# Atopy as a Risk Factor for Habitual Snoring at Age 1 Year*

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*Study objectives:* **To determine the prevalence of habitual snoring (HS) in 1-year-old children, and to assess the relationship between HS and atopic status in these children.**
*Design:* **Cross-sectional evaluation of a birth cohort selected from the population.**
*Setting:* **Ohio and Kentucky River Valley communities.**
*Participants:* **Children participating in the Cincinnati Childhood Allergy and Air Pollution Study (CCAAPS) were recruited for this study.**
*Measurements and results:* **At age 1 year, the children were evaluated for atopic status and exposure to environmental tobacco smoke (ETS). Parents were asked to complete a questionnaire pertaining to their snoring frequency and that of their child. Children with HS (snoring three or more times per week) were compared to those who either did not snore or snored less than three times per week. Data were available on 681 of the 700 children participating in CCAAPS study. Of these 681 children (377 boys and 304 girls), 542 were white (80%), 118 were African American (17%), and 21 were biracial or Asian (3%). The mean age (± SD) of our cohort at the time of assessment for snoring was 13.7 ± 2.6 months. Of the 681 children, 105 snored habitually (15%). There was a significant association between HS and the following: (1) positive atopic status (p = 0.005); (2) African-American race (p < 0.01); and (3) a history of snoring in the father (p < 0.01) or in the mother (p < 0.01). There was, however, no association between HS and ETS.**
*Conclusions:* **We found a 15% prevalence of HS in 1-year-old children born to atopic parents and a significant association with positive atopic status.** *(CHEST 2006; 129:942–946)*

**Key words:** allergic rhinitis; children; environmental tobacco smoke; skin-prick test; obstructive sleep-disordered breathing

**Abbreviations:** CCAAPS = Cincinnati Childhood Allergy and Air Pollution Study; ETS = environmental tobacco smoke; HS = habitual snoring; OR = odds ratio; SDB = sleep-disordered breathing; SPT = skin-prick test

C hildhood obstructive sleep-disordered breathing (SDB) is a disorder characterized by prolonged increased upper airway resistance, partial upper airway obstruction, or complete obstruction that disrupts pulmonary ventilation, oxygenation, or sleep quality.[1] Snoring is the most common symptom of this disorder. Several authors have reported the association of habitual snoring (HS) during childhood with attention deficit hyperactivity disorder[2] and cognitive deficits.[3,4] Others[5,6] have reported an association between permanent cognitive deficits and HS treated later in childhood. It is thus impor-

tant that predisposing factors for HS be identified early in life. As an initial step, the relationship between childhood obstructive SDB and common childhood diseases and environmental exposures must be determined. Because allergic disease affects > 40 million children in westernized countries and the incidence of allergic respiratory diseases is rising, we addressed the association between atopic status and HS in young children. Although previous studies[7–10] have indicated that having a history of allergic respiratory diseases is a risk factor for obstructive SDB, these studies either have not included an objective assessment of atopy[8–10] or have been limited by referral bias.[7] The purpose of the present study was therefore to determine the prevalence of HS in 1-year-old children born to atopic parents and to assess the relationship between HS and atopic status in these children, objectively assessing the latter.

## Materials and Methods

### Participants and Study Design

The Cincinnati Childhood Allergy and Air Pollution Study (CCAAPS) is a prospective birth cohort study of infants born to atopic parents. The study includes families residing in the Greater Cincinnati Metropolitan Region of southwestern Ohio and northern Kentucky, referred to as the Ohio and Kentucky River Valley region. Monthly birth certificate records were used to identify families with newborns. From the 1,879 families meeting CCAAPS eligibility criteria,[11] 1,152 families (72.6%) made and kept their appointments for a skin-prick test (SPT). There were 881 parents who were SPT positive, and 700 parents (80%) enrolled their infants, defined as bringing their child at his/her first birthday for an SPT. At age 1 year, the 700 children in the CCAAPS study were evaluated for atopic status and exposure to environmental tobacco smoke (ETS). Additionally, parents of these children were asked to complete a questionnaire pertaining both to their snoring and snoring in their child. Snoring frequency was classified as follows: never, rarely (less than once per week), sometimes (once or twice per week), frequently (three or four times per week), and almost always (five to seven times per week). HS was defined as snoring three or more times per week, thus including the latter two classifications. All children with HS (snoring three or more times per week) were compared to children with either no snoring or snoring less than three times per week.

