Individual and Neighborhood-Level Factors in Predicting Asthma

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Objective: To identify the neighborhood socioeconomic and housing factors at the census-block level and the sociodemographic factors at the individual level that are associated with the risk of asthma.

Design: Cross-sectional study of children aged between 5 and 18 years seen in a network of urban primary care clinics.

Setting: A network of urban primary care clinics (Indiana University Medical Group) in Marion County, Indiana, in the calendar year 2000.

Participants: A total of 2544 subjects with 1541 black children (947 girls, 594 boys) and 1003 white children (568 girls, 435 boys).

Main Outcome Measure: Whether a subject ever had asthma.

Results: The prevalence rate of ever having asthma was 21% with the lowest (14.6%) in white girls and the highest (27.4%) in black boys. None of the census-block characteristics were significant in predicting ever having asthma. The significant predictors for childhood asthma were age, race, sex, and body mass index. Boys who were overweight had 3.1 times higher odds and girls who were overweight had 1.8 times higher odds of having asthma than girls who were normal weight. There was a stronger association between asthma and being overweight in female subjects than in male subjects. Black children had 1.3-fold higher odds of ever having asthma than white children. The highest likelihood of having asthma is among boys who were young, black, and overweight and the lowest among girls who were older, white, and normal weight.

Conclusion: Increased efforts at prevention, screening, and treatment may need to be directed at certain subpopulations such as children living in socially and physically at-risk families and neighborhoods.

Asthma is now the most common chronic childhood disease, occurring in approximately 54 of 1000 children. The rate of self-reported asthma among children and adolescents in 1995 was higher in boys and higher for black children than for white children. In addition to race and sex, asthma disparities may be related to exposure to socioeconomic and environmental factors. Asthma hospitalization was highest in the youngest children and the poorest communities where poor housing conditions and environmental exposures might contribute to a high incidence of asthma.

Neighborhood-level factors represent an important area of investigation for association with asthma. Research into the association of housing age and housing value with childhood blood lead levels found that both the decade the house was built and the house’s value are important screening factors. Collective efficacy, measured as trust and shared expectations for beneficial community action, was found to be a protective factor against asthma and breathing problems in 338 Chicago neighborhoods for adults. To our knowledge, no reported studies have verified a relationship between neighborhood-level variations and childhood asthma.

Asthma is also associated with being overweight, another chronic condition on the rise among children. In a study of 14- to 16-year-old primarily minority adolescents, significantly more children with asthma were overweight or at risk of being overweight compared with controls. Asthma severity, however, was not related to being overweight. In another study of overweight children aged 7 years or younger, 30% of the overweight children had asthma compared with approximately 10% of the control group.
search comparing the prevalence of being overweight in African American and Hispanic 2- to 18-year-old children with a reference control population showed a significant association between being overweight and asthma severity symptoms.

To model the risk of ever having childhood asthma, we studied a sample of 2544 children, aged 5 to 18 years, who were receiving health care in a network of 6 Midwestern urban primary care clinics. The primary focus of this study was to investigate the association between asthma and neighborhood-level social and physical indicators along with a secondary interest in identifying individual-level predictors for developing childhood asthma. We hypothesized that lower neighborhood socioeconomic status and older age of homes would be associated with higher risk of asthma. We further hypothesized a positive relationship between risk of asthma and being overweight.

We followed the conceptual framework for a model of the determinants of health in a community proposed by Evans and Stoddart. Their proposed model includes the following components: social and physical environment, genetic endowment, health care, prosperity, and individual-level behavior and biology. The social and physical environmental components of our investigation included median family income (MFI), educational attainment, single-parent families, family linguistic isolation, and median age of neighborhood housing at the neighborhood level. The individual-level factors included age, sex, race, and body mass index (BMI).

STUDY DESIGN AND SUBJECTS

We queried an electronic medical record system (Regenstrief Medical Record System, Indianapolis, Ind) to identify all children between the ages of 5 and 18 years seen in a network of urban primary care clinics (Indiana University Medical Group) in Marion County, Indiana, in the calendar year 2000. We identified a subset of these children who had simultaneous height and weight measurements (n = 2801). If a child visited Indiana University Medical Group clinics multiple times during the period, we included only the most recent measurements. The final cohort included 2544 subjects with 1541 black children (947 girls, 594 boys) and 1003 white children (368 girls, 435 boys) after excluding subjects with illogical BMI (less than 10 or greater than 77) and uninterpretable race information.

