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A Multi-Stage Asthma Screening Procedure for Elementary School Children*

Lynn B. Gerald, Ph.D., M.S.P.H.^{1,2,5}, David Redden, Ph.D.⁶, Anne Turner-Henson, D.S.N.³, Ronald Feinstein, M.D.^{4,7}, Mary Pat Hemstreet, M.D.^{4,7}, Coralie Hains, M.D.^{4,7}, C. Michael Brooks, Ed.D.^{1,2}, Sue Erwin C.R.T.¹, and William C. Bailey, M.D.^{1,5}

¹ Lung Health Center,

² School of Health Related Professions,

³ School of Nursing,

⁴ Department of Pediatrics,

⁵ Division of Pulmonary and Critical Care Medicine, University of Alabama at Birmingham

⁶ Research Triangle Institute, Division of Biostatistics,

⁷ The Children's Hospital of Alabama

Abstract

This paper describes an asthma screening procedure developed to identify children with asthma for an intervention study. Students were classified into three categories based on questionnaire responses (previous asthma, suspected asthma, and no evidence of asthma). Those classified as suspected asthma by questionnaire underwent further testing including spirometry and exercise challenge. Using the questionnaire alone, the measured asthma prevalence was 32%; the addition of spirometry and step testing reduced this estimate to 9.89%. The diagnosis of asthma was confirmed in 96% of children who saw the study physician. This screening procedure can identify school children with suspected undiagnosed asthma.

Keywords

Asthma; Screening; Schools; Children; Spirometry

INTRODUCTION

Pediatric asthma represents a large public health burden in this country and morbidity from this condition results in high health care costs (1,2). Approximately 10 million children in the United States under the age of 16 have asthma (3). Between 1980 and 1994, the prevalence rate for asthma in the United States increased by 75% and the most substantial increase was in children (4). Pediatric asthma morbidity and mortality have also been increasing (3–6). Asthma accounts for over 2 million office visits and 370,000 emergency room visits and hospitalizations each year in children aged 5 (4). In fact, asthma is the most common reason for children to be admitted to the hospital or visit the emergency department (1,7,8). While most deaths from asthma occur in adults, a significant number occur in children and their

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Corresponding author: Lynn B. Gerald, University of Alabama at Birmingham, Lung Health Center, 620 S. 20th Street, NHB104, Birmingham, AL 35233-7337. Fax: (205) 975-6118. E-mail: gerald1@uab.edu.

mortality rate has been increasing (3–5). From 1980 to 1993, the mortality rate from asthma for persons aged 5–14 increased about 77% (3,4).

Asthma also has high indirect costs (1). It is the most common chronic illness in children and accounts for more school absenteeism than any other chronic childhood condition (9–11). Mak et al. (12) found that nearly 50% of children with asthma missed 6 or more days of the school year due to the disease. These absenteeism rates can cause poor performance in school (11, 13–16). Other indirect costs associated with pediatric asthma include activity limitations in children with asthma as well as parental days missed from work (1).

Asthma morbidity and mortality are largely preventable with optimal diagnosis and treatment as well as improved patient education (17,18). Asthma begins in 80% of children by 6 years of age and 95% of children by age 9 (5,19), yet under-diagnosis is common (20–22). This under-diagnosis is problematic because it results in therapy delay, which can increase morbidity and mortality (23).

Despite the increased asthma prevalence and morbidity, problems with under-diagnosis in children, and importance of early diagnosis, valid and reliable asthma screening measures have yet to be developed. Asthma screening in school-age children provides an ideal opportunity for early detection and implementation of preventive and therapeutic interventions. Many elementary schools currently incorporate early detection and screening for other diseases and conditions (such as vision, hearing, and speech evaluations) and they provide an ideal setting for identifying school-age children at high risk for asthma.

Many questionnaires exist for use in screening for and surveillance of asthma (3,4,24–29). While questionnaires may be appropriate for surveillance, they are not adequate for asthma screening. Screening for asthma with questionnaires of asthma symptoms may result in low specificity and identify large numbers of children who do not truly have the disease. Therefore, questionnaire screening programs may not be cost-effective in that they result in large numbers of children without the disease being referred to a physician. Particularly in areas where access to health care is difficult, such as inner-city minority populations, it is important to have a more cost-effective and specific screening procedure.