Atopic status was determined by a SPT to a panel of 17 aeroallergens and food allergens.[12] SPTs were performed with a bifurcated testing device (Accusets Test; ALK America; Round Rock, TX). All tests were administered and interpreted by an allergist who was blinded to HS status. Children were tested for both outdoor and indoor allergens, including meadow fescue and timothy grass pollens, white oak, maple mix, American elm, red cedar, short ragweed, Alternaria, *Aspergillus fumigatus*, Penicillium mix, Cladosporium, dust mite mix, German cockroach, cat, and dog. Foods tested included egg white and whole milk. A positive SPT result was defined as the presence of a wheal ≥ 3 mm than the wheal size of control (saline solution).[13]

To determine exposure to ETS, a history of maternal smoking as well as smoking by other household members was obtained.

Positive exposure to maternal or household ETS was defined as consumption of one or more cigarettes per day by the mother or any household member, respectively. This study was approved by the institutional review board at University of Cincinnati, and informed consent was obtained on all subjects.

### Statistical Analysis

Descriptive statistical analysis was performed to calculate the mean and median ages of children and their breakdown by gender and race. The data were stratified by the frequency of snoring. Prevalence rates for each of the snoring frequency strata were then calculated. The comparisons between children with HS and those without HS were performed using a Student $t$ test for continuous variables and a $\chi^2$ test for categorical variables. Univariate logistic regression analysis was performed to identify risk factors that independently predicted the presence of HS in participants. Multiple logistic regression analysis was then used to calculate odds ratios (ORs), which were adjusted for the effects of other risk factors in the model. Statistical software (SAS version 8.2 for Windows; SAS Institute; Cary, NC) was used for all analyses; $p < 0.05$ was considered significant.

## Results

Data were available on 681 of the 700 children in the CCAAPS study: 377 boys (55%) and 304 girls (45%). Of the 681 children, 542 were white (80%), 118 were African American (17%), and 21 were biracial or Asian (3%). The family income was ≥ \$40,000/yr in 65% and < \$40,000/yr in 35% of the families. The mean and median ages of these children at the time of assessment for atopy and snoring were 13.7 ± 2.6 months (± SD) and 12.6 months, respectively. The prevalence of snoring is shown in Table 1. An absence of snoring was reported in 368 of 682 children; however, HS was reported in 105 children (15%). An increased prevalence of HS was reported in children with atopy (21.5% vs 13.0%, p = 0.005), in African-American children (31.0% vs 11.6%, p < 0.001), and in children with a parental history of HS (21.8% vs 7.7%, p < 0.001). Among parents of the 681 children, 138 of the mothers (20%) and 315 of the fathers (46%) were reported to have HS. As determined by a positive SPT, atopy was seen in 195 children (29%). Positive household exposure to ETS was reported in 183 children (27%), with reports of maternal smoking in 98 children (19%).

**Table 1—Prevalence of Snoring (n = 681)***

| Snoring Frequency | Data |
| --- | --- |
| Never | 368 (54) |
| Rarely (< 1 night/wk) | 103 (15.1) |
| Sometimes (1 to 2 nights/wk) | 105 (15.4) |
| Frequently (3 to 4 nights/wk) | 36 (5.2) |
| Almost always (5 to 7 nights/wk) | 69 (10.1) |

*Data are presented as No. (%).

Our cohort comprised 105 children who were habitual snorers (snoring more than three times per week) and 576 children who either did not snore or snored less than three times per week. Habitual snorers did not differ from others in age or gender (Table 2). There was, however, a significant association between HS and the following: (1) positive atopy (p = 0.005) [Table 2]; (2) African-American race (p < 0.01) [Table 2], and (3) a history of snoring in the father (p < 0.01) or in the mother (p < 0.01) [Table 2]. There was no association between HS and ETS, as measured by both maternal smoking (p > 0.1) and household smoking (p > 0.1) [Table 2]. The presence of atopy increased the risk for HS almost twofold. This association was observed even after controlling for parental history of snoring, race, and exposure to ETS (OR, 2.0; 95% confidence interval, 1.2 to 3.0) [Table 3].

## Discussion

Our study is a prospective study of HS in a birth cohort selected from the population. We found a 15% prevalence of HS in 1-year-old children born to atopic parents and a significantly increased prevalence of HS in children with atopy (21.5%), in African-American children (31%), and in children with a parental history of HS (21.8%). Our overall HS prevalence was within the range reported (10 to 15%) in earlier studies of preschool[14] and school-age children.[15] This is of particular significance in light of the fact that obstructive SDB in school-age children is associated with permanent cognitive deficits.[16] The early identification and treatment of this disorder is thus potentially beneficial.

