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Official publication of the American College of Chest Physicians



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Chest 2010;138:519-527; Prepublished online February 19, 2010;
DOI 10.1378/chest.09-1926

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ISSN:0012-3692





Prevalence and Risk Factors of Habitual Snoring in Primary School Children

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Objective: Our study aimed to determine the prevalence of habitual snoring (HS) in primary school children and to evaluate the diurnal symptoms and conditions that may be associated with it.

Methods: A validated questionnaire completed by parents was used to assess the sleep and daytime behaviors of Chinese children aged 5 to 14 years. Thirteen primary schools in two representative districts were randomly selected.

Results: A total of 6,349 out of 9,172 questionnaires (response rate 69.2%) with complete answers were returned. The prevalence rate of HS was 7.2%. Male sex (odds ratio [OR] [95% CI]: 2.5 [1.7-3.6]), BMI *z* score (OR [95% CI]: 1.4 [1.1-1.6]), maternal HS (OR [95% CI]: 3.4 [2.0-5.7]), paternal HS (OR [95% CI]: 3.8 [2.7-5.5]), allergic rhinitis (OR [95% CI]: 2.9 [2.0-4.2]), asthma (OR [95% CI]: 2.4 [1.2-5.2]), nasosinusitis (OR [95% CI]: 4.0 [1.5-10.6]), and tonsillitis (OR [95% CI]: 3.1 [1.9-5.1]) in the past 12 months were identified to be independent risk factors associated with HS. HS was also associated with daytime, nocturnal, parasomniac, and sleep-related breathing symptoms. HS was demonstrated to be an independent risk factor for parent-reported poor temper (OR [95% CI]: 1.9 [1.4-2.5]), hyperactivity (OR [95% CI]: 1.7 [1.2-2.5]), and poor school performance (OR [95% CI]: 1.7 [1.2-2.5]).

Conclusions: HS was a significant and prevalent problem in primary school children. Male sex, obesity, parental HS, atopic symptoms, and history of upper respiratory infections were significant risk factors. HS was also associated with sleep-disordered breathing symptoms and adverse neurobehavioral outcomes.

CHEST 2010; 138(3):519-527

Abbreviations: AR = allergic rhinitis; HS = habitual snoring; OSA = obstructive sleep apnea; URTI = upper respiratory tract infection

Snoring is the most important and common manifestation related to obstructive sleep apnea (OSA) and may cause hypoxemia and hypercapnia because of partial obstruction of the upper airway during sleep.¹ In adults, habitual snoring (HS) is associated

with hypertension,² cardiovascular/cerebrovascular disease,^{3,4} and daytime sleepiness.⁵ Our research group has previously demonstrated higher BP in children with HS compared with healthy controls.⁶ Recent studies have also documented impaired neu-

Manuscript received August 13, 2009; revision accepted January 8, 2010.

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Funding/Support: This study was supported by the Research Grants Council of the Hong Kong Special Administrative Region, China [Grant CUHK4161/02M].

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DOI: 10.1378/chest.09-1926

For editorial comment see page 469

ropsychologic functioning in children with a history of snoring.^{7,8} Thus, the clinical importance of HS as a potential marker of morbidity and even mortality is increasingly being recognized.

The prevalence of HS has been reported to vary between 2.4% and 34.5% in children.⁹ Such a wide range may be attributed to the discrepancy in the definition of HS, different age groups, and methods of sampling. Most studies examining the prevalence of HS and associated risk factors have been carried out in populations from Western countries.⁹ A telephone survey that was carried out locally reported an

HS prevalence of 10.9%. However, the study had a response rate of only 50%, such that sampling bias might exist.¹⁰ A variety of parameters have also been reported to be associated with HS. Some studies suggested a positive relationship between HS and male sex,¹⁰⁻¹⁵ overweight,¹⁴⁻¹⁸ exposure to tobacco smoke,^{11,12,18-22} and low socioeconomic status,¹⁶ whereas others have not been able to confirm these findings.²³⁻²⁵ Using a large population-based sample, we aimed to determine the prevalence of HS and its association with clinical features, environmental and socioeconomic factors, neurobehavioral outcomes, and other sleep-related symptoms in primary school Chinese children.

