Asthma is a common chronic condition that most often begins in childhood and has been reported to affect between 7% and 20% of children by the age of 18 years. Despite the high prevalence of recognized asthma in school-aged children, many additional school children may have unrecognized asthma. These children may experience symptoms, lost school days, and lost activity days due to this unrecognized and thus untreated chronic health condition.

Allergies are also common, affecting as many as 10 million to 20 million children in the United States, including approximately 80% of children with asthma. Allergic rhinitis may trigger asthma exacerbations and contributes to reduced quality of life, lost activity days, and increased health care costs. Like asthma, allergies are often unrecognized.

Recent attempts to improve the identification of children with unrecognized asthma and allergies, thereby improving their chances of access to appropriate symptom management, have been focused on schools. Schools are one of the few sites in which almost all children gather and thus are available for screening or identification programs. T

School-based asthma and allergy case identification programs require a validated screening tool that provides sufficient sensitivity to identify most of the cases, while limiting the number of referrals of children who do not have asthma or allergy. To be useful throughout the United States, the tool needs to be valid in multiple socioeconomic, racial, and ethnic groups and easy and inexpensive to administer. This study aims to evaluate the feasibility and validity of using a questionnaire-based screening tool to identify undiagnosed asthma and respiratory allergies in children in kindergarten to grade 6.

Methods
Study Design
Using information from a series of preliminary studies on school-based asthma and allergy screening performed by our collaborative research group, we developed a short questionnaire-based screening tool and validated it against independent, standardized assessments that included physical examination, pulmonary function testing, and allergy skin testing. The validation sites consisted of four geographically diverse centers that participated in an initial, collaborative school-screening program funded by the American College of Asthma, Allergy and Immunology. The combined study population consisted of racially and ethnically diverse children across socioeconomic strata. The study was approved by the local institutional review boards at each site. The final validated asthma and allergy screening tool that resulted from this study is designed to be useful in a variety of geographic locales as the foundation for school-based programs to improve asthma and allergy recognition and care.

Questionnaire Development and Distribution
An asthma and allergy screening questionnaire was developed based on preliminary, independent phase 1 work performed at each of the four validation sites (Chicago, IL; Cleveland, OH; Dallas, TX; and Rochester, MN). In brief, during phase 1, each site independently tested distinct asthma and allergy screening questionnaires, assessing their predictive validity, community acceptance, response rates, and feasibility of use. Using the aggregate findings, individual questionnaire items that appeared to have had the best psychometric properties and/or highest levels of concordance with asthma and/or allergy were selected. Items were modified to improve their face validity across sites. Two versions of the survey were developed: a student questionnaire (SQ) and a parent questionnaire (PQ).

The newly developed questionnaires were distributed to families of elementary-aged children at the four study sites.

Each site surveyed at least 400 children in kindergarten to grades 5 or 6. Parents or guardians were asked to complete the PQ for each student in kindergarten through grade 6. Surveys were distributed by “backpack express” (ie, the child took it home for
the parents to complete), by mail, and/or at
school open house forums. All children in
grades 2 to 6 also were asked to complete the
SQ. According to the preferences of the
local schools, these surveys were either
distributed with the PQ and completed at
home (Rochester) or distributed and
completed in school (homeroom, health
class, or special assemblies) (Cleveland,
Chicago, and Dallas). If these surveys were
distributed in schools, a standard preamble
was read by a community volunteer or
research staff member, and each question
was read out loud, with no attempt to
provide any asthma or allergy education
that might influence answers.

Validation Protocol
The parents of all students who agreed to
participate in a validation study were asked
to bring their child to a convenient site for
further evaluation. After informed consent
from the parent or guardian and assent from
the child were obtained, a physician with
expertise in the treatment and diagnosis of
asthma conducted a clinical evaluation of
each student. The physician and/or a research
nurse–physician team also obtained histo-
ries using standardized forms. Physicians
and nurses were blinded to the results of the
screening questionnaires. Baseline spirometry
was performed using standardized approaches;
spirometry was repeated 15 minutes follow-
ing inhalation of 2 puffs of an albuterol
bronchodilator for children with reduced or
questionably reduced pulmonary function
levels. Children with symptoms that the
examining physician thought consistent with
possible asthma underwent allergy skin prick testing.

