

Snoring and Atopic Disease: A Strong Association

Seo Yi Chng, MRCPCH,* Daniel Yam Thiam Goh, MMed Paediatrics, Xiao Shan Wang, MSc, Teng Nging Tan, BSc Hons, and Natalie Bee Hwa Ong, MRCPCH

Summary. The prevalence and factors associated with snoring and habitual snoring in Asian children are largely unknown. Our objectives were to evaluate the prevalence and factors associated with snoring and habitual snoring in preschool and primary school children in Singapore. A self-response questionnaire on snoring was administered to parents of children aged 4–7 years in randomly selected preschools and primary schools in Singapore. The overall response rate was 91.3% ($n = 11,114$). Snoring and habitual snoring were reported in 28.1% and in 6.0% of the children, respectively. On multivariate logistic regression analysis, snoring was significantly associated with male gender, race, atopy (asthma, allergic rhinitis, or atopic dermatitis), maternal atopy (allergic rhinitis or atopic dermatitis), maternal smoking, and breastfeeding. Habitual snoring was significantly associated with obesity (odds ratio (OR), 3.75; 95% confidence interval (CI), 1.67–8.42), allergic rhinitis (OR, 2.90; 95% CI, 2.06–4.08), atopic dermatitis (OR, 1.80; 95% CI, 1.28–2.54), maternal smoking (OR, 2.22; 95% CI, 1.09–4.53), and breastfeeding (OR, 1.49; 95% CI, 1.11–1.98). Atopy was the strongest risk factor for habitual snoring, and the effect was cumulative. The odds ratio of a child with all three atopic diseases (asthma, allergic rhinitis, and atopic dermatitis) to have habitual snoring was 7.45 (95% CI, 3.48–15.97). In conclusion, snoring and habitual snoring are common in Asian children. Atopy is strongly associated with snoring and habitual snoring. We suggest that children who are significantly atopic receive additional attention during screening for snoring, habitual snoring, and other features of obstructive sleep apnea syndrome. *Pediatr Pulmonol.* 2004; 38:210–216. © 2004 Wiley-Liss, Inc.

Key words: snoring; atopy; obesity; breastfeeding; smoking.

INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is a common and important disorder in children.^{1,2} OSAS in children is defined as a disorder of breathing during sleep characterized by prolonged partial upper airway obstruction and/or intermittent complete obstruction (obstructive apnea) that disrupts normal ventilation during sleep and normal sleep patterns.³ If left untreated, childhood OSAS can result in cardiovascular complications⁴ and neurocognitive⁵ and behavioral⁶ impairment. Childhood OSAS is very unlikely in the absence of habitual snoring.¹ If a history of habitual snoring is elicited, a more detailed history for other associated abnormalities during sleep is necessary.¹

The prevalence and demographic factors affecting snoring and habitual snoring have been studied in Caucasian children.^{7–12} Similar data are lacking in Asian children.

Apart from demographic factors, genetics (ethnicity),¹³ atopy (asthma and allergic rhinitis),¹³ and environmental exposure (parental smoking)¹⁴ have also been implicated as risk factors for snoring and habitual snoring. However, these have not been well-characterized.

The objectives of this study were to determine:

1. The prevalence of snoring and habitual snoring in Asian preschool and primary school children (aged 4–7 years) in Singapore; and

Pediatric Pulmonary, Sleep and Critical Care Service, Children's Medical Institute, National University Hospital, Singapore.

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*Correspondence to: Dr. Seo Yi Chng, MRCPCH, Pediatric Pulmonary, Sleep and Critical Care Service, Children's Medical Institute, National University Hospital, 5 Lower Kent Ridge Road, Singapore 119074. E-mail: paev18@nus.edu.sg

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2. The factors (demography, atopy, and environmental exposure) associated with snoring and habitual snoring in these children.

The age group of 4–7 years was selected for this study, as habitual snoring and OSAS are thought to be most prevalent in this age group, when the tonsils and adenoids are largest in relation to underlying airway size. Also, children of this age group can be easily accessed through preschools and lower primary schools locally.

MATERIALS AND METHODS

Subjects

The study population consisted of preschool and primary school children aged 4–7 years, randomly selected from 115 preschools and 24 primary schools in Singapore. All preschool children aged 4–6 years and all first grade primary school children aged 6–7 years from these schools were included in this study. The parents of the children were asked to complete a self-administered questionnaire delivered through the schools.