MATERIALS AND METHODS

Study Population

As part of our childhood OSA epidemiology study, we have chosen two representative primary school districts for subject recruitment. Because the income distribution of the two districts is similar to the whole of Hong Kong, results obtained from this study should be a good representation of the territory. Thirteen primary schools from the two districts were randomly chosen to participate in this study. The study population consisted of children aged 5 to 14 years. Approval by the ethics committee of the Chinese University of Hong Kong was obtained.

Questionnaire

A questionnaire based on parental report was used (Hong Kong Children Sleep Questionnaire²⁶). Parents were invited to attend an education forum in each participating school during which full explanation of the purpose of the study was given by the investigators. An envelope containing the questionnaire to be filled out by parents and a personally addressed letter asking for consent was then distributed to children at the chosen schools with the help of their teachers within a week after the forum. The parents were asked to return the completed questionnaire within a week. For those who failed to return the questionnaire within the defined period, another copy was given with a self-addressed envelope enclosed for ease of return.

The following information from the questionnaire was extracted for analysis: (1) demographics and body size: age, sex, weight, and height. The *z* score for BMI was calculated from local normal reference²⁷; (2) clinical features: atopic symptoms, upper respiratory tract infection (URTI) in the past 12 months, and parental history of HS; (3) environmental factors: household smoking, household furry pets, breast-feeding (≥ 6 months), number of siblings, and sleep environment (sleep in own room, cosleeping); (4) socioeconomic factors: family income, overcrowding (living space per person < 5.5 m²), parental education, and single parenthood; (5) neurobehavioral outcomes: poor temper, hyperactivity, and poor school performance; (6) sleep duration during weekdays, weekends, and vacations; and (7) snoring frequency and 23 sleep-related symptoms rated on a five-point rating scale (0-4): 0 = never; 1 = rarely, for zero to one night per month; 2 = sometimes, for one to two nights per month; 3 = often, for one to two nights per week; 4 = frequently, for three nights or more per week. Factor analysis categorized the 23 items into six factors, namely daytime symptoms, nocturnal symptoms, parasomnia, insomnia, sleep-related movement, and sleep-related

breathing (Table 1). The total variance explained by this six-factor model was 50.3%. Factor scores were calculated using regression method. The subjects were divided into three groups for comparisons: (1) nonsnорers, those reporting “never” in the questionnaire; (2) occasional snорers, those reporting “rarely” to “often,” and (3) habitual snорer, those reporting “frequently.”

Data Analysis

Data were presented as mean $\pm$ SD, median (interquartile range), and percentages, for parametric, nonparametric, and categorical data, respectively. Parametric and nonparametric variables were compared using one-way analysis of variance and Kruskal-Wallis tests. Post hoc tests (Tukey or Games-Howell method) were carried out for pairwise comparisons. Categorical variables were compared using χ^2 tests. The significance level for pairwise comparisons were adjusted to $P < .016$. The 95% CIs of prevalence of HS were calculated using the modified Wald method suggested by Agresti and Coull.²⁸

Multivariate logistic regression analyses were subsequently performed to further confirm the association between potential risk factors and HS. All the analyses compared habitual snорers with nonsnорers. The association was assessed in two logistic regression models: (1) adjusted for age, sex, and BMI *z* score only; (2) further adjusted for clinical features, and environmental and socioeconomic factors simultaneously. Independent variables with a *P* value of $< .1$ in model 1 were included in model 2. Multivariate logistic regression analyses were also used to assess the association between snoring and neurobehavioral outcomes while adjusting for possible confounders. All analyses were performed using SPSS version 15.0.