Cost is not the only consideration for an asthma screening program. False positive screening test results for a serious chronic disease such as asthma can be stressful for parents and children as well as overburden physician offices with referrals. Therefore, false positives need to be minimized. Furthermore, exercise-induced asthma (EIA) occurs in almost 90% of children and adolescents with asthma and in approximately 40% of individuals with allergic rhinitis (30). EIA may occur in otherwise healthy individuals where exercise may be the only stimulus for their asthma. Unrecognized EIA exists in approximately 5–15% of children and adolescents (31–34) and should be considered in asthma screening programs for children.

As a result of these problems inherent in asthma screening questionnaires, we developed a multi-stage screening procedure composed of a symptoms questionnaire, spirometry, and an exercise challenge test. This screening procedure was used to identify children with previously diagnosed and suspected undiagnosed asthma for a National Heart Lung and Blood Institute (NHLBI) funded asthma intervention study. This article describes the UAB School Based Asthma Screening Program which was used to screen a largely African American urban elementary school population for asthma and presents the results of the screening process.

METHODOLOGY

Subjects

All 52 elementary schools from a single urban system, with a combined enrollment of 13,247 students, are currently participating in the UAB School Based Asthma Intervention Study. The schools were randomly divided into three cohorts and schools within cohorts were randomly divided between immediate intervention and delayed intervention programs. The major hypothesis of the intervention study is that a school-based asthma education and intervention program will result in improved functional status and more appropriate health care utilization in a group of inner-city and largely minority children with asthma. The intervention consists of an educational program for students (with and without asthma), teachers, and school personnel as well as the formulation of individual asthma action plans (IAAP) for each child with asthma. National Institute of Health educational materials, including “Asthma Awareness” and “Managing Asthma: A Guide for Schools,” as well as the American Lung Association’s “Open Airways” program, form the foundation of the asthma educational programs. The IAAPs are developed during an appointment with a pediatric allergist/immunologist at the Children’s Hospital of Alabama and are reviewed with the parents and children. Delayed intervention schools will receive the intervention after 1 year of follow-up data are collected. The study was approved and monitored by the University of Alabama at Birmingham’s Institutional Review Board.

Screening Procedure

In order to identify children with asthma who should be targeted for the asthma intervention program, children in all 52 elementary schools were screened for asthma to identify those previously diagnosed with asthma and those with undiagnosed asthma. The UAB multi-stage asthma screening procedure has three stages involving a symptoms questionnaire, spirometry testing, and a submaximal exercise challenge.

First, the parents of school age children (1st–4th graders) were asked to complete a 12-item screening questionnaire (Table 1). Based on responses to the screening questionnaire, children were classified as previously diagnosed asthma, no evidence of asthma, or suspected asthma (Fig. 1). Second, consent forms requesting permission for the child to undergo spirometry and exercise challenge testing were sent to parents of children who were classified with suspected asthma by questionnaire. Students with suspected asthma, whose parents gave consent to testing, performed pre-exercise spirometry using a portable Multispiro Spirometer. Students were tested by respiratory therapists who had extensive experience and training in performing pulmonary function tests on children. Three forced vital capacity (FVC) maneuvers were performed on each child and predicted values were determined based on the standards of Polgar and Promadhat (35). Children with $FEV_1/FVCs < 80\%$ were referred to a physician for confirmation of suspected asthma (36). Third, children with normal spirometry ($FEV_1/FVCs \geq 80\%$) performed a submaximal exercise challenge test. This test involved stepping up and down on a single step (The Step). Step height was set for each student depending on his or her height. The level of intensity of exercise was selected to maintain a heart rate (HR) between 150 and 200 beats per minute while stepping continuously for 5 min after reaching the target heart rate. A Polar Favor heart rate monitor was used to continuously monitor the heart rate throughout exercise. A standard metronome was used to maintain the stepping rate and students were encouraged to “step” to the beat. Study personnel stepped with the students and provided encouragement. Pulmonary function tests were completed at 3 and 10 min after cessation of the exercise challenge. Students were referred to a physician for suspected asthma if there was a greater than 15% decrease in FEV_1 or at least a 25% decrease in FEF_{25-75} from baseline after the exercise challenge. The procedures for and results of the exercise challenge are reported in detail elsewhere (37).

Since the main purpose of this study was to test an asthma intervention and not the sensitivity and specificity of the screening procedure, only children within immediate intervention schools who tested positive for suspected asthma or who were previously diagnosed with asthma were referred to one of two pediatric allergist/immunologists at the Children's Hospital of Alabama for further evaluation. Children enrolled in the delayed intervention schools who tested positive for suspected asthma were referred to their private physician or the public health department for further evaluation. At the end of the study, children enrolled in the delayed intervention schools who have a medical diagnosis of asthma will take part in the planned intervention activities. However, data regarding confirmed medical diagnosis of asthma by a physician is available only on the children from the immediate intervention schools who tested positive for suspected asthma or who were previously diagnosed with asthma. No data is available on children who screened negative for asthma.

