completed with reasonable success except the last element. It was difficult to connect with the primary care physicians by telephone or letter, and a very small number provided action plans to the schools as requested (see "Discussion" section).

Data Collection and Analysis

The children's parents or caretakers were interviewed by telephone at baseline and at 12 months and 24 months subsequent to the intervention. The questionnaire inquired extensively into the type and frequency of asthma symptoms and efforts of the parents to manage asthma. School records for all years of the study, reporting mathematics, science, reading, and physical education (PE) grades, were obtained from the Detroit Public Schools (DPS) Office of Research and Evaluation. Data on school absences were obtained from two sources: DPS data files reporting absences for all reasons during the project period, and parent interview data describing school absences due to asthma symptoms at baseline and for the previous 3-month and 12-month periods.

In addition to assessing individual grades, an academic grade index (A = 4, B = 3, C = 2, D = 1, and F = 0) was created for each child. An overall mean score and the means for class specific scores were calculated for mathematics, science, and reading grades. Mean scores were also computed for PE grades. The series of questions that tapped parents' asthma management strategies were summed into a 15- to 60-point index. Questions included items such as administering medicines, avoiding symptoms, observing signs and symptoms, and removing triggers in the environment. Parents also reported day and nighttime asthma symptoms experienced by the child at baseline and in the past 3 months and 12 months. Symptom data were provided in a form that enabled assessment of severity adapting the National Asthma Education and Prevention Program guidelines.

All data were analyzed with Statistical Analysis System (SAS Institute; Cary, NC) version 8 (TS M0) on the SunOS 5.8 platform. To account for the correlation between the repeated measures of the outcome variables, generalized estimating equations were used throughout the analysis. Poisson or normal regression models were used depending on the variable type. Generalized estimating equations were also used to obtain correct coefficients when data may not have conformed exactly to Poisson or normal distributions. Baseline outcome measures, demographic variables (sex of child, family income, age of the child), and baseline severity were adjusted in all statistical models. There were no significant differences in asthma severity between treatment and control groups at baseline. Summary statistics were generated for outcome variables. Baseline outcomes were compared to see if the two study arms (treatment and control) were balanced for outcomes before the intervention. Main effect models were built. Interactions between covariates were also explored. Significance was taken as $p < 0.05$.

Results

Description of the Children

See the Appendix for data on the number of children enrolled in the research according to the study criteria and the symptoms reported by children surveyed regardless of enrollment status. Table 1 presents the number of children classified with persistent disease. There were no significant differences between groups at baseline. According to baseline interviews, 87%, 4%, and 6% of respon-

Table 1—*Severity Classification

Variables	Treatment (n = 416)	Control (n = 419)	p Value
Mild persistent	111 (27)	125 (30)	0.312
Moderate	67 (16)	61 (15)	0.535
Severe	22 (5)	18 (4)	0.502
Mild persistent and above	200 (48.1)	204 (48.7)	0.860
Moderate persistent and above	89 (21.4)	79 (18.9)	0.360

*Data are presented as No. (%).

dents (*ie*, child's caregiver) were mothers, fathers, and grandmothers, respectively. Of these respondents, 87% had a high school diploma or higher education, and 53% had one or more years of college-level education. English was the first language for 99.8% of the households. Ninety-three percent of the children were between 7 years and 10 years of age. Almost all of the children (98%) were African American. Just less than half (45%) of the families had annual incomes < $15,000. Of the enrolled children, 256 reported having prescribed asthma medicines. Of these, 56% had controller medicines and 88% had reliever medicines. There were no treatment-control differences.

Symptoms

Compared to the control group children, those in the treatment group experienced a significant decline in annual daytime symptoms by the time of the second follow-up. Table 2 illustrates that treatment children experienced 17% fewer days with symptoms when compared to control children. We explored whether there were differences in results for control children compared to treatment children according to whether children had persistent vs intermittent asthma. For both levels of disease, the program effect was significant (p = 0.0001).

We then examined annual nighttime symptoms. For these, the program had a result that was opposite than expected. Table 2 illustrates that treatment children reported 40% more nighttime symptoms than control children. We again explored the effect according to whether children had persistent or intermittent disease. Children in the treatment group with persistent disease had significantly (15%, p = 0.001) fewer nighttime symptoms than control children with persistent asthma. However, treatment children with mild intermittent asthma had more than twice the nighttime symptoms (p = 0.0001) of control children with mild intermittent disease. This finding is explored in the "Discussion" section. There were no differences between treatment and control groups in asthma medicines prescribed by physicians and no changes in therapies used over time between groups.