Table 1—Summary of Items and Factor Loadings of the Six Factors

Factor	Factor Loading
Daytime symptoms	
Feeling unrefreshed in the morning	0.782
Daytime fatigue	0.742
Unwilling to get up in the morning	0.679
Morning dry mouth	0.463
Morning headache	0.414
Insomnia	
Difficulty initiating sleep	0.678
Feeling anxious when going to bed	0.676
Interrupted sleep	0.582
Early morning awakening	0.531
Nocturnal symptoms	
Restless sleep	0.642
Sleep in prone position	0.625
Bruxism	0.569
Night sweating	0.500
Nocturnal enuresis	0.315
Sleep-related breathing disorder symptoms	
Nocturnal labored breathing	0.735
Nocturnal oral breathing	0.673
Witnessed apnea	0.608
Parasomnia	
Sleep walking	0.756
Sleep terror	0.731
Sleep talking	0.497
Nightmares	0.308
Sleep-related movements	
Repetitive head rolling or banging when falling asleep	0.760
Periodic limb movements during sleep	0.653

RESULTS

Subject Characteristics

Of 9,172 children enrolled, 6,471 questionnaires were returned giving a response rate of 70.6%. One hundred twenty-two questionnaires were excluded from analysis because of missing snoring information, making a final response rate of 69.2%. The characteristics of the remaining 6,349 children are shown in Table 2.

Prevalence of HS

Overall, there were 454 habitual snorers (7.2%), 2,780 occasional snorers (43.8%), and 3,115 nonsnorers (49.1%). Figure 1 showed the prevalence of HS by age and sex. HS was significantly more prevalent in boys than in girls among subjects from age 7 to 11 years. The prevalence of HS was highest in 7-year-old boys and 6-year-old girls.

Risk Factors of HS

The possible risk factors of HS were compared among different groups and the results were tabulated in Table 3. A number of variables were demon-

strated to have a dose-response relationship with snoring frequency. Body size increased, whereas age decreased across groups. The proportions of male sex, parental snoring, atopic symptoms and upper respiratory tract infection in the past 12 months, and single child increased across groups, whereas the proportions of breast-feeding for ≥ 6 months, having two or more siblings, poverty (family income per person $< \text{HK\$}2500$), poor parental education (full-time education up to primary level), and overcrowding (living space per person $< 5.5 \text{ m}^2$) decreased across groups.

Table 4 shows the results of logistic regression analyses identifying risk factors for HS. With reference to the nonsnoring group, male sex, BMI z score, parental HS, and history of allergic rhinitis (AR) symptoms, wheezing, nasosinusitis, and tonsillitis in the past 12 months were significantly associated with HS in the fully adjusted model. Children who slept in their own room were demonstrated to be less likely to have HS.

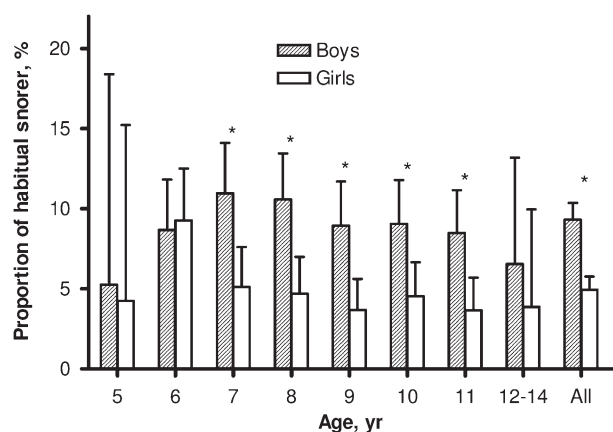
Sleep-Related Symptoms Associated With HS

The HS group had significantly higher factor scores of daytime symptoms, nocturnal symptoms, parasomnia,