The questionnaires were administered in English, Chinese, Malay, or Tamil, according to the parents' preference. Translation of the questionnaires from English to Chinese, Malay, and Tamil was performed in accordance with International Study on Asthma and Allergies (ISAAC) guidelines,¹⁵ to exclude linguistic interpretation problems that may affect the results.

Questionnaire

The questionnaire was divided into several sections, including questions on:

- A. Demography: age, gender, race, height, and weight.
- B. The child's snoring and sleep:
 1. Does your child snore during sleep? (yes, no)
 2. How often does the snoring occur? (never, occasionally, frequently, constantly)
 3. Does your child have unusual sleeping postures? (yes, no)
 4. Does your child wake up frequently during sleep? (yes, no)
 5. Does your child have excessive daytime sleepiness? (yes, no)
 6. How often does your child have difficulty catching his breath during sleep, not including coughing, blocked nose, or wheezing? (never, occasionally, frequently, constantly)
 7. Does your child stop breathing for short periods during sleep? (yes, no)
- C. Atopy in the child and in the parents: asthma, allergic rhinitis and atopic dermatitis.

- D. Environmental factors: parental smoking and breast-feeding.

Definition of Terms

Habitual snoring: Snoring that occurred frequently or constantly (i.e., >3 nights per week).

Asthma, allergic rhinitis, and atopic dermatitis: The child or parent was determined to have asthma, allergic rhinitis, and/or atopic dermatitis if the diagnosis was reported as having been confirmed by a doctor.

Overweight and obesity: Height and weight data were available only for the children aged 6–7 years in our study. As per the International Obesity Task Force recommendations, a male child at age 6.5 years in Singapore was considered overweight or obese if the body mass index (BMI) was more than 18.4 kg/m² or 22.4 kg/m², respectively. At age 6.5 years, a female child in Singapore was considered overweight or obese if the BMI was more than 18.3 kg/m² or 21.1 kg/m², respectively.^{16,17}

Statistical Analysis

Statistical analysis was performed with SAS software. Chi-square tests were used to determine differences in snoring. Odds ratios (OR) with 95% confidence intervals (CI) were calculated where relevant. Multivariable logistic regression analysis was used to assess the association between the various dichotomous variables and snoring. Statistical significance was set at <0.05.

RESULTS

Demographics of Responders

Of 12,173 questionnaires, 11,114 responses were returned, giving a response rate of 91.3%. Information on snoring was available from 10,279 children, while the remaining 835 respondents did not fully complete the questions on snoring.

The mean age of subjects was 5.8 ± 1.0 years. The ethnic distribution of responders was 74.9% Chinese, 17.7% Malays, and 7.4% Indians. The gender of responders was 48.5% female and 51.5% male.

The prevalence of asthma, allergic rhinitis, and atopic dermatitis in our subject population was 14.6%, 7.2%, and 10.8%, respectively. The paternal prevalence of asthma, allergic rhinitis, and atopic dermatitis was 6.3%, 6.3%, and 5.7%, respectively. The maternal prevalence of asthma, allergic rhinitis, and atopic dermatitis was 6.7%, 6.1%, and 7.4%, respectively.

Prevalence of Snoring and Habitual Snoring

Snoring and habitual snoring were reported in 28.1% and 6.0% of the children, respectively.

TABLE 1—Frequency of Sleep Abnormalities in Nonsnorers, Snorers, and Habitual Snorers¹

	Unusual sleeping posture (%)	Frequent awakening (%)	Excessive daytime sleepiness (%)	Difficulty breathing during sleep (%)	Observed apneas during sleep (%)
Nonsnorers	68/1,165 (5.8)	54/1,145 (4.7)	15/1,117 (1.3)	304/6,720 (4.5)	44/6,946 (0.6)
Snorers	560/2,660 (21.3)	336/2,602 (12.9)	125/2,521 (5.0)	385/2,845 (13.5)	53/2,853 (1.9)
Habitual snorers	155/559 (27.7)	87/547 (15.9)	43/523 (8.2)	131/606 (20.0)	25/607 (4.1)

¹*P* values for above variables were all <0.0001.

Compared to children who did not snore, children who had snoring or habitual snoring were more likely to have unusual sleeping postures, frequent awakening during sleep, excessive daytime sleepiness, difficulty in catching one's breath during sleep, and observed breathing cessation during sleep (Table 1).

Factors Associated With Snoring and Habitual Snoring: Univariable Analysis

Demographic Factors

Snoring was significantly more common in boys than girls, and habitual snoring was significantly more common in obese children. The prevalence of snoring and habitual snoring was also different between races: snoring was most common among Chinese, but habitual snoring was most common among Malays (Table 2).