RESULTS

The results of the screening procedures are presented in Fig. 2. Using the UAB Multi-Stage Screening procedure, the measured asthma prevalence rate in this elementary school population rose by 23% from 8.05% (those previously diagnosed with asthma as identified through the screening questionnaire) to 9.89% (those previously diagnosed with asthma plus those identified by the multi-stage screening procedure as having asthma). The data show that 18.7% of asthmatics were undiagnosed prior to this screening procedure indicating a substantial burden of undiagnosed asthma.

A response rate of 83% was achieved for the screening questionnaire, of the possible 13,247 students, 10,997 returned the screening forms. Based upon responses to the screening questionnaire, students were classified into the following groups: 68% (7481) as showing no evidence of asthma, 8% (885) as having previously diagnosed asthma, and 24% (2631) as having suspected asthma. Of the students with previously diagnosed asthma, 59% ($n=526$) agreed to participate in follow-up. Consent to perform further testing was received from 60% ($n=1574$) of parents of the children classified as having suspected asthma based upon questionnaire results. Baseline spirometry was then performed and 130 students were classified as having suspected asthma by spirometry. Those students who had normal spirometry were then asked to perform the step test and 73 of these students were classified as having suspected asthma based upon the step test results. Therefore, of the 1574 children consenting to further evaluation, 203 (13%) were classified as suspected asthma (130 by spirometry; 73 by step-test). A small percentage (2%) of the students whose parents consented to spirometry and step-testing were not tested due to mental or physical disabilities or repeated absences during scheduled testing periods at the schools.

Children who were classified as having previous asthma by questionnaire, or having suspected asthma by spirometry and step test, and who were in intervention schools were referred to the study physician for confirmation of the diagnosis of asthma. Of the 379 intervention students who were enrolled in the study, 310 (82%) saw one of the two study physicians. Students in the delayed intervention schools were referred immediately to their pediatrician or the public health department. Data was not collected on the results of these physician visits nor is data available on any of the students who tested negative for asthma.

Table 2 shows the results of the physician visits for the intervention children. Of the 279 children who were classified as previously diagnosed asthma and agreed to follow-up, 224 (80%) saw the study physician. Of these 224, the diagnosis of asthma was confirmed in 219 (98%). Of the 62 children who tested suspected asthma by spirometry, 54 (87%) saw the study physician and 49 (91%) were confirmed to have asthma. Of the 38 children who tested

suspected asthma by step test, 32 (84%) saw the study physician and 28 (88%) were confirmed to have asthma.

DISCUSSION

Using the UAB Multi-Stage Screening procedure, which includes a symptoms questionnaire, spirometry, and an exercise challenge test, the measured asthma prevalence rate in this elementary school population rose by 23%. In addition, a large percentage of children with asthma who had not been previously diagnosed were identified through the screening procedure. In fact, 18.7% of asthmatics were undiagnosed prior to this screening procedure indicating a substantial burden of undiagnosed asthma.

Questionnaires are most likely an inefficient way of screening for asthma and may result in large numbers of children being referred to health care providers for evaluation. Therefore, multi-stage screening procedures may be a more effective way to screen for asthma in the schools. Using our questionnaire alone, we would have estimated the asthma prevalence at 32% (a rate similar to those seen in other studies using questionnaires). However, the addition of clinical measures in those students identified as having possible asthma appears to increase the specificity of the screening procedure. The measured prevalence of asthma was greatly decreased (to 10%) with the addition of these simple-to-perform clinical tests. Furthermore, this protocol using spirometry and exercise testing appears to be highly specific to asthma as evidenced by the high rate of physician confirmation of a positive screen. Although the use of spirometry and step testing in an asthma screening procedure is more costly than the use of screening questionnaires alone, this method results in much smaller numbers of children who must be referred to a physician for confirmation of the diagnosis. The initial costs are likely to be outweighed by the fewer number of required physician visits. In addition, the fewer number of false positive diagnoses produced by this multi-stage screening procedure prevents children and their families from experiencing the stress associated with the potential diagnosis of a chronic disease. Furthermore, in areas where there is little access to health care or where most families must see health department physicians, the use of a multi-stage screening procedure can prevent overload on overburdened health care facilities.