Handling asthma symptoms is a key feature of disease management. We gave scores to parents on a management index of items measuring the number and frequency of actions they took to keep the disease of their children under control. By the second follow-up period, treatment group parents had significantly higher (2.19 higher, p = 0.02) scores on the management index; that is, they took more, and more frequent, steps to manage the disease.

Table 2—*Annual Symptom and Severity Treatment Effects*

Symptoms/Severity*	Treatment Effect as Adjusted Percentage of Control Symptoms (Change)	p Value
Day		
Combined	83 (− 0.17)†	< 0.0001
Intermittent	78 (− 0.22)	< 0.0001
Persistent	86 (− 0.14)	< 0.0001
Treatment Severity		0.128
Night		
Combined	140 (+ 0.40)	< 0.0001
Intermittent	355 (+ 2.55)	< 0.0001
Persistent	86 (− 0.14)	< 0.0001
Treatment Severity		< 0.0001

*Poisson regression with generalized estimating equation, controlling for baseline daytime symptoms, sex, income, and age (measured by grade in school). Intermittent includes mild intermittent disease according to National Heart, Lung, and Blood Institute classification; persistent includes mild, moderate, and severe persistent disease according to National Heart, Lung, and Blood Institute classifications.

†Treatment group had 83% (or 17% fewer) of the daytime symptoms evident in the control group.

District Record of School Grades

Table 3 presents the model for academic grades, adjusting for baseline scores and age, sex, and income. There were no significant differences in the overall grade index scores or the mean scores for mathematics or reading. Science grades for treatment children, however, were significantly higher than control children 24 months after intervention. While all academic grades declined over the evaluation period, science grades for treatment children declined significantly less than for control subjects (− 0.2,713 vs − 0.4361, p = 0.02). No statistically significant differences between groups on PE grades reported in school records were noted. There was no significant correlation between academic grades and severity. There was a significant negative correlation at baseline between PE grades and severity (0.19, p = 0.001). Children with more severe asthma had better PE grades. This finding may reflect accom-

Table 3—*End-of-Year Academic Grades Reported by DPS*

Outcome Difference*	Adjusted Means†		p Value
	Treatment	Control	
Index			
Combined	− 0.2278	− 0.2605	0.59
Intermittent	− 0.305	− 0.278	0.712
Persistent	− 0.149	− 0.242	0.270
Treatment severity			0.311
Math			
Intermittent	− 0.2473	− 0.1832	0.54
Persistent	− 0.327	− 0.219	0.459
Treatment severity	− 0.165	− 0.145	0.873
Science			0.542
Intermittent	− 0.2713	− 0.4361	0.02‡
Persistent	− 0.300	− 0.504	0.026
Treatment severity	− 0.240	− 0.367	0.115
Reading			0.622
Intermittent	− 0.1605	− 0.1477	0.88
Persistent	− 0.244	− 0.118	0.159
Treatment severity	− 0.078	− 0.178	0.394
			0.134

*Follow-up 2 minus baseline, adjusted for baseline, sex, and income.
†Normal regressions with generalized estimating equations, adjusted for baseline scores, sex, income and age (measured by grade in school).
‡At follow-up 2, the treatment group science grades dropped 0.2713 points while the control group dropped ± 0.4361 points from baseline ($p = 0.02$).

Table 4—*Treatment Effects on School Absences Reported by Parents**

Asthma-Related Absences	Treatment Effects as Adjusted Percentage of Control Absences (Change)	p Value
Previous 3-mo period	66 (− 0.34)†	< 0.0001
Intermittent	69 (− 0.31)	0.002
Persistent	66 (− 0.34)	< 0.0001
Treatment severity		0.731
Previous 12-mo period	92 (− 0.08)‡	< 0.05
Intermittent	94 (− 0.06)	0.365
Persistent	93 (− 0.07)	< 0.144
Treatment severity		0.905

*Poisson regression with generalized estimating equation, controlling for baseline absences, sex, income, and age (measured by grade in school).
†The treatment group had 66% of the absences evident in the control group, *ie*, 34% fewer.
‡The treatment group had 92% of the absences evident in the control group, *ie*, 8% fewer.

modation by the teacher or that the most ill children do not attend classes when they feel unwell and participate in PE when they are most able. There were no treatment and control group differences in correlations between severity and academic or PE grade.