Atopy

Snoring and habitual snoring were all significantly related to a personal, paternal, or maternal history of atopy (Table 3).

Environmental Factors

Snoring and habitual snoring were both significantly associated with current maternal smoking as well as maternal smoking in the first year of the child's life. In

addition, habitual snoring was also significantly associated with current paternal smoking. Snoring and habitual snoring were both significantly more common in children who were ever breastfed (Table 4).

Factors Associated with Snoring and Habitual Snoring: Multivariable Analysis

On multivariable logistic regression analysis (Table 5), snoring was significantly associated with male gender, race, personal atopy (asthma, allergic rhinitis, or atopic dermatitis), maternal atopy (allergic rhinitis or atopic dermatitis), maternal smoking, and breastfeeding.

Habitual snoring was significantly associated with obesity (OR, 3.75; 95% CI, 1.67–8.42), allergic rhinitis (OR, 2.90; 95% CI, 2.06–4.08), atopic dermatitis (OR, 1.80; 95% CI, 1.28–2.54), maternal smoking (OR, 2.22; 95% CI, 1.09–4.53), and breastfeeding (OR, 1.49; 95% CI, 1.11–1.98). Atopy was the strongest risk factor for habitual snoring. The odds ratio of a child with all three atopic diseases of asthma, allergic rhinitis, and atopic dermatitis to have habitual snoring was 7.45 (95% CI, 3.48–15.97).

Discussion

Obstructive sleep apnea syndrome (OSAS) is a common and important disorder in children.^{1,2} Symptoms include habitual snoring and disturbed sleep. The 28.1% prevalence of snoring in Asian children is comparable to

TABLE 2—Demographic Factors and Their Association With Snoring Status: Univariable Analysis

	n	Snorers (%)	<i>P</i> value	Habitual snorers (%)	<i>P</i> value
Sex					
Male	5,212	1,619 (31.1)		366 (7.0)	
Female	4,939	1,237 (25.1)	<0.0001	240 (4.9)	<0.0001
Race					
Chinese	7,421	2,206 (29.7)		452 (6.1)	
Malay	1,751	431 (24.6)		111 (6.3)	
Indian	746	138 (18.5)	<0.0001	32 (4.3)	<0.05
BMI ¹					
Normal weight	2,746	676 (24.6)		145 (5.3)	
Overweight	343	111 (32.4)		24 (7.0)	
Obese	115	47 (40.9)	<0.0001	16 (13.9)	0.0003

¹Data for BMI were available only for children aged 6–7 years.

TABLE 3—Atopy and Its Association With Snoring Status: Univariable Analysis¹

	n	Snorers (%)	P value	Habitual snorers (%)	P value
Personal atopy					
Asthma					
+	1,427	529 (37.1)		135 (9.5)	
—	8,380	2,221 (26.5)	<0.0001	451 (5.4)	<0.0001
AR					
+	674	303 (45.0)		84 (12.5)	
—	8,688	2,335 (26.9)	<0.0001	475 (5.5)	<0.0001
AD					
+	1,028	438 (42.6)		100 (9.7)	
—	8,470	2,246 (26.5)	<0.0001	471 (5.6)	<0.0001
Asthma, AR, and AD					
+	58	27 (46.6)		12 (20.7)	
Asthma, AR, or AD					
—	6,520	1,565 (24.0)	<0.0001	313 (4.8)	<0.0001
Paternal atopy					
Asthma					
+	630	236 (38.1)		57 (9.2)	
—	9,315	2,533 (27.2)	<0.0001	528 (5.7)	0.0003
Allergic rhinitis					
+	611	245 (40.1)		61 (10.0)	
—	9,111	2,474 (27.1)	<0.0001	512 (5.6)	<0.0001
Atopic dermatitis					
+	552	242 (43.8)		49 (8.9)	
—	9,140	2,454 (26.9)	<0.0001	514 (5.6)	0.0015
Maternal atopy					
Asthma					
+	677	244 (36.0)		67 (9.9)	
—	9,294	2,550 (27.4)	<0.0001	522 (5.6)	<0.0001
Allergic rhinitis					
+	598	277 (46.3)		67 (11.2)	
—	9,132	2,446 (26.7)	<0.0001	510 (5.6)	<0.0001
Atopic dermatitis					
+	721	306 (42.4)		70 (9.7)	
—	9,006	2,412 (26.8)	<0.0001	508 (5.6)	<0.0001

