Prevalence of possible undiagnosed asthma and associated morbidity among urban schoolchildren

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Objective: The extent to which urban children endure the symptoms and consequences of asthma without a physician diagnosis has not been well studied. Our objective was to obtain an estimate of the prevalence of possible undiagnosed asthma in a population of urban schoolchildren.

Design and methods: A population-based cross-sectional study was conducted in urban schoolchildren, grades 3 to 5. Undiagnosed asthma was defined as caretaker report of symptoms and/or bronchial hyperresponsiveness, defined as a 15% or greater drop in baseline forced expiratory volume in 1 second, after exercise challenge.

Results: A total of 230 children (61% of those eligible) participated in the study. Forty children (17.4%; 95% Confidence Interval (CI) = 12.5% to 22.3%) had reports of a physician diagnosis of asthma. Of these, 33 (14.3%; 95% CI = 9.8% to 18.9%) reported wheezing in the past 12 months. Among the remaining 189 eligible children, 11 (5.8%; 95% CI = 2.5% to 9.2%) met study criteria for undiagnosed asthma based on bronchial hyperresponsiveness (BHR). Another 16 (8.5%; 95% CI = 4.5% to 12.4%) met study criteria for undiagnosed asthma through modified American Thoracic Society symptom criteria. Overall, 27 children (27/189; 14.3%) fulfilled criteria for undiagnosed asthma. Children identified as having undiagnosed asthma were compared with children who had no BHR and no symptoms and who did not report a physician diagnosis of asthma (children without asthma). Children with BHR were more likely to have a report of allergies and eczema than children without asthma, odds ratios (OR) = 8.5 (95% CI = 2.4 to 30.7) and 6.4 (95% CI = 1.1 to 38.1), respectively. Children meeting symptom criteria were more likely to have a report of allergies, OR = 6.2 (95% CI = 2.0 to 19.1), and bronchitis, OR = 6.7 (95% CI = 2.0 to 22.4), and were also more likely to report sleep disruption, OR = 7.1 (95% CI = 2.3 to 21.8) and missed physical education classes, OR = 15.0 (95% CI = 4.8 to 46.7), compared with children without asthma.

Conclusions: We estimated a prevalence of 14.3% for possible undiagnosed asthma among urban schoolchildren, grades 3 to 5, through caretaker report of symptoms or BHR postexercise challenge. Children with undiagnosed asthma re-
agnoses and on symptoms indicative of asthma. Questions regarding "wheeze" asked about its occurrence in the past 12 months. Caretakers were asked how often wheezing, coughing, or shortness of breath disturbed the child's sleep and how often these symptoms resulted in the child's inability to participate in physical education classes. Caretakers were also asked about previous diagnoses of allergy, bronchitis, or eczema; those who did not report a survey were contacted by telephone and interviewed when possible. Incentives (i.e., T-shirts, gift certificates) were used to encourage participation.

Information on school attendance was obtained directly from school records for all third to fifth graders attending the participating schools, Date of school enrollment, total days absent, and school exit date were collected. Total number of classroom days and dates of school holidays were obtained from the Detroit Board of Education.

Research assistants received 16 hours of training in performing pulmonary function testing on pediatric subjects. They obtained baseline spirometric measurements and were instructed to procure three acceptable maneuvers, allowing no more than eight attempts. Research assistants were not aware of survey results before testing.

Pulmonary function testing was performed at the school. Height was measured and recorded when the child came for testing. After the baseline pulmonary function maneuver, the child was asked to perform an exercise challenge that consisted of a step test with three progressive stepping stages, each of 3 minutes' duration. Cadence increased with each successive stage. There was a 30-second pause between stages (enough time for a 10-second heart rate check). Cassette tapes with previously recorded stepping cadences and verbal commands were obtained from Dr. M. Jette, of the University of Ottawa, Ontario.

The step test was performed on a set of double 20 cm steps.

Children were tested according to standardized methods described by Tausig and others. Baseline heart rate was obtained before exercise started. Children were allowed a cool-down period of 3 to 6 minutes after completing the exercise. Pulmonary function testing was then repeated. Children with baseline forced expiratory volume in 1 second that was less than 60% of that predicted for age and height were not asked to exercise.

Equipment. We used a portable, MultiSPIRO-SX spirometer (MultiSPIRO, Inc., Tempe, Ariz.). The software for this system was installed onto two laptop computers used in conjunction with standard-size VGA color monitors. This system met or exceeded all medical and governmental spirometry standards, including those of the American Thoracic Society and Occupational Safety and Health Administration, and has been certified to reproduce all 24 ATS spirometry waveforms with zero errors. Standard prediction equations used were Polgar/Intermountain Thoracic Society (Pediatrics), along with the appropriate ethnic adjustments. Spirometers were calibrated twice per day. The spirometry software included colorful incentives for children to encourage maximum exhalation.