School Absences

There were no significant differences in absences between groups observed in school records. However, school district data reported absences for all reasons, not distinguishing asthma from other causes of missed days of school. Data from the parents' questionnaire, regarding absences specific to episodes of asthma did reveal differences. Table 4 presents the model showing these differences between groups for the previous 3-month and 12-month periods. At the 24-month follow-up, the unadjusted mean days missed due to asthma were 1.41 days and 1.79 days at 3 months for treatment and control, respectively; at 12 months, 4.25 days were missed for both treatment and control. Adjusting for baseline absence, sex, income, and age, the previous 3-month asthma-related school absences for treatment children were 34% ($p < 0.0001$) fewer than for control children. The previous 12-month asthma-related absenteeism was 8% ($p = 0.05$) less than control children. As may be expected, there were significant correlations ($p < 0.006$) between severity and school absences for asthma at 3 months and 12 months at both baseline and follow-up. There were no differences in correlations between treatment and control groups.

Discussion

A previous study of "Open Airways for Schools"[6] suggested that school-based management education focusing on children with asthma can produce improved grades for elementary school attendees, and improve parent management and duration of symptoms. That study assessed outcomes after 1 year. The present evaluation of a comprehensive school-based program, adding several components to "Open Airways for Schools," provides evidence that expanding the intervention to reach not only the child, but also the important people in the child's social and physical environments, can result in similar and additional outcomes evident up to 2 years after intervention. Further, this study illustrates that effect was most significant for children with persistent disease.

Symptom reduction is an important goal in asthma. The expanded intervention significantly improved daytime symptoms for all participants. However, only for children with persistent disease did nighttime symptoms also improve. Indeed, program children with mild intermittent asthma reported more nighttime symptoms than control group children subsequent to the program. One or two factors may account for this finding. Program children with intermittent disease (and their parents) likely be-

came more aware of asthma and the nature of asthma symptoms as a result of their participation. Mild intermittent asthma requires less interaction with clinicians and less frequent use of medicines. Both situations make asthma less central in family life until something calls it to attention. It may be that taking part in the range of activities comprising the comprehensive program caused families, where the child's disease was mild, to notice symptoms more frequently and attribute them to asthma. Control children and parents, given no program to call attention to asthma, were less likely to notice or attribute nighttime symptoms to the disease. As outcomes related to grades and absences generated benefits in the right direction for children at both levels of severity, increased attention seems a likely explanation for more nighttime symptoms being reported by intervention children with mild intermittent asthma. Findings do show that program parents exercised more efforts to manage asthma and its symptoms regardless of severity. If nocturnal symptoms were present but not recognized at baseline, some children may have been misclassified as having mild intermittent asthma. As least one study[8] has shown that reports by low-income parents can underestimate a child's condition. However, severity of asthma in this study was assessed through queries about frequency of symptoms that reflect National Asthma Education and Prevention Program guidelines and this way of classifying patients is thought to be reasonably accurate.[2]

Generally, as children progress from one grade to the next in school, their academic grades decline.[6] Science grades for treatment children in this study declined much less steeply than those for control children. When we looked at science grades for children with more frequent attendance at asthma program sessions, the strength of the difference increased ($p = 0.0001$). We speculate that the science grades are better for one or two reasons. For example, the intervention included age-appropriate lessons related to the physiology and functioning of the pulmonary system. This information was likely relevant to some aspects of study in science classes. Further, the problem-solving, deductive nature of program activities, especially related to identifying environmental precipitants of asthma, may have enhanced the ability of the children to tackle science problems in general. That there were no differences in reading and mathematics grades likely indicates that program lessons were less relevant to these areas. Missing less school does not appear to play a role in higher science grades. Although treatment children missed school far less often because of their asthma, their overall absenteeism did not differ from control group children. A complication in measuring school absences is that official records do not account for the cause of the absence. Therefore, it was not possible to compare parents' reports with school system records regarding classes missed because of asthma. While treatment parents reported fewer asthma absences, school district figures showed no differences in overall absences. This lack of difference likely reflects the many reasons children are absent from school and high levels of absenteeism in low-income urban areas**.** PE grades declined in both groups of children, and the decline for treatment children was less severe. However, the differences between groups did not reach statistical significance. We can speculate on why there were no changes in PE grades for treatment children despite a decline in their daytime symptoms. It may be that while health status of children changed, perceptions of teachers did not. The intervention did not specifically focus on PE teachers' views or practices toward children with asthma. Teachers may have continued to view these students as different even if their asthma status improved. A study based in elementary schools has shown that PE teachers frequently feel uninformed about asthma and unsure about what children can and should do.[9]