¹AR, allergic rhinitis; AD, atopic dermatitis.**TABLE 4—Environmental Factors and Their Association With Snoring Status: Univariable Analysis**

	n	Snorers (%)	P value	Habitual snorers (%)	P value
Paternal smoking					
Smoking presently					
+	3,054	856 (28.0)		217 (7.1)	
—	7,041	1,975 (28.1)	0.98	386 (5.5)	0.0016
Maternal smoking					
Smoking presently					
+	253	110 (43.5)		33 (13.0)	
—	9,769	2,720 (27.8)	<0.0001	563 (5.8)	<0.0001
Smoking in first year of life					
+	78	33 (42.3)		11 (14.1)	
—	4,745	1,207 (25.4)	0.0007	282 (5.9)	0.0069
Smoking during pregnancy					
+	72	33 (45.8)		7 (9.7)	
—	5,220	1,569 (30.1)	0.0057	301 (5.8)	0.20
Breastfeeding					
+	5,968	1,798 (30.1)		389 (6.5)	
—	4,044	1,021 (25.3)	<0.0001	207 (5.1)	0.0037

TABLE 5—Demographic, Atopic, and Environmental Factors and Their Association With Snoring Status: Multivariable Logistic Regression Analysis Results

	Snoring OR (95% CI)	Habitual snoring OR (95% CI)
Sex, male	1.35 (1.18–1.54)	Not significant
Race	0.72 (0.64–0.82)	Not significant
BMI		
Obese	Not significant	3.75 (1.67–8.42)
Personal atopy		
Asthma	1.30 (1.07–1.59)	Not significant
Allergic rhinitis	1.97 (1.58–2.45)	2.90 (2.06–4.08)
Atopic dermatitis	1.73 (1.41–2.11)	1.80 (1.28–2.54)
All three	1.97 (1.02–3.79)	7.45 (3.48–15.97)
Paternal atopy		
Asthma	Not significant	Not significant
Allergic rhinitis	Not significant	Not significant
Atopic dermatitis	Not significant	Not significant
Maternal atopy		
Asthma	Not significant	Not significant
Allergic rhinitis	1.55 (1.18–2.04)	Not significant
Atopic dermatitis	1.41 (1.10–1.80)	Not significant
Paternal smoking		
Smoking presently	Not significant	Not significant
Maternal smoking		
Smoking presently	2.36 (1.53–3.63)	2.22 (1.09–4.53)
Breastfeeding	1.32 (1.14–1.52)	1.49 (1.11–1.98)

the prevalence from Western studies, with estimates ranging from 16.7–30.6%.^{6,8,10,12} The 6.0% prevalence of habitual snoring in Asian children is comparable to the prevalence from Western studies, with estimates ranging from 3.2–12.1%.^{6–12} The prevalence of habitual snoring in this study is also comparable to the 8.5% prevalence obtained from the only other published Asian study, conducted in Thailand.¹⁸ The prevalence of excessive daytime sleepiness was low at 5.0% in snorers and 8.2% in habitual snorers, and this finding is in agreement with that in Western children. Excess daytime sleepiness is a common symptom in adults with OSAS, but is found in only a minority of children with OSAS.¹⁹

The factors associated with snoring and habitual snoring in Asian children were examined in detail in this study, using multivariable logistic regression analysis.

Snoring, but not habitual snoring, was significantly more prevalent among male Asian children. The lack of relationship between gender and habitual snoring is consistent with previous data from Western studies.^{10,13} Snoring was significantly more prevalent among Chinese, followed by Malays and then Indians. However, there was no significant difference in habitual snoring between races. This lack of relationship between habitual snoring and race is in disagreement with the findings from an earlier paper.¹³ Redline et al.¹³ reported that African American children were 3.5 times more likely to have sleep-disordered breathing than white American children,

and that this may be related to differences in adenotonsillar hypertrophy between African Americans and white Americans. We postulate that Chinese, Malays, and Indians may be less genetically heterogeneous than African and white Americans; this may explain why we were unable to document a racial difference in habitual snoring in this study.

