Identification of Population Subgroups of Children and Adolescents With High Asthma Prevalence

Findings From the Third National Health and Nutrition Examination Survey

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Objectives: To provide national estimates of asthma prevalence in African-American, Mexican American and white (non-Latino) children and adolescents using several common definitions; to evaluate familial, sociodemographic, and environmental risk factors that are independently associated with current asthma in children; and to identify subgroups at particular risk for current asthma using 2 complementary data analytic approaches.


Setting: Eighty-nine mobile examination centers in the United States.

Participants: Twelve thousand three hundred eighty-eight African American, Mexican American, and white (non-Latino) children and adolescents, aged 2 months through 16 years, selected from a systematic random, population-based, nationally representative sample.

Main Outcome Measure: Current asthma, defined by caregivers who reported that their child currently had doctor-diagnosed asthma.

Results: The overall prevalence of current asthma was 6.7% (95% confidence interval [CI], 5.6-7.8). Odds ratios for current asthma from the multiple regression analysis were 4.00 (95% CI, 2.90-5.52) for children with a parental history of asthma or hay fever, 1.94 (95% CI, 1.09-3.46) for children with body mass index (calculated as weight in kilograms divided by the square of height in meters) greater than or equal to the 85th percentile, and 1.64 (95% CI, 1.20-2.26) for children of African American ethnicity. African American and Mexican American children showed a consistent prevalence of current asthma across age while white children showed an increase in prevalence with age. The 2 highest-risk subgroups identified by the signal detection analysis were composed of children with a parental history of asthma or hay fever who were 10 years or older with a body mass index greater than or equal to the 85th percentile (31.0% current asthma), and children with a parental history who were 10 years or younger and of African American ethnicity (15.6% current asthma).

Conclusions: The findings from this analysis show a strong independent association between obesity and current asthma in children and adolescents, and confirm previous reports of a parental history of asthma or hay fever and African American ethnicity as additional important risk factors.

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ASTHMA IS the most common chronic disease in children, affecting millions. In the United States, asthma has increased in prevalence during the past 25 years, increasing 160% in children up to age 4 years and 74% in children aged 5 to 14 years.  

Among children, asthma is most prevalent in those younger than 15 years compared with children older than 15 years and has been associated with familial, sociodemographic, and environmental factors. Among infants and young children, having an allergy or a family history of allergy are factors strongly associated with persistent asthma throughout childhood. Several national studies of asthma prevalence in children have shown higher self-reported asthma prevalence in African Americans compared with other ethnic groups. Some studies have demonstrated higher asthma prevalence in African Americans independent of socioeconomic status (SES) using national and nonnational samples, and others have shown no ethnic differences. While less is known about asthma prevalence in

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METHODOLOGICAL

The NHANES III is a multistage stratified probability survey of households conducted to assess the health status of persons aged 2 months and older. The sample was selected to represent the civilian noninstitutionalized population residing in the United States during 1988 to 1994. The survey oversampled children, African Americans, and Mexican Americans, and represented all socioeconomic strata for all ethnic groups, allowing for a rigorous examination of study questions. Details of the NHANES III design, sample selection, operational plan, and quality control have been published.

The NHANES III survey was conducted in two 3-year phases: 1988-1991 (phase 1) and 1991-1994 (phase 2). The survey included both an interview conducted in the home and a medical examination subsequently conducted at one of 89 mobile examination centers. A trained interviewer obtained a medical history of specific medical conditions, including asthma. The survey included socioeconomic, demographic, and health-related information. Survey instruments were available in English and Spanish. The overall response rate for the survey was 86%.

Our analysis of NHANES III includes children and adolescents aged 2 months through 16 years (N=12,388), the age limit that coincides with the ages included in the youth questionnaire. The youth questionnaire was administered to a proxy respondent, usually the child’s parent or guardian.