INDIVIDUAL AND NEIGHBORHOOD DATA

For the 2801 children who had simultaneous height and weight measurements, we queried their medical records for whether they were ever diagnosed with asthma. Patients were identified as having asthma based on physicians’ diagnosis. We also extracted demographic information, including address, age, race, and sex. A geographic information system was used to define the neighborhood-level socioeconomic indicators. We converted patient addresses into geographic coordinates using a process called geocoding. We successfully geocoded 82% of our study subjects residing in 436 census blocks in Marion County. After we geocoded patient addresses, we determined the census-block group in which each patient resided. Census-block groups were used as proxies for neighborhoods. They are geographic regions defined by the US Census Bureau to contain an average of 1500 people.

Data on year 2000 socioeconomic indicators indexed by census-block groups were obtained through the Social Assets and Vulnerabilities Indicators Project (The Polis Center, Indianapolis, Ind; http://www.savi.org). We included neighborhood factors, such as median age of housing, family income, educational attainment (percentage of people aged 23 years or older with no high school diploma), single-parent families (percentage), and families with linguistic isolation (percentage), as specific socioeconomic factors. For age of neighborhood housing, we considered the proportions of homes built before 1939 as well as before 1949 and the time to the median year the house was built from 2003. We used MFI as a measure of neighborhood income. Median family income reports only income for related people; therefore, MFI is more likely to include a larger subset of the population of interest (ie, families with children) and less likely to be diluted with single-person households. We developed income categories by comparing the MFI of the census-block group against the mean MFI of the Indianapolis Metropolitan Statistical Area (555 191). We classified each block into 1 of the following income categories, based on the definitions used by the US Department of Housing and Urban Development (Washington, DC): extremely low (<30% MFI of the Indianapolis Metropolitan Statistical Area), very low (30% and <50%), low (50% and <80%), moderate (80% and <95%), middle (95% and <120%), and upper (120%).

STATISTICAL ANALYSIS

The BMI was calculated as weight in kilograms divided by the square of height in meters. We used the SAS codes (SAS Institute Inc, Cary, NC) available on the Web site of the Centers for Disease Control and Prevention (Atlanta, Ga; http://www.cdc.gov) to compute age- and sex-adjusted BMI percentiles. We defined normal weight (BMI percentile <85), at risk of being overweight (≥85 and <95), and being overweight (≥95) based on the Centers for Disease Control and Prevention guidelines. A multiple logistic regression model was used to model the risk of asthma as a function of BMI, demographic variables (race, sex, and age), and neighborhood socioeconomic characteristics (age of housing, income, percentage of single-parent families, percentage of people aged 25 years or older with no high school diploma, and percentage of families with linguistic isolation). We used a 2-stage approach to model the risk of asthma because subjects were nested within census blocks as they shared the same neighborhood-level environment. When the model included any neighborhood characteristics at the census-block level, we used generalized estimating equations in conjunction with the logistic regression model to adjust all hypothesis tests for correlations among the subjects living in the same census block. Asthma rates are presented as percentages and based on data about whether subjects ever had asthma.

RESULTS

The individual-level factors and the neighborhood-level factors of the study subjects are summarized in Table 1. The average subject age was 14.7 ± 2.0 years (mean ± SD) with 25% between 5 and 13 years and 25% between 16 and 18 years. In the sample, 60.6% of the subjects were black children and 39.6% were girls. The percentages of subjects who were overweight and at risk of being overweight were 29.3% and 18.1%, respectively. Twelve-three percent of the children lived in neighborhoods with poor income (<80% MFI of the Indianapolis Metropolitan Statistical Area), and 40.2%
lived in neighborhoods with a median age of housing of at least 60 years. The rates of ever having asthma by demographic, socioeconomic, and census-block neighborhood characteristics are shown in Table 2. In our study cohort, the asthma prevalence was about 21%, but the rate varied by race and sex. White girls had the lowest asthma rate (14.6%), and black boys had the highest asthma rate (27.4%). Asthma prevalence for black children was about 4% higher than that for white children, both for boys and girls. However, boys had much a higher risk of asthma than the girls, a difference of 9% for both white and black children. Girls who were overweight or at risk of being overweight were more likely to have asthma than girls who were normal weight. The risk of asthma for overweight boys was substantially higher than the risks for boys who were normal weight or at risk of being overweight. Although girls who were at risk of being overweight and girls who were normal weight had considerably different risks, boys who were at risk of being overweight and boys who were normal weight had similar risks of asthma.