Study definitions. Undiagnosed asthma was defined as either BHR or fulfillment of modified ATS symptom criteria and no previous diagnosis of asthma by a physician. BHR was defined as a drop in baseline FEV₁ after exercise of 15% or greater.

The ATS instrument was used to evaluate symptoms. The instrument was modified by adding "persistent cough" to the following list of symptoms: wheeze with cold, wheeze apart from colds, dyspnea with wheeze, and wheeze after exercise. Asthma was defined as caretaker report of three or more of these symptoms observed in the child in the past 12 months.

Physician-diagnosed asthma was identified by caretaker survey. The comparison group of children without asthma was defined as children who did not report a physician diagnosis of asthma, did not have BHR, and did not fulfill modified ATS symptom criteria.

Analysis. Prevalence estimates of undiagnosed asthma were computed by dividing the number of subjects meeting study criteria for undiagnosed asthma by the number of subjects with enough data for classification, excluding subjects reporting a physician diagnosis of asthma. Exact 95% confidence intervals for proportions were calculated. The proportion of total school days absent was determined by dividing the total days absent by the number of possible school days of attendance for each child. Differences in the mean proportion of school days for BHR and children without asthma, and for modified ATS symptoms and children without asthma, were tested with the Student t test. In addition, percentile cutoff points (3rd and 67th) were used to create categories of school absenteism (i.e., 0% to 2%, 3% to 5%, ≥6%). Odds ratios and 95% CIs for the association of undiagnosed asthma with the category of percentage of school days absent were calculated by means of the 0% to 2% category as the reference group. Frequency of sleep disruption and missed PE classes were dichotomized to "ever" versus "never" resulting from small sample size. Odds ratios and corresponding 95% CIs were used to determine the association of medical history and morbidity with undiagnosed asthma.

RESULTS

Prevalence of undiagnosed asthma. Survey information was obtained for 85% of the children (322/380). Seventy-two percent of the children (264/380) took part in the survey and pulmonary function testing. Sixty-one percent (230/380) had complete information regarding an asthma diagnosis.
Table 1. Demographic characteristics by study participation of schoolchildren, grades 3 to 5, in two Detroit public elementary schools (N = 380)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Subjects with complete information (n = 230)</th>
<th>Subjects with incomplete information (n = 150)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)</td>
<td>No. (%)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>226 (98%)</td>
<td>147 (98%)</td>
<td>1.0*</td>
</tr>
<tr>
<td>Nonblack</td>
<td>4 (2%)</td>
<td>3 (2%)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>119 (52%)</td>
<td>79 (53%)</td>
<td>0.9</td>
</tr>
<tr>
<td>Female</td>
<td>111 (48%)</td>
<td>71 (47%)</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤8</td>
<td>199 (87%)</td>
<td>134 (89%)</td>
<td>0.4</td>
</tr>
<tr>
<td>≥9</td>
<td>31 (13%)</td>
<td>16 (11%)</td>
<td></td>
</tr>
<tr>
<td>Diagnosis of asthma†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>40 (17%)</td>
<td>11 (16%)</td>
<td>0.7†</td>
</tr>
<tr>
<td>No</td>
<td>190 (83%)</td>
<td>59 (84%)</td>
<td></td>
</tr>
</tbody>
</table>

*Fisher Exact Test.
†Diagnosis made by physician.
‡Based on number reporting physician diagnosis on survey; 80 children either did not return a survey or did not answer this question.

Subjects with complete and those with incomplete information were not significantly different regarding race, gender, age, or prevalence of physician diagnosis of asthma. Table I shows the demographic information for the 230 participants and the 150 nonparticipants available from school records and surveys. Forty children who completed the survey and pulmonary function testing reported a physician diagnosis of asthma, resulting in a cumulative prevalence of 17.4% (95% CI = 12.5% to 22.3%). Of these, 33, or 14.3% (95% CI = 9.8% to 18.9%), reported an attack of wheeze within the preceding 12 months (period prevalence).

One hundred ninety children did not have a physician diagnosis of asthma. One child with baseline FEV₁ less than 60% of that predicted for age and height was not asked to exercise and was excluded from further analyses. Of the remaining 189 children, 27 children (14.3%) fulfilled criteria for undiagnosed asthma. These children were classified as follows: 11, or 5.8% (95% CI = 2.5% to 9.1%), of these children had BHR. (One child in the BHR group also fulfilled modified ATS symptom criteria. This child is included in the BHR group for purposes of analysis. Exclusion of this child from either group made no difference in the direction of the associations presented.) Sixteen children, or 8.5% (95% CI = 4.5% to 12.4%), exhibited no BHR but met modified ATS symptom criteria for asthma. Thus 162 children were left to serve as the nonasthma comparison group. Children in the comparison group had no BHR or symptoms and did not report a physician diagnosis of asthma.