VARIABLE DEFINITIONS

We examined several definitions of asthma and respiratory illness to provide a comparison of how prevalences vary by definition of asthma. Lifetime prevalence of doctor-diagnosed asthma was determined by asking, “Has a doctor ever told you that (child) had asthma?” Children were categorized as having active doctor-diagnosed asthma if their parent/guardian answered yes to the questions, “Did a doctor ever say that (child) had asthma?” and “Does (child) still have asthma?” Consistent with previous reports, self-reported episodes of wheezing or whistling in the chest during the past 12 months were categorized into 2 groups: 0 to 2 episodes and 3 or more episodes. Hospitalization for wheezing was defined as a response of 1 or greater to the question, “How many times in the past 12 months was (child) hospitalized overnight or longer for these episodes of wheezing or whistling?”

We used 2 complementary analytic methods (described below) to examine the association of 12 familial, sociodemographic, and environmental variables with current doctor-diagnosed asthma. These independent variables were chosen because of their past associations with asthma in local and national samples of US children and/or because of their significant bivariate associations with active asthma in NHANES III (data not shown). Missing values for these and all other variables used in this analysis ranged from 0.2% to 8.3%. The definitions of the 12 variables follow.

1. Age: child’s age in years at the last birthday except for children younger than 1 year, for whom age in months was reported.
2. Sex: female or male.
3. Race/ethnicity: African American; Mexican/Mexican American; non-Hispanic white; Asian or Pacific Islander; Aleut, Eskimo, or American Indian; or other. Only the first 3 categories are included because of the few participants sampled from the other racial/ethnic groups.
4. Education of head of household: 1 of 2 indicators of SES, defined as the highest grade or year of school completed by the head of the household.
5. Family income divided by family size: 1 of 2 indicators of SES, total combined family income during the last 12 months, collected as 1 of 26 categories, coded in either $1000 or $5000 increments. Using the midpoint of each income category, family income was then divided by family size.
6. Type of health insurance: Medicaid, private health insurance (insurance plans obtained privately or through an employer or union), or not covered in the month preceding the survey.
7. Urban or rural status: urban defined as central and fringe metropolitan county populations of 1 million or more; nonmetropolitan (rural) defined otherwise.

An estimated 3.85 million children were reported to have current doctor-diagnosed asthma, an overall prevalence rate of 6.7% (95% confidence interval [CI], 5.6-7.8).

Table 1 presents the ethnic-specific prevalence accord-
rural defined as counties with populations of fewer than 1 million.
8. Geographic region of residence: Northeast, South, Midwest, or West.
9. Parental history of asthma or hay fever: positive response to the question “Has either of (child’s) biological parents ever been told by a doctor that he or she had asthma or hay fever at any age?”
10. Body mass index (BMI): less than, or greater than or equal to the 85th percentile, calculated as weight in kilograms divided by the square of height in meters. Body mass index was a measure of body fat, determined relative to the BMI distribution of children in the respective 1-year age group. The cut point of greater than or equal to the 85th percentile was selected because it is a measure easily identified by clinicians and comparable with previous literature.31,32
11. Passive smoking exposure: current household exposure, defined as the total number of cigarettes smoked by household members in the house per day (0, 1-19, or ≥20 cigarettes). Reported household exposure to tobacco smoke in NHANES III has been significantly associated with serum cotinine levels.39

ANALYSES

The association between the 12 independent variables and current doctor-diagnosed asthma was assessed by 2 analytic methods: forward stepwise logistic regression and signal detection methodology (a form of recursive partitioning).40 The logistic regression allowed us to identify the strongest risk factors associated with asthma. The signal detection analysis allowed us to identify subgroups of children at high and low risk of asthma by examining the interrelationship among the 12 factors, including higher-order interrelationships among factors that were not feasible to examine by the regression analysis. This latter methodology is especially useful in informing public health interventions because of its delineation of groups at particular risk for a given outcome.41 Both methodologies deal with collinearity among the independent variables well. The outcome variable for both analytic methods was current doctor-diagnosed asthma.