Table 2—Subject Characteristics by Sex

Characteristics	Girls (n = 3,139)	Boys (n = 3,210)	P Value
Demographics and clinical features			
Age, y	9.2 $\pm$ 1.8	9.2 $\pm$ 1.8	.938
Height, cm	134.2 $\pm$ 12.5	134.1 $\pm$ 11.9	.717
Weight, kg	30.3 $\pm$ 8.9	31.7 $\pm$ 9.7	< .0001
BMI, kg/m ²	16.5 $\pm$ 2.8	17.3 $\pm$ 3.3	< .0001
BMI z score	0.13 $\pm$ 1.14	0.25 $\pm$ 1.16	.0002
Maternal HS, %	7.8	9.0	.099
Paternal HS, %	36.6	36.6	.968
Atopic symptoms			
AR symptoms (past 12 mo), %	38.7	50.1	< .0001
Wheezing (past 12 mo), %	3.9	6.4	< .0001
Eczema ever, %	5.4	5.4	.983
URTI symptoms	12.2	13.3	.215
Nasosinusitis (past 12 mo), %	1.8	2.8	.018
Tonsillitis (past 12 mo), %	10.9	12.3	.101
Otitis media (past 12 mo), %	2.4	1.8	.123
Environmental factors			
Household smoking, %	33.2	32.3	.448
Furry pet keeping, %	10.8	8.4	< .001
Breast-feeding ≥ 6 mo, %	9.4	8.9	.550
Single child, %	16.9	18.7	.086
No. of siblings			
1	52.0	54.9	
≥ 2	31.1	26.5	< .0001
Sleep in own room, %	24.5	27.6	.005
Co-sleep, %	28.3	26.9	.210
Socioeconomic factors			
Poverty, %	32.3	29.1	.012
Household crowding, %	7.7	5.9	.006
Poor maternal education, %	20.4	18.5	.064
Poor paternal education, %	19.1	18.3	.420
Single parent, %	6.9	6.4	.461

AR = allergic rhinitis; household crowding = living space per person $< 5.5 \text{ m}^2$; HS = habitual snoring; poverty = family income per person $< \text{HK\$}2,500$; poor parental education = full-time education up to primary level; URTI = upper respiratory tract infection.



Age, yr		5	6	7	8	9	10	11	12-14	All
Boys	% of HS	5.3	8.7	11.0	10.6	9.0	9.1	8.5	6.5	9.3
	Total N	38	415	483	548	536	541	542	107	3210
Girls	% of HS	4.3	9.3	5.1	4.7	3.7	4.5	3.7	3.9	4.9
	Total N	47	410	450	490	570	550	519	103	3139

FIGURE 1. Prevalence of habitual snoring (HS) by age and sex. *Significant difference between boys and girls ($P < .05$).

and sleep-related breathing than the nonsnorer group. On the other hand, no significant differences could be found in the factor scores of insomnia and sleep-related movements between the two groups (Table 5).

Neurobehavioral Outcomes of HS

The habitual snorer group had a greater proportion of subjects having poor temper, hyperactivity, and poor school performance compared with nonsnorers (Table 5). Multivariate logistic regression analysis demonstrated that HS was significantly associated with a higher risk for all these neurobehavioral outcomes with reference to nonsnoring after adjusting for all possible confounders, whereas occasional snoring was not (Table 6).

There was a significant decreasing trend in sleep duration from nonsnorers, to occasional snorers, and then to habitual snorers (Table 5). However, after adjusting for age, sex, BMI z score, atopic symptoms, and socioeconomic factors, neither HS nor occasional snoring was significantly associated with sleep duration.

DISCUSSION

To our knowledge, this is one of the largest epidemiologic research studies carried out in this region to examine for the prevalence of HS among 5- to 14-year-old primary school children. We found the

Table 3—Characteristics of Subjects According to Snoring Status

Characteristics	Nonsnorers (n = 3,115)	Occasional Snorers (n = 2,780)	Habitual Snorers (n = 454)	P for Trend
Clinical features				
Age, y	9.4 ± 1.8	9.0 ± 1.8	9.0 ± 1.8	< .0001
Male sex, %	43.8	55.6	65.9	< .0001
Height, cm	134.9 ± 12.3	133.5 ± 12.0	133.9 ± 12.1	.0007
Weight, kg	30.7 ± 8.9	31.0 ± 9.5	32.7 ± 10.8	.0006
BMI z score	0.06 ± 1.12	0.28 ± 1.16	0.52 ± 1.18	< .0001
Maternal HS, %	5.6	9.5	20.8	< .0001
Paternal HS, %	29.1	41.0	59.9	< .0001
Atopic symptoms				
AR symptoms (past 12 mo), %	33.9	53.2	63.2	< .0001
Wheezing (past 12 mo), %	2.9	6.7	11.5	< .0001
Eczema ever, %	3.5	6.7	9.5	< .0001
URTI				
Nasosinusitis (past 12 mo), %	1.3	2.9	5.4	< .0001
Tonsillitis (past 12 mo), %	7.1	14.5	24.3	< .0001
Otitis media (past 12 mo), %	1.2	2.8	4.6	< .0001
Environmental factors				
Household furry pet, %	8.5	10.6	10.9	.007
Household smoking, %	33.3	32.3	31.6	.336
Breast-feeding ≥ 6 mo	11.0	7.5	7.4	< .0001
Single child, %	13.9	21.8	20.5	< .0001
No. of siblings				
1	51.6	55.8	52.0	
≥ 2	34.5	22.5	27.5	< .0001
Sleep in own room, %	25.8	26.8	22.7	.719
Cosleep, %	26.9	28.2	28.4	.256
Socioeconomic factors				
Poverty, %	37.3	24.9	22.2	< .0001
Household crowding, %	9.1	4.5	5.5	< .0001
Poor maternal education, %	24.3	14.7	16.7	< .0001
Poor paternal education, %	21.8	16.0	15.4	< .0001
Single parent, %	6.5	6.9	6.2	.809