Habitual snoring was 3.7 times more common in obese Asian children. The risk of habitual snoring in obese Asian children is comparable to that in American children, where the odds ratio between obesity and sleep disordered breathing is 4.7.¹³ However, the association between obesity and habitual snoring in children is still less than that in adults, where the odds ratio for OSAS in obese adults is 10–12.^{20,21}

Snoring and habitual snoring were 2.4 times and 2.2 times more common, respectively, in Asian children whose mothers smoked. However, there was no relationship between paternal cigarette smoking and childhood snoring. This relationship between exposure to cigarette smoking in the household (in particular, maternal cigarette smoking) and snoring was established in previous studies.^{7,14,22} Snoring is thought to reflect the enhanced proliferation of lymphoid tissue induced by chemical irritation of the upper respiratory tract at an age that characteristically exhibits accelerated growth of tonsils and adenoids.²³

Snoring and habitual snoring were 1.3 times and 1.5 times more common, respectively, in Asian children who had been breastfed, and this increased risk was independent of obesity, atopy, and maternal smoking. These were unexpected findings. To the best of our knowledge, the relationship between snoring and breastfeeding has not been previously studied.

A recent large longitudinal study²⁴ concluded that breastfeeding does not protect children against atopy and asthma, and may even increase the risk. We suggest that an unknown mechanism (possibly immunological in nature), by which breastfeeding increases the risk of atopy and asthma, may also independently increase the risk of snoring and possible obstructive sleep apnea syndrome. A postulated mechanism may involve the passive transfer of immunological responses from mother to child through breastmilk that promotes atopy and airway inflammation, resulting in wheezing and snoring. It could also be that some of the nonatopic children in this study were preatopic and developed frank asthma, allergic rhinitis, and atopic dermatitis only later.

Our study did not differentiate between methods of breastfeeding (exclusive, predominant, or mixed breastfeeding) or duration of breastfeeding. Thus, it was not possible to perform further stratified analyses to explore the proper effects of different methods and durations of breastfeeding on snoring. The relationship between breastfeeding, snoring, and OSAS is certainly interesting

and warrants further research, including large-scale longitudinal prospective studies using population-based birth cohorts.

Another interesting finding from this study was the association between atopy and snoring. The relationship between asthma and allergic rhinitis with snoring and OSAS was previously studied in Caucasian adults and children. In these studies, asthma^{13,25} and allergic rhinitis^{7,8} were both shown to increase the risk for snoring and OSAS.

Upper airway problems such as allergic rhinitis are associated with inflamed and narrowed upper airways that result in increased upper airway resistance and consequently snoring and OSAS. Nasal corticosteroid sprays for the treatment of allergic rhinitis also improve obstructive sleep apnea.²⁶ Lower airway problems such as asthma are also associated with snoring and OSAS, but the causation may be bidirectional, and each may exacerbate the other. OSAS may exacerbate asthma by the following mechanisms: OSAS alters oropharyngeal reflexes and increases negative intrathoracic pressure,^{27,28} and both factors may increase cholinergic tone and promote bronchoconstriction.^{27,28} Treatment of snoring and OSAS was shown to improve the control of nocturnal asthma.^{27,29} Asthma may exacerbate OSAS by the following mechanism: nocturnal asthma disrupts sleep and may result in sleep deprivation; the adverse effects of sleep deprivation on respiratory control may increase the frequency of apneas in snorers.³⁰ Finally, asthma, snoring, and OSAS may be linked because of common risk factors that promote airway inflammation and disturbed neuromuscular control of breathing.

Snoring and habitual snoring were both significantly more common in children who have atopic dermatitis. It could be that these children with atopic dermatitis and skin inflammation also have airway inflammation and narrowing, not sufficient to manifest as symptoms of allergic rhinitis or asthma; but they may be at an increased risk for snoring.

The strongest association with snoring and habitual snoring was in children who had all three diseases of asthma, allergic rhinitis, and atopic dermatitis. This association was independent of the other risk factors of obesity, maternal smoking, and breastfeeding.

Contrary to previous belief, the most significant risk factor for snoring, habitual snoring, and OSAS may not be obesity but atopy. From multivariable logistic regression analysis, the odds ratio for habitual snoring in highly atopic children was 7.45 (95% CI, 3.48–15.97), whereas the odds ratio for habitual snoring in obese children was only 3.75 (95% CI, 1.67–8.42). The risk for habitual snoring in atopic children may be cumulative. The risk for habitual snoring in children with all three diseases of asthma, allergic rhinitis, and atopic dermatitis is 7.5 times that of normal children and 2 times that of obese children.

It would be worthwhile to pay added attention to this group of atopic children during screening for snoring, habitual snoring, and OSAS.

In conclusion, snoring and habitual snoring are common in Asian children. There is a strong association between atopy (asthma, allergic rhinitis, and atopic dermatitis) and snoring and habitual snoring. We suggest that children who have a strong personal history of atopy receive additional attention during screening for snoring, habitual snoring, and other features of obstructive sleep apnea syndrome.

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