The regression analyses used SUDAAN, Version 7.11 (Research Triangle Institute, Research Triangle Park, NC), a software program that adjusts for the complex sampling units, strata, and weights used in NHANES III. The regression analyses also incorporated sampling weights that adjusted for unequal probabilities of selection. All estimates were calculated using the sampling weights to represent children aged 2 months through 16 years in the United States. Forward stepwise logistic regression began with no variables in the model. At each step, the variable that contributed most to the regression as determined by the significance of the Wald statistic and was significant at the .05 level was entered. When none of the unselected variables met the entry criteria, the stepwise process ended. Exploratory analyses were used to identify interactions among the variables in the model.

The signal detection analysis sequentially partitions data to identify mutually exclusive groups and cut points that most optimally distinguish between groups relative to the outcome variable, which must be binary. The 12 independent variables were entered and then the algorithm selected a variable and cut point based on a combined optimal measure of sensitivity and specificity with regard to the outcome variable. For this analysis, sensitivity and specificity were each given equal weights of 50%. After choosing and splitting on the first optimally efficient variable, the signal detection program separately searched each subgroup or “branch” of the first split for the next most efficient variable and cut point, again using all initial independent variables as candidates. This procedure was repeated separately in each subgroup and ended when subgroup samples became small (n<25) and/or when no further significant discriminating variables were found (P<.001). This analysis was based on unweighted data from NHANES III because the signal detection analysis cannot incorporate sampling weights. In addition, signal detection can only use data on participants who have complete data for all variables being analyzed. The use of unweighted data and the lower sample size explain the slightly different overall prevalence in the signal detection analysis.

Table 2 presents the results from the stepwise logistic regression model for current doctor-diagnosed asthma. The odds ratios and 95% CIs are presented for those factors that were significant: age, ethnicity, parental history of asthma or hay fever, and BMI greater than or equal to the 85th percentile. For children with a parental history of asthma or hay fever, the likelihood of current asthma was 4 times greater than for children without a parental history of asthma or hay fever. Children with BMIs greater than or equal to the 85th percentile were 1.94 times more likely to have current asthma than children with BMIs less than or equal to the 85th percentile. Significant interactions were noted between both African American and Mexican American ethnicity and age. African American and Mexican American children showed a consistent prevalence of current asthma across Mexican Americans had a higher hospitalization rate than whites but this did not reach statistical significance (1.4% vs 0.8%; P>.05).

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The severity of disease within the 6 signal detection subgroups is presented in Table 3. The subgroup with the highest number of episodes of wheezing and hospitalizations for wheezing was group 1 (children with a parental history of asthma, who were 10 years and older, and who had BMIs greater than or equal to the 85th percentile). This subgroup was 2 times more likely to have 3 or more episodes of wheezing and 16 times more likely to be hospitalized in the past year than their counterparts who had BMIs less than the 85th percentile (group 2). Among the younger age subgroups with a parental history of asthma, African American children (group 3) were approximately 2 times more likely to be hospitalized for wheezing than white or Mexican American children (group 4). The subgroups with no parental history of asthma (group 5 and 6) had the least severe disease.

In this national sample of children from the 3 largest ethnic groups in the United States, the prevalence of current doctor-diagnosed asthma was 6.7% (95% CI, 5.6-7.8). This estimate was substantially higher than the 3.6% found in NHANES II, 1976 to 1980, which used a similar definition for asthma. Our estimate was also higher than the 4.3% found in children younger than 17 years with asthma in the past year, noted in the 1988 National Health Interview Survey. This increase in asthma prevalence has been previously reported but the reason for this increase is unclear.

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Table 1. Estimated Prevalence* of Asthma and Respiratory Illness by Selected Definitions for US Children and Adolescents Aged 2 Months Through 16 Years, by Ethnicity, 1988-1994†