See Table 2 for explanation of terms and expansion of abbreviations.

Table 4—Risk Factors Associated With HS With Reference to Nonsnorers

Risk Factors	Model 1 ^a		Model 2 ^b	
	OR (95% CI)	P Value	OR (95% CI)	P Value
Demographics and clinical features				
Age	0.90 (0.84-0.95)	.0005	0.90 (0.81-1.00)	.050
Male sex	2.56 (2.03-3.22)	<.0001	2.47 (1.72-3.55)	<.0001
BMI <i>z</i> score	1.44 (1.30-1.60)	<.0001	1.36 (1.14-1.62)	.0007
Maternal HS	4.20 (2.94-6.02)	<.0001	3.39 (2.00-5.73)	<.0001
Paternal HS	3.82 (2.93-4.99)	<.0001	3.83 (2.66-5.52)	<.0001
Atopic symptoms				
AR symptoms (past 12 mo)	3.35 (2.64-4.25)	<.0001	2.91 (2.01-4.20)	<.0001
Wheezing (past 12 mo)	3.86 (2.46-6.04)	<.0001	2.44 (1.15-5.17)	.020
Eczema ever	2.59 (1.67-4.02)	<.0001	1.85 (0.93-3.66)	.080
URTI				
Nasosinusitis (past 12 mo)	4.42 (2.37-8.26)	<.0001	4.01 (1.52-10.57)	.005
Tonsillitis (past 12 mo)	3.50 (2.55-4.81)	<.0001	3.08 (1.85-5.14)	<.0001
Otitis media (past 12 mo)	4.01 (1.97-8.17)	.0001	1.78 (0.54-5.90)	.344
Environmental factors				
Household smoking	0.92 (0.72-1.17)	.503		
Household furry pets	1.42 (0.97-2.10)	.073	1.37 (0.77-2.44)	.284
Breastfeeding $\geq$ 6 mo	0.68 (0.45-1.02)	.060	0.96 (0.49-1.87)	.911
Single child, %	1.43 (1.06-1.93)	.019	1.06 (0.57-1.97)	.855
1 sibling vs no sibling	0.76 (0.55-1.03)	.079		
$\geq$ 2 siblings vs no sibling	0.60 (0.42-0.86)	.005	0.91 (0.58-1.42)	.680
Sleep in own room, %	0.78 (0.59-1.02)	.071	0.64 (0.41-1.00)	.048
Co-sleep, %	1.04 (0.80-1.33)	.787		
Socioeconomic factors				
Poverty	0.50 (0.38-0.66)	<.0001	0.70 (0.43-1.15)	.156
Household crowding, %	0.69 (0.40-1.18)	.023	0.96 (0.39-2.40)	.934
Poor maternal education	0.76 (0.56-1.02)	.069	0.91 (0.52-1.61)	.755
Poor paternal education	0.74 (0.54-1.02)	.064	0.91 (0.51-1.62)	.757
Single parent	0.90 (0.55-1.47)	.685		

OR = odds ratio. See Table 2 for explanation of terms and expansion of other abbreviations.

^aAdjusted for age, sex, and BMI *z* score.