There are limitations to this study and further research is needed before such screening programs are widely implemented. While the data indicate a substantial burden of undiagnosed asthma and a large majority of children who saw the study physicians were confirmed to have asthma (96%), not all children classified as suspected asthma by the screening procedure had these “diagnoses” confirmed by the physician. Children in the delayed intervention group were not recruited for a visit to the study physician. However, a large majority (84%) of the immediate intervention students did visit the study physician. There is no reason to expect that the procedure would produce different confirmation rates in the delayed intervention schools.

One major limitation of the study was that none of the children who were classified as no evidence of asthma by either questionnaire, spirometry, or exercise testing were evaluated by a physician for asthma. Therefore, future research is necessary to determine the sensitivity and specificity of the UAB screening protocol. Another limitation to the study is that students were evaluated only once in an indoor environment. Additional children with mild asthma may have been identified if exercise testing was completed under various environmental or seasonal conditions. Current research is examining the questionnaire to determine which questions were most predictive of an asthma diagnosis and preliminary results indicate that only a few questions are necessary to accurately identify children with asthma (38). In addition, a recently funded NHLBI study will be examining the sensitivity and specificity of this screening procedure.

CONCLUSIONS

A significant number of children attending elementary schools have undiagnosed asthma. Limiting screening evaluations to use of only a questionnaire will identify approximately one-quarter of the student body as having possible asthma. This study has found that use of a simple, reproducible, and portable spirometry and step-test exercise protocol in conjunction with a screening questionnaire can be used to identify children with suspected undiagnosed asthma in a school-based program.

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Figure 1.
UAB Multi-stage Asthma screening procedure.

Figure 2.
Results of UAB Multi-stage Asthma screening procedure.

Table 1

UAB Asthma Screening Questionnaire

Name of School:		Asthma Screening Form		Child's Grade:
Name of Child (First, Middle, Last):	Child's Date of Birth:	Name of Teacher:		
Month, Day, Year, □□ □□ □□ □□				
1. Has your child ever had a cough that would not go away or ever seemed to be coughing more than other children of the same age?			YES ☐	NO ☐
2. Has your child ever had wheezing?			YES ☐	NO ☐
3. Has your child ever had to stop running or playing because of coughing or wheezing?			YES ☐	NO ☐
4. Has your child ever said his/her chest felt tight or heavy or that his/her chest hurt?			YES ☐	NO ☐
5. Has your child ever had breathing problems (coughing, wheezing, shortness of breath, chest tightness) that woke him/her up at night?			YES ☐	NO ☐
6. Has your child ever had breathing problems (coughing, wheezing, shortness of breath, chest tightness) when he/she first woke up in the morning?			YES ☐	NO ☐
7. Has a doctor ever said your child has asthma ?			YES ☐	NO ☐
8. Does your child take asthma medicine prescribed by a doctor daily or even occasionally?			YES ☐	NO ☐
9. Has a doctor ever said your child had bronchiolitis ?			YES ☐	NO ☐
10. Has a doctor ever said your child had bronchitis ?			YES ☐	NO ☐
11. Has a doctor ever said your child had asthmatic bronchitis ?			YES ☐	NO ☐
12. Has a doctor ever said your child had pneumonia (more than one time)?			YES ☐	NO ☐
Signature of Parent/Caregiver:				
Questionnaire Responses				
No Asthma			Previous Asthma	Suspected Undiagnosed Asthma
<ul style="list-style-type: none"> All "no" answers Answer "yes" to question 2 only Answer "yes" to question 4 only Answer "yes" to question 10 only Answer "yes" to questions 2 & 10 only 			<ul style="list-style-type: none"> "Yes" to questions 7 & 8 	<ul style="list-style-type: none"> All other combinations of answers

Table 2

Confirmation of Asthma by the UAB Study Physician^a

	Previous Asthma by Questionnaire	Possible Asthma by Spirometry	Possible Asthma by Step Test	Totals
Number went to MD	224	54	32	310 (82%)*
Number confirmed asthma	219 (98%)	49 (91%)	28 (88%)	296 (95.5%)
Number declared "no asthma"	5 (2%)	5 (9%)	4 (13%)	14 (4.5%)

^a Due to the design of the study, only children in intervention schools visited one of the two UAB study physicians to determine whether a diagnosis of asthma was truly indicated.

* Students in the delayed intervention schools were not recruited to see the study physician. Therefore, the total number of students requested to visit the study physician was 379.