There was no uniform trend in rising asthma rate with the rise in the median age of housing at the census-block level; rather, the rate was very similar in all categories except the category with a median age less than 30 years, which had a lower rate but a small sample size. Children from neighborhoods with low-income categories had similar asthma rates as well as children from neighborhoods in the moderate- or middle-income categories. However, children from poor neighborhoods had higher asthma rates when compared with children from neighborhoods with moderate- or middle-income categories. Although we observed a high prevalence in the upper-income category, the sample size in this category was very small.

### MULTIPLE LOGISTIC REGRESSION MODEL

We first attempted to identify the significant predictors for asthma by including 1 variable at a time in the model. None of the census-block characteristics: (median age of housing, MFI, percentage of single-parent families, and percentage of people aged 25 years or older with no high school diploma) were significant in predicting ever having asthma. Asthma risk did not depend on the proportion of houses built before 1949, the proportion of houses built before 1939, or the time to the median year the house was built.
Interaction (sex and obesity)

Table 3. Parameter Estimates ± SE and P Values From Multiple Logistic Regression

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate ± SE</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>−0.96 ± 0.39</td>
<td>.015</td>
</tr>
<tr>
<td>Race*</td>
<td>0.25 ± 0.10</td>
<td>.015</td>
</tr>
<tr>
<td>Sex†</td>
<td>0.68 ± 0.15</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age</td>
<td>−0.08 ± 0.03</td>
<td>.003</td>
</tr>
<tr>
<td>BMI status‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk of being overweight</td>
<td>0.64 ± 0.18</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Overweight</td>
<td>0.60 ± 0.16</td>
<td>.06</td>
</tr>
<tr>
<td>Interaction (sex and obesity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk of being overweight × sex</td>
<td>−0.67 ± 0.28</td>
<td>.02</td>
</tr>
<tr>
<td>Overweight × sex</td>
<td>−0.15 ± 0.23</td>
<td>.50</td>
</tr>
</tbody>
</table>

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters).

*Race was coded 0 for whites and 1 for blacks.
†Sex was coded 0 for girls and 1 for boys.
‡BMI status was coded 0 for children who were normal weight and 1 for children who were overweight or at risk of being overweight.

Table 4. Point Estimates and 95% Confidence Intervals for Odds Ratios

<table>
<thead>
<tr>
<th>Factor</th>
<th>Estimated Odds Ratio (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1.0</td>
</tr>
<tr>
<td>Black</td>
<td>1.29 (1.05-1.58)</td>
</tr>
<tr>
<td>Age, y</td>
<td>0.93 (0.88-0.97)</td>
</tr>
<tr>
<td>BMI and sex</td>
<td></td>
</tr>
<tr>
<td>Girls who were normal weight</td>
<td>1.0</td>
</tr>
<tr>
<td>Girls who were at risk of being overweight</td>
<td>1.90 (1.35-2.68)</td>
</tr>
<tr>
<td>Girls who were overweight</td>
<td>1.82 (1.33-2.49)</td>
</tr>
<tr>
<td>Boys who were normal weight</td>
<td>1.98 (1.48-2.65)</td>
</tr>
<tr>
<td>Boys who were at risk of being overweight</td>
<td>1.93 (1.24-3.00)</td>
</tr>
<tr>
<td>Boys who were overweight</td>
<td>3.10 (2.23-4.27)</td>
</tr>
</tbody>
</table>

One aim of this study was to test the hypothesis that lower neighborhood socioeconomic status and older age of homes would be associated with childhood risk of asthma. Specifically, we believed that characteristics of communities not reducible to the individual level, such as the age of housing and neighborhood-level poverty, would be associated with increased risk of asthma. This hypothesis was not supported by the results. One possible explanation is that older housing stock may not be where significant numbers of low-income children live, in light of recent trends in providing housing vouchers that allow low-income families to choose to live in newer apartment complexes in suburban neighborhoods. This is further compounded by redevelopment efforts in older neighborhoods where homes have been completely rehabilitated and rent and purchase prices have increased. Many older homes in older neighborhoods are now owned by medium- to high-income persons or families. Another possible explanation is that the median age of neighborhood housing needs to be examined in light of information on the actual age of the dwelling and the presence of asthma risk factors, such as cockroaches, dust mites, and mold. Important negative findings in our study were that none of the census-block characteristics were significant in predicting the incidence of asthma.