^bAdjusted for all factors with a *P* < .1 in model 1 simultaneously.

prevalence of HS in this age group to be 7.2%, which is less compared with figures from Australia,^{15,19} South America,^{22,25} and the United States^{21,29} involving a similar age group, reported to range from 10.5% to 27.6% (Table 7).

On the other hand, our prevalence rate is greater than that reported from various Middle East and European countries, namely Italy,^{13,17} Turkey,^{23,30,31} and Greece.¹¹ This discrepancy may be related to different diagnostic criteria used for the definition of

Table 5—Comparison of the Factor Scores of Sleep-Related Symptoms, Sleep Duration, and Neurobehavioral Outcomes Between Groups

Factor	Nonsnorers (n = 3,115)	Occasional Snorers (n = 2,780)	Habitual Snorers (n = 454)	P for Trend
Factor scores of symptoms				
Daytime symptoms	−0.09 ± 0.96	0.05 ± 0.98 ^a	0.44 ± 1.35 ^a	<.0001
Nocturnal symptoms	−0.24 ± 0.89	0.24 ± 1.02 ^a	0.49 ± 1.21 ^a	<.0001
Insomnia	−0.11 ± 0.94	0.13 ± 1.02 ^a	0.05 ± 1.24	<.0001
Parasomnia	−0.08 ± 0.87	0.08 ± 1.04 ^a	0.19 ± 1.61 ^a	<.0001
Sleep-related movements	0.00 ± 0.89	−0.03 ± 1.02	0.24 ± 1.59	.134
Sleep-related breathing disorder symptoms	−0.18 ± 0.70	0.11 ± 1.02 ^a	0.89 ± 2.09 ^a	<.0001
Mean sleep duration during weekdays, h	9.21 ± 0.95	9.14 ± 0.94 ^a	9.07 ± 1.00 ^a	.0002
Mean sleep duration during weekends, h	10.14 ± 0.96	10.03 ± 0.90 ^a	9.97 ± 0.99 ^a	<.0001
Mean sleep duration during vacations, h	10.26 ± 0.97	10.17 ± 0.87 ^a	10.16 ± 0.94	.0004
Poor temper, %	21.0	24.8	34.9 ^a	<.0001
Hyperactivity, %	13.8	16.0 ^a	23.1 ^a	<.0001
Poor school performance, %	13.5	14.4	23.6 ^a	<.0001

^aSignificantly different from nonsnoring controls.

HS, and/or there is a genuine racial difference in the prevalence of HS.

In our study, HS was more prevalent in boys, especially from 7 to 11 years of age. The issue of sex difference in the prevalence of HS is controversial, and has only been reported in a few of the published studies.⁹⁻¹⁵ In adults HS is more common in men,³⁶ and sex hormones and their influence on respiratory control and/or body fat distribution have been suggested to play a crucial role. Clearly, these factors would be much less prominent in prepubertal children, which accounted for the majority of subjects in our study. Increased prevalence of AR among male Hong Kong children could explain the sex discrepancy in children with HS.¹⁰ AR causing inflammation and narrowing to the upper airways would increase flow resistance and hence one's liability to snore. In addition, nasal corticosteroid spray used for the treatment of AR also improved OSA.³⁷ In the current study, further analysis showed that the prevalence of AR in boys was significantly higher than in girls at age 7 to 11 years, sharing the same pattern as the prevalence of HS (Fig 2). Moreover, AR was significantly associated with HS in the multivariate model. The observed male predominance in AR may be explained by the relative male disadvantage in terms of possible reduced adaptive immunity during the early period of life.³⁸

Our result indicated that having one parent who is a habitual snorer significantly increased the risk of HS by nearly 3.4-fold. This finding corresponded to previous reports and provides further support to the role of genetics in the development of HS.^{11,39} Genetic factors that determine craniofacial structure, body composition, and neuromuscular control of the upper airway interact to produce a phenotype. A previous study involving children with a mean age of 1 year when there was less opportunity for environmental influence demonstrated similar risk inheritance in HS across generations.³⁹