Suit et al[8] recently demonstrated the association between symptoms of atopy and obstructive SDB in school-age children. Our study builds on these important findings by performing objective testing for atopy. We found that the presence of atopy in-

Table 3—*Predictors of HS*

| Variables | OR (Adjusted) | 95% Confidence Interval | p Value |
|---|---|---|---|
| African-American race | 3.3 | 1.9–5.1 | < 0.01 |
| SPT positive | 2.0 | 1.2–3.0 | 0.01 |
| Parent HS | 2.9 | 1.6–5.0 | 0.02 |
| ETS positive (maternal) | 1.2 | 0.7–2.0 | 0.41 |
| ETS positive (household) | 1.1 | 0.8–2.0 | 0.42 |

creased the risk for HS almost twofold. These findings are particularly significant given that allergic diseases are highly prevalent.[17] The upper airway inflammation that is present in patients with atopy is believed to contribute to the development of obstructive SDB. Because exposure to ETS can lead to upper airway inflammation, in our analysis we controlled for the confounding effects of ETS on the association between HS and atopic status.

Similar to the reported findings of Redline et al,[18] we found an increased prevalence of HS in African-American children. The effect of race persisted even after controlling for exposure to ETS. This increased prevalence is believed to be secondary to abnormal ventilatory control and craniofacial development.[19] Our results also indicated that having at least one parent who is a habitual snorer increased the risk of HS by almost threefold. This finding corroborates those of previous reports[18,19] indicating the role of heredity in the development of HS in young children. It has been estimated that approximately 40% of the variance in severity of obstructive SDB can be explained by familial factors.[20] It is likely that genetic factors associated with craniofacial structure, body fat distribution, and neural control of the upper airway muscles interact to produce the obstructive SDB phenotype.[20] Because our study population was much younger than that in the studies cited above, there was less opportunity for environmental influences; as such, it was an ideal population for studying the influence of genetic factors.

We found no association between exposure to ETS and HS in children. Also, our results did not indicate any modifying effect of exposure to ETS on the association between atopy and HS. These results corroborate the findings of Redline et al,[18] who investigated risk factors for obstructive SDB in children. It is important to mention that prior reports[9,21,22] showing a significant association between tobacco smoke and obstructive SDB differed from our study in that they had a higher prevalence of parental smoking (54% vs 27%)[22] or older study participants (age 8 to 9 years vs 1 year).[9] Having a mean age of 13.7 months, participants in our study benefited from lack of prolonged exposure to ETS.

Table 2—*Baseline Characteristics**

| Characteristics | HS Present | HS Absent | p Value |
|---|---|---|---|
| Mean age, yr | 1.13 | 1.16 | NS† |
| Male gender, % | 50 | 45 | NS‡ |
| African-American race, % | 37 | 14.5 | < 0.01‡ |
| Atopy, % | 40 | 26.5 | 0.005 |
| Paternal HS, % | 65.3 | 43.2 | < 0.01 |
| Maternal HS, % | 35.2 | 17.5 | < 0.01 |
| Maternal ETS positive, % | 19.4 | 14 | NS |
| Household ETS positive, % | 33 | 27 | NS |

*NS = not significant.
†Student *t* test.
‡$\chi^2$ test.

This suggests that a critical duration of ETS exposure may be necessary before this association can be detected.

Childhood obstructive SDB is associated with daytime behavioral problems,[2,3,23] cognitive deficits,[16] and cardiovascular[24,25] and metabolic sequelae.[26] As such, recommendations of the American Academy of Pediatrics include screening for obstructive SDB in all children.[27] Furthermore, children with symptoms and those at increased risk for obstructive SDB are advised to undergo objective overnight polysomnography.[27] Since this testing is expensive and currently available only at specialized pediatric centers, children who might benefit should be prioritized. Identification of predisposing risk factors for obstructive SDB will facilitate better utilization of resources as well as early detection and treatment. Children with highly prevalent risk factors such as allergic respiratory diseases should receive special attention. In addition, prospective studies are needed to determine the effect of environmental risk factors on the natural course of childhood obstructive SDB.

A limitation of our study is the lack of objective testing for obstructive SDB. Although this would be ideal, parental-reported HS and objectively measured pathologic snoring have nevertheless been reported to have a significant association in young children.[28] The parents of our study subjects are also at higher risk for snoring due to their atopic status. Thus increased awareness of this disorder may have resulted in better recognition of snoring in the child. Another possible limitation is the underreporting of maternal and household smoking by parents. This could potentially result in misclassification of subjects and thereby affect results. Future studies should include objective assessment of biomarkers such as cotinine levels for classification of ETS exposure. Also, we did not have data on the sleep environment of these infants. This could affect our results due to underreporting of snoring in infants sleeping in their own room compared to those who sleep with their parents.

## CONCLUSION

In a large cohort born to a parent with atopy, we found a 15% prevalence of HS in 1-year-old children and a significant association with positive atopic status, African-American race, and a parental history of HS. Given the extent of this problem in very young children and the negative impact of obstructive SDB on the cognitive functioning of school-age children, we strongly recommend that these high-risk groups be targeted for early identification and treatment. Furthermore, we recommend that longitudinal studies be conducted to investigate the effect of atopy on the natural course of childhood obstructive SDB.

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