The second hypothesis of a positive relationship between risk of asthma and being overweight was supported. Although we found an association between asthma and BMI, the nature of our study design cannot establish a causal relationship, nor does it suggest directionality. The relationship of BMI and asthma has been studied, but consensus on how pulmonary function might determine the influence of BMI on asthma, or asthma on BMI, is lacking. The rate of ever having asthma in this study was higher than what was observed in other similar Canadian and US studies, this may be attributable to the high prevalence of children who were overweight or at risk of being overweight in our study population and the sociodemographic characteristics of our study group being mostly urban, black, and poor.

In this study, the rate of ever having asthma was 21%. The rates varied by race and sex, ranging from lowest for white girls to highest for black boys. However, within each race group, the boys-to-girls ratio of asthma rate was 1.3. The rates also varied by sex and BMI with the lowest for girls who were normal weight and the highest for boys who were overweight. There was no uniform trend in asthma rates for increases either in MFI or median age of housing at the census-block level.
The significant predictors for childhood asthma were age, race, sex, and BMI. The interaction effect between sex and BMI was marginally significant. Boys who were overweight had 1.6 times higher odds of having asthma than boys who were at risk of being overweight or normal weight. On the other hand, girls who were overweight and at risk of being overweight had about 2 times higher odds of having asthma than girls who were normal weight, indicating a stronger association between asthma and BMI in female subjects than male subjects. The differential BMI effect between male subjects and female subjects was also observed in several studies in adults and adolescents.17-19 While we found significant relationships of asthma and BMI for boys and girls, von Kries et al20 found a significant relationship for girls. A positive association between high BMI and asthma in children and adolescents was reported in several studies.21-23 Our study found that for children of the same race and age, children who were normal weight, overweight, and at risk of being overweight had a higher risk of having asthma compared with girls who were normal weight. Boys who were normal weight and at risk of being overweight had similar risks of asthma, but boys who were at risk of being overweight in contrast, girls who were overweight and at risk of being overweight had similar risks of asthma, but the rates were substantially higher compared with that for girls who were normal weight. The risk of asthma was highest for young, black, overweight boys and the lowest for older, white, normal-weight girls.

Although a strength of this study is that we relied exclusively on physician diagnosis to define asthma, the study is not without limitations. Future studies need to include the severity and length of time that the children had asthma and were overweight. The choice of using census-block groups as the defined regions for characterizing community contextual factors such as housing age may have masked variations that would have been noted at smaller units of aggregation. Individual socioeconomic status might be a better predictor than neighborhood socioeconomic status. The high prevalence of ever having asthma in our study population may not be generalizable for the general population because our study group had a high prevalence of being overweight or at risk of being overweight, and most of the subjects had the characteristics urban, black, and poor.

CONCLUSIONS

In summary, the results of this study suggest that in a predominantly urban population of children, the highest likelihood of having asthma is among young, black, overweight boys and the lowest among older, white, normal-weight girls. There was no association between asthma and the neighborhood characteristics age of home or family income. Prospective studies of the role of socioeconomic indicators associated with childhood asthma risk need to further refine income and neighborhood indicators that can influence the personal health of children. Health care providers should consider the relationship between asthma and BMI and family and neighborhood demographics. Increased efforts at prevention, screening, and treatment may need to be directed at certain subpopulations, such as children living in socially and physically at-risk families and neighborhoods.

Accepted for Publication: February 13, 2005.
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Funding/Support: This study was supported by grant 5K08DK064866-0 from the US Department of Health and Human Services, Washington, DC.

Acknowledgment: We thank Sharon Kandris and Jane Wang for help in preparing the data.

REFERENCES