Determination of Disease Status
De-identified copies of the validation data
collection forms completed for each student
were distributed to the principal investiga-
tors (R.S.G., S.R., R.L.W., B.P.Y.) at each of the
four study sites. Each investigator reviewed
the history and physical examination
results and the spirometry and skin test
results of the children of all four sites. Based
on these data (and independent of data col-
lected from the screening questionnaires),
the four site principal investigators catego-
rized the likelihood of asthma and allergic
rhinoconjunctivitis for each student as
definite, probable, possible, or unlikely. A
definite designation of asthma required
history-identified respiratory symptoms
that were episodic and trigger-related (by
exercise, allergens, respiratory infections, or
changes of weather conditions) with evidence
of either reversible airflow limitation
by spirometry or audible wheezing or
prolongation of expiration by physician
examination. The student was considered to
have probable asthma when symptoms were
consistent with asthma (as above) but
supportive spirometry or physical findings
were absent. Possible asthma identified
students with some symptoms or other
findings that could be consistent with
asthma but were less typical than the ones
above. Unlikely referred to absence of any
symptoms or findings suggestive of asthma.

Each investigator's designation was
further collapsed into definite/probable and
possible/unlikely categories; the designations
made by all 4 investigators for each student
were summarized. Each student was
assigned a final designation of definite/prob-
able or possible/unlikely asthma and allergic
rhinoconjunctivitis that reflected a consensus
designation (ie, agreement by at least 3 of the
investigators). When at least 3 investigators
did not initially classify the student's disease
status similarly, that case was discussed
among investigators on one of several
conference calls held to resolve differences
in designations.

Using the final clinical consensus designa-
tions as the “gold standard,” the sensitivity
and specificity of data obtained from the
PQ and SQ were determined.

Results
From all four sites, 1,673 PQs and 1,788
SQs were returned. The students screened
in Chicago and Cleveland were predomi-
nantly African American (100% and 84%,
respectively), whereas in Rochester they
were mostly white (81%) and in Dallas they
were of varied racial/ethnic backgrounds
and included the largest proportion of
Hispanic children (30%). The age of the
students from each site ranged from 5 to 13
years; there was an approximately equal
representation of boys and girls. The charac-
teristics of the 190 students in the validation
sample largely reflected the underlying
ethnic composition of the targeted popula-
tions. Most students (63%) in the validation
study were in grades 2 to 6, and the remaining
were in kindergarten to grade 1.

Overall, using data from either the SQ
or PQ, most of the individual asthma
symptoms were moderately predictive of the
asthma clinical consensus designation, with
odds ratios of approximately 3. However, 2
questions regarding symptoms in association
with exposure to pets had no significant
association with asthma. Parent, but not
student, responses to the question regarding
missing school due to breathing problems
were associated with asthma. Each of the allergy
symptoms was modestly to moderately
predictive of the allergic rhinoconjunctivitis
designation, using either student- or parent-
reported responses.

Analyses showed that for asthma, little
predictive ability was lost when restricting
the pool of asthma-like questions from the
SQ to 7 and from the PQ to 8 (eliminating
questions with weak predictive ability, those
that were redundant, and those thought to be
poorly generalizable to diverse geographical
areas). Also, no single question or specific
combination of questions appeared to be
clearly superior to others. Rather, optimal
prediction appeared to relate to considering
the number of positive questions from the
best “pool” of questions.

Discussion
Several methods have been proposed for
school-based asthma and allergy screening,
including questionnaire screening, pulmonary
function testing, and exercise challenges. Of
these, questionnaires are the least invasive
and expensive and the easiest to implement
in diverse settings. Before a widespread
adoption of any screening instrument,
its universal applicability across diverse
communities must be demonstrated. Most
of the screening questionnaires that have
been validated to detect asthma among
schoolchildren are specific for a particular
population in which the validation was
performed; the generalizability of such find-
ings to other populations is often uncertain.
For example, the questionnaire developed
from the International Study of Asthma and
Allergies in Childhood (ISAAC), a widely
used but population-specific tool, did not
adapt well to an inner-city population of
school children. For the present study, we
created a composite tool informed by the coordinated experiences of four sites that represented broad geographic, ethnic, and socioeconomic backgrounds with the goal of developing a screening instrument that would be broadly generalizable. The current work demonstrates the potential utility of a single questionnaire for screening asthma and allergy in school-aged children and further shows that most children in grades 2 to 6 can complete the questionnaire.