Because only one child met both BHR and mod-ATS criteria, we examined group differences further. Of the 11 children with BHR, eight had reports of one or two symptoms, falling short of meeting the three-symptom criterion of the mod-ATS definition. Six of the sixteen mod-ATS children showed a decrease in FEV₁ of 5% or greater, and three of the six showed a decreased FEV₁ of 10% or more, but less than 15%. Prevalence estimates are presented separately for BHR and mod-ATS children.

Absenteeism. The mean proportion of total school days missed for BHR children and for mod-ATS children were compared with that of children without asthma (Table II). Children exhibiting BHR did not miss more days than children without asthma (mean difference = -0.1 [95% CI = -3.1 to 3.02]; p = 1.0). The mod-ATS children missed more days of school than children without asthma, although this difference did not reach statistical significance (mean difference = 2.0 [95% CI = -0.6 to 4.6]; p = 0.12). For comparison, the proportion of school days missed is presented for children with a physician diagnosis of asthma. Compared with children without asthma, those with physician-diagnosed asthma missed significantly more days (mean difference = 3.1 [95% CI = 1.2 to 4.1]; p = 0.002). The number of days absent from school was not significantly different between children with physician-diagnosed asthma and children who fulfilled mod-ATS criteria (mean difference = 1.1 [95% CI = -2.6 to 4.8]; p = 0.54).

When absenteeism was categorized as percentage of school days missed (Table III), mod-ATS children appeared to miss more school days. This association was significant for children in the category of 6% or more of school days missed (odds ratio = 4.3 [95% CI = 1.0 to 17.5]).

Sleep disruption. As shown in Table III, both the BHR group and the mod-ATS group of children were more likely to have reports of sleep disruption caused by symptoms than were the nonasthma group of children (OR = 1.8 [95% CI = 0.5 to 6.7] and 7.1 [95% CI = 2.3 to 21.8], respectively), although the association was not statistically significant.
Exercise challenge is difficult to standardize for field use. Several studies have used free running to estimate the prevalence of BHR, but our experience during the pilot phase of this study indicates that free running by children does not always result in heart rates of 80% or greater of the maximum. We found the step test, modified for children, to be a practical and acceptable means of exercise challenge, and one that ensured that children would reach, or come close to reaching, their maximal heart rate. This method is as effective as treadmills and bicycle ergometers in obtaining maximal oxygen consumption. In a sample of 92 children who finished the step test, the range of maximal heart rates reached by the end of the third step session was 74% to 100% (SD = 0.09 [goal = 80%]).

In summary, our estimate of undiagnosed asthma may be higher than previous estimates because we included both children with asthma and children with multiple asthma symptoms. If we exclude the children who had BHR only, our estimates of undiagnosed asthma would be 18 (8.9%) of 190 subjects, again similar to other reports. The relationship of BHR to identification of clinical asthma remains uncertain. It has been suggested that the presence of BHR may indicate a genetic tendency toward bronchospasm. The associations found between BHR and reports of allergy and eczema in children with asthma and in children without asthma suggest that all these abnormalities are related to a common pattern of physiologic responsiveness.

Despite the subjectiveness of symptoms reporting and the questionable value of exercise-induced BHR, these remain the currently available, practical methods of screening in a public-school setting. Children identified as having possible undiagnosed asthma through their response to specific questions (on a survey or by BHR postexercise challenge) should undergo a more extensive clinical evaluation. This evaluation should include the demonstration of airway reversibility and the presence of allergen sensitivity.

Anecdotal evidence suggests that some children receive a diagnosis of asthma as a result of a severe attack that requires a visit to the emergency department. Children so identified in this study are unlikely to be at risk of an asthma fatality; however, these children may not be reaching full potential academically or socially and may have a reduced quality of life because of chronic, untreated symptoms.

We were able to identify possible undiagnosed asthma by using caretaker report of symptoms and BHR. Children with possible undiagnosed asthma were more likely to have a report of atopic disease and previous bronchitis and to have had some morbidity to a greater extent than children without asthma. Reports of a high prevalence of asthma in urban populations are plentiful. Our results suggest that a substantial amount of undiagnosed asthma may exist in these populations. If so, community screening for asthma may benefit high-risk populations.

Special thanks to the Detroit Board of Education for support and cooperation. Many thanks to Michelle Berris, Angela Blount, Pamela Devens, Vanessa Harris, Vernita Harris, Adrienne Jenkins, Susan McGuinness, Ernie Munzen, Darin Reynolds, Kristine Sanders, and Lisa Spurlock for their technical assistance.

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