This study assessed an intervention that combined a number of approaches thought to enhance the management of asthma in a child. A pivotal feature was involving the child, and indirectly the parent, in problem-centered asthma education, and emphasizing that children themselves could learn to manage the disease well. As evident in these findings, indirect involvement of parents has been shown in previous studies[10] to enhance their asthma management skills. However, the study design does not enable us to say which program element contributed most to the results.

One program component, connecting clinicians and school personnel, did not occur as envisioned. Few physicians could be contacted by program staff, and only a handful provided information to the school about a child's asthma condition and clinical regimen. Baseline data indicated that the level of asthma medical treatment provided to study children was inadequate. Across all severity levels, just over one quarter of the children were on regimens meeting National Asthma Education and Prevention Program guidelines.[3] Control of asthma is dependent on an effective partnership between a patient and a clinician who treats the disease according to recommended protocols.[2] School-based programs can augment, but not replace, this partnership. Children in the areas where this study was conducted need improved clinical care.[3] Had clinical care been at a higher level of quality, intervention effects may have been greater.

Conclusion

A comprehensive school-based intervention enhanced health status and school performance for elementary school-aged children. Fewer symptoms, higher academic grades in science, and reduced school absences for asthma resulted. Children, their disease, the environment, clinical care, and family situations change over time. Programs provided periodically over the course of elementary school, as children mature and new challenges arise, may help them and their families to manage the disease. That in this study children with persistent asthma were most likely to improve regarding symptom control suggests that these children may be the priority for school-based interventions.

Appendix

Identification of Asthma in Children by Study Criteria and Symptoms in Past Year

Variables	% (n = 3,433)
Physician's diagnosis and active symptoms or diagnosis and use of prescription medicines in the past year	16.4
No diagnosis but three or more of seven asthma symptoms or symptoms on exercise three times or more in past year	8
Symptoms in past year*	
Cough	24.2
Wheeze with cold	28
Wheeze without cold	16.2
Wheeze with difficulty catching breath	13.6
Wheeze with exercise	14.4
Cough with exercise	22.6
Chest tightness	19.7

*Any child who reported asthma symptoms but not necessarily fitting study criteria.

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References

1 Lara M, Rosenbaum S, Rachelefsky G, et al. Improving childhood asthma outcomes in the United States: a blueprint for policy action. Pediatrics 2002; 109:919–930
2 Guidelines for the Diagnosis and Management of Asthma: Asthma Education and Prevention Program; expert panel report II. Bethesda, MD: National Asthma Education Program, Office of Prevention, Education, and Control. Bethesda MD, National Heart, Lung, and Blood Institute, 1997
3 Clark NM, Brown R, Joseph CLM, et al. Issues in identifying asthma and estimating prevalence in an urban school population. J Clin Epidemiol 2002; 55:870–881
4 Kass D, Brown C, Garg R, et al. The burden of asthma among elementary school-aged children in central Harlem, Manhattan. New York, NY: NYC Department of Health and Mental Hygiene, 2002 (Spring)
5 Joseph CL, Foxman B, Leickly FE, et al. Prevalence of possible undiagnosed asthma and associated morbidity among urban schoolchildren. J Pediatr 1996; 129:735–742
6 Evans D, Clark NM, Feldman CH, et al. A school health education program for children with asthma aged 8–11 years. Health Educ Q 1987; 14:267–279
7 Joseph CM, Clark NM, Brown R, et al. Factors associated with smoking in urban elementary school children [abstract]. Toronto, Canada: ALA/ATS International Conference, 2000
8 Cabana MD, Slish KK, Lin X, et al. Asking the correct question: parent's description of their child's asthma severity [abstract]. Presented at European Respiratory Society Annual Congress, Vienna, Austria, September 27 to October 1, 2003
9 Neuharth-Pritchett S, Getch YQ. Asthma and the school teacher: the status of teacher preparedness and training. J Sch Nurs 2001; 17:323–328
10 Evans D, Clark NM, Levison MJ, et al. Can children teach their parents about asthma? Health Educ Behav 2001; 28: 500–511