Overall, compared with their parents, children tend to report more symptoms, a finding that has also been observed by others. Despite the rather low levels of agreement for responses to individual items from each questionnaire, we found that after considering the best grouping of responses from each questionnaire, the PQ and SQ provided fairly equivalent levels of prediction regarding each outcome, with generally better sensitivity for analyses using the SQ and better specificity for the PQ. Furthermore, an extensive series of analyses demonstrated that there was no gain in combining the parent and student responses. The high sensitivity for data obtained directly from the students is of particular importance given that a major obstacle for school-based screening is in eliciting participation of parents, especially in some low-income neighborhoods where there are challenges in getting forms back and forth between the school and home. Our data suggest that directing initial efforts at screening the students, who may be directly surveyed in classroom settings, may provide a relatively easy means for accessing nearly all school-aged children. Having both questionnaires available, however, may provide flexibility for screening under differing circumstances, especially in circumstances where higher specificity may be needed or in situations where students’ reading levels are extremely low.

We included the detection of allergies in the screen for several reasons. Like asthma, inhalant allergies are both common and often unrecognized in children. Furthermore, there is significant morbidity associated with allergies, including sleep loss and school absenteeism. Common pathophysiological mechanisms also often underlie allergic rhinoconjunctivitis and asthma, and information on symptoms of each condition may help improve the identification of the other condition. Additionally, since allergies are relevant in the development and aggravation of asthma, information on allergic symptoms may help target children at increased risk for developing asthma.

Analysis of the allergy-specific questions provided a similar pattern to that of asthma. We used only 2 allergy-specific questions, but requiring either “itchy eyes” or “runny nose” as constituting a positive screen showed high sensitivity and modest specificity. Combining the 2 allergy questions produced a marked reduction in sensitivity but made the screen very specific. If the goal of allergy screening is to minimize false-negative results, then considering a positive response to either student allergy question would yield a sensitivity of 80%.

The ultimate cost of any asthma-allergy screening program will depend in part on the number of children identified who will require additional testing. With a goal of achieving moderate sensitivity (ie, considering positive responses to 3 of the best 7 asthma questions), more than 35% of children (and as many as 49% of children in high-risk areas) with no reported history of prior asthma diagnosis would require additional testing for asthma. Our data suggest that approximately 50% of these children are likely to meet clinical criteria for asthma. The overall societal costs for identifying and treating between 15% and 25% of targeted school populations who may have undiagnosed asthma, as well as the costs of evaluating children whose test results prove to be false positive, need to be weighed against potential gains in reduced morbidity and improved quality of life of detecting and treating children with asthma and respiratory allergies.

In our study, asthma and allergy symptoms were highest in our 2 inner-city, African American sites, where approximately 50% to 60% of children were reported to have asthma symptoms, resulting in an estimate of undiagnosed asthma as high as 25% to 30%. Previous research from Chicago, New York, and Detroit also has suggested that the prevalence of wheezing symptoms and undiagnosed asthma is extremely high among disadvantaged minority children, with symptoms such as nocturnal cough reported by 54% of inner-city, African American children.

Asthma is not clearly defined in young children, and there are no good objective tests available for a pediatric age group that are easily applied. Often the “gold standard” adopted is based on the opinion of an expert in the diagnosis and management of asthma. As has been done previously, we adopted this approach to validate the respiratory screen in this study.

We chose to use site-specific methods for distributing and collecting the questionnaires to optimize local acceptability and maximize response rates. Three sites used modest incentives to enhance participation (Cleveland and Dallas used gift certificates to educational stores for teachers and food or ice cream certificates for children, and Chicago provided a pizza party for students). Our experience, however, indicated that even when distribution methods were designed to accommodate site-specific needs, participation rates varied substantially, suggesting the influences of intrinsic community, school, and cultural differences among the sites.

The resulting response rate of completed pairs of parent and student surveys was 57% after 2 reminders. Based on these site-to-site differences, we recommend that the choice of using a student or parent screen or both and the distribution method should be tailored to the prevailing culture of the school and community.

This study has several limitations that are often associated with multicenter studies. As discussed herein, not all sites were able to implement the study using the same methods of survey dissemination and completion, and the proportion of students who completed questionnaires varied. It is possible that differences in the relationships between symptoms and clinical designations may have been observed if the sample included in the validation studies was more cooperative and better able to complete questionnaires than the sample not represented.

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