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Doctor-diagnosed asthma (lifetime prevalence)</th>
<th>Doctor-diagnosed asthma (current prevalence)</th>
<th>Self-reported episodes of wheezing or whistling in chest during past 12 mo (≥3 episodes)</th>
<th>Hospitalized overnight or longer for wheezing or whistling in chest during past 12 mo (≥1 episodes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American</td>
<td>10.2 (8.4-11.9)</td>
<td>7.8 (5.9-9.7)</td>
<td>7.8 (6.3-9.2)</td>
<td>10.2 (1.2-2.2)</td>
</tr>
<tr>
<td>Mexican American</td>
<td>5.6 (4.7-6.5)</td>
<td>5.2 (4.3-6.3)</td>
<td>5.2 (4.3-6.3)</td>
<td>1.4 (0.9-2.0)</td>
</tr>
<tr>
<td>White</td>
<td>9.3 (7.6-11.0)</td>
<td>6.7 (5.2-8.2)</td>
<td>8.3 (7.5-9.1)</td>
<td>0.8 (0.4-1.2)</td>
</tr>
</tbody>
</table>

*Prevalence was calculated using sampling weights.
†Data are given as percentage (95% confidence interval).
‡P = .04 for comparison of African American with non-Latino white children.
§Significant interactions with ethnicity at .05.

The signal detection analysis identified 6 mutually exclusive subgroups of children, based on their probability of having current doctor-diagnosed asthma (Figure 1). The best single discriminator of the population was a parental history of asthma or hay fever. Age, BMI greater than or equal to the 85th percentile, and African American ethnicity further distinguished those with a parental history of asthma or hay fever. Among children who had a parental history of asthma or hay fever and were 10 years or older with BMIs greater than or equal to the 85th percentile, 31.0% had current asthma (group 1); in contrast, among those who had a parental history of asthma and were 10 years or older with BMIs less than the 85th percentile, only 14.9% had asthma (group 2). Among children who had a parental history of asthma or hay fever and were younger than 10 years and African American, 15.6% had asthma (group 3); children who had a parental history of asthma and were younger than 10 years but not African American had half the rate of asthma (8.3%) (group 4). Among children with no parental history of asthma or hay fever, African American ethnicity further distinguished children at high risk for asthma.

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<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>BMI</th>
<th>Parent History of Asthma or Hay Fever</th>
<th>3+ Episodes of Wheezing</th>
<th>Hospitalized for Wheezing</th>
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<tr>
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<tr>
<td>Group 1</td>
<td>Parental history, older age, higher BMI†</td>
<td>10.4% of Sample</td>
<td>6.8% Asthma</td>
<td>1.2 (0.7-1.5)</td>
<td>0.4 (0.1-1.3)</td>
</tr>
<tr>
<td>Group 2</td>
<td>Parental history, older age, lower BMI</td>
<td>10.5% of Sample</td>
<td>7.1% Asthma</td>
<td>1.1 (0.7-1.6)</td>
<td>0.3 (0.1-0.9)</td>
</tr>
<tr>
<td>Group 3</td>
<td>Parental history, younger age, African American</td>
<td>10.5% of Sample</td>
<td>7.1% Asthma</td>
<td>2.3 (1.3-4.0)</td>
<td>1.0 (0.4-2.5)</td>
</tr>
<tr>
<td>Group 4</td>
<td>Parental history, younger age, white or Mexican American</td>
<td>10.5% of Sample</td>
<td>7.1% Asthma</td>
<td>1.9 (1.2-2.9)</td>
<td>0.6 (0.3-1.5)</td>
</tr>
<tr>
<td>Group 5</td>
<td>No parental history, African American</td>
<td>10.5% of Sample</td>
<td>7.1% Asthma</td>
<td>1.4 (0.8-2.2)</td>
<td>0.6 (0.3-1.5)</td>
</tr>
<tr>
<td>Group 6</td>
<td>No parental history, white or Mexican American</td>
<td>10.5% of Sample</td>
<td>7.1% Asthma</td>
<td>1.3 (0.8-2.2)</td>
<td>0.5 (0.3-1.1)</td>
</tr>
</tbody>
</table>

*Based on weighted data. Data are given as percentage (95% confidence interval).
†BMI indicates body mass index (calculated as weight in kilograms divided by the square of the height in meters).

ous reports of increased prevalence of disability due to asthma in African-American children and increased use of emergency department and inpatient services for asthma by African American children compared with white children. Hospitalization rates for Mexican American children were higher than for whites but did not reach statistical significance. This latter finding is in contrast to a recent analysis of NHANES III that reported children from Spanish-speaking families were at high risk for receiving inadequate therapy.

In addition to the higher prevalence of current asthma among older children and higher hospitalization rates for wheezing in African American children, we found significant higher asthma prevalence in children with obesity. Obesity has been associated with asthma in previous studies of adults. Our findings are consistent with Luder et al, who previously reported children with asthma as having a relative risk of 1.34 for a BMI greater than or equal to the 85th percentile and consistent with Gennuso et al, who reported 1.5 times greater obesity in children with asthma than in those without asthma. An association between obesity and asthma or wheezing has been noted in 1 previous national study. However, the association was not significant after adjusting for age, race, and sex.

The findings in this study of a strong independent association of obesity with asthma in children and adolescents is cause for concern given the increases in obesity among children and adolescents. In a previous analysis of NHANES III, Winkleby et al found large significant ethnic differences in BMI between African American and Mexican American girls and young women and their white counterparts after accounting for SES. These differences were apparent by ages 6 to 9 years.

The mechanism underlying the relationship between obesity and asthma is unclear. It is possible that asthma may predispose young children to inactivity and this in turn may promote weight gain. Another possible mechanism examined in previous studies is that obesity may contribute to increased bronchial hyperreactivity. It is also possible that obese children with asthma are diagnosed more frequently than nonobese children with asthma. However, a study from Denmark suggests that obese children who suffer from asthma may be underdiagnosed. Additionally, since both asthma and obesity can be seen as developmental disorders, a common underlying mechanism could be considered as well.

A recent report from a longitudinal study of children in Tucson, Ariz, reports that girls who became overweight or obese between ages 6 and 11 years had a 7-fold increased risk of developing asthma symptoms at age 11 or 13 years. Understanding the relationship between obesity and asthma is an important area for future research, particularly given recent evidence that weight reduc-
Although asthma is the most common chronic disease during childhood and is increasing in prevalence, the contributions of asthma risk factors to the increasing prevalence of asthma in children are not fully understood. Data on more than 12000 ethnically diverse children from NHANES III show a strong association of obesity with current asthma in children and adolescents. The data also confirm previous reports that a parental history of asthma or hay fever and African American ethnicity are additional important risk factors.

Children and adolescents with a parental history of asthma or hay fever comprised the groups with the highest prevalences of asthma. Children with a family history of asthma who were 10 years or older and who had BMIs greater than or equal to the 85th percentile had the highest prevalence of asthma. While they were the smallest group, almost 1 of every 3 currently had asthma. In general, the groups most likely to have asthma were also the groups to have the most severe cases of asthma (Table 3). With or without family history, African American children (groups 3 and 5) had a 2-fold greater rate of hospitalization for wheezing than Mexican American and white children (groups 4 and 6).

Limitations of the findings include self-report, which is dependent on recall. In addition, the nature of this cross-sectional study does not allow us to establish causation or determine the direction of the associations. It does, however, allow us to describe the frequency and distribution of disease. Reporting asthma by proxy may be imprecise but current doctor-diagnosed asthma may be a more conservative measure of asthma prevalence than that based on self-reporting of symptoms. Therefore, using doctor-diagnosed asthma may underdiagnose asthma in this population and the degree of underdiagnosis may vary by access to care and other sociodemographic characteristics.

Clinicians have the responsibility of diagnosing children as having asthma and classifying them by severity to help guide their treatment. We have identified several strong predictors of current asthma and very high-risk groups that can inform interventions. The substantially different rates of asthma among subgroups have implications for early identification and management of children who are at particularly high risk. This information can be used by clinicians and asthma management programs to identify children in need of close supervision and counseling about healthy lifestyles that include low-fat diets and mild exercise.

The results of this national study suggest a strong association among asthma, parental history of asthma, and obesity. Additional studies are needed to determine whether tailored intervention can minimize the negative effects of asthma.