Sore throat and enlarged tonsils as independent risk factors for HS have been reported.^{16,17,30,31,33-35} Our study showed that nasosinusitis and tonsillitis in the past 12 months were associated with a higher risk for HS. These parameters could be markers of viral exposure, which causes adenotonsillar hypertrophy

leading to pharyngeal airway narrowing and thus snoring. Household crowding may allow more accurate reporting of nighttime symptoms. It has been shown that snoring may go unreported in a single-child family where the child tends to sleep alone.²⁰ In this study, neither household crowding nor single-child family was significantly associated with the risk of HS. On the other hand, children who slept in their own room were shown to be less likely to have HS. This was possibly related to the accuracy of parental report. It was reasonable to presume that nighttime symptoms of these children were not detected by their parents.

Smoking has been suggested to result in obstruction and collapse of the pharyngeal airway by inducing inflammation and mucosal edema, predisposing to snoring.²⁰ Passive parental smoking was reported to be a risk factor for snoring in children.^{11,12,18-22} Corbo et al²⁰ demonstrated a significant dose-effect correlation between prevalence of HS and number of cigarettes smoked by parents. We did not, however, find significant association between household smoking and HS or a dose-effect relationship between prevalence of household smoking and frequency of snoring. It was possible that parents underreported household smoking, given the fact that many parents think smoking in the bathroom or kitchen well away from their child is acceptable.

Factor analysis is a commonly used statistical method to reduce a large number of clinical parameters to a relatively small number of independent factors. As each factor groups associated parameters, the results help to provide an insight into the pathophysiology of complex diseases. Being free of a predetermined hypothesis on any interrelated parameters, this technique can be seen as a hypothesis-generating tool. It was not surprising to document strong correlation between HS and various sleep-related symptoms, especially those related to OSA, as HS is a cardinal symptom of the condition. There is accumulating evidence to suggest snoring, which signifies upper airway narrowing, is associated with neurocognitive deficits.^{21,40} Although the information obtained from this questionnaire was a crude way to assess neurocognitive outcome, we found a dose-dependent

Table 6—Associations Between Snoring and Neurobehavioral Outcomes

Outcome	Occasional Snoring vs No Snoring		HS vs No Snoring	
	OR (95% CI)	P Value	OR (95% CI)	P Value
Poor temper	1.13 (0.93-1.38)	.206	1.86 (1.36-2.54)	< .0001
Hyperactivity	1.21 (0.95-1.54)	.119	1.72 (1.18-2.50)	.005
Poor academic performance	1.13 (0.89-1.45)	.308	1.69 (1.15-2.47)	.007

P value adjusted for age, sex, BMI z score, atopic symptoms, URTI, environmental factors, and socioeconomic factors. See Tables 2 and 4 for expansion of abbreviations.

Table 7—Prevalence and Risk Factors of HS in Different Countries

Risk Factors of HS													
Definition of HS	No.	Location	Age, y	Prevalence, %	Male	Obesity	Parental Snoring	History of Allergy	Rhinitis	Asthma	URTI	Parental Smoking	Adenotonsillar Hypertrophy
Always	1,211	Turkey ³⁰	6-13	2.4									+
> 3 times/wk	1,198	Turkey ²³	3-11	3.3					+				
Often	1,784	Turkey ³¹	4-17	4.1									+
Always	3,680	Greece ¹¹	1-18	4.2	+		+					+	
Always	895	Italy ¹³	3-11	4.9	+								
Often	2,209	Italy ¹⁷	10-15	5.6		+			+				+
NA	5,979	China ³²	2-12	5.6									
> 3 times/wk	10,279	Singapore ¹⁸	4-7	6.0		+		+	+			+	
Often	2,147	Turkey ¹²	5-13	7.0	+				+	+		+	
Often	1,615	Italy ²⁰	6-13	7.3					+			+	+
≥ 3 times/wk	1,844	Sweden ³³	5-7	7.5							+		
≥ 3 times/wk	2,900	Iran ¹⁴	11-17	7.9	+	+				+			
Most nights	1,008	Thailand ³⁴	6-13	8.5					+				+
Frequently	976	Portugal ²⁴	6-11	8.6							+		
Often	190	France ³⁵	5-6	10.0				+					+
Frequently	1,144	Germany ¹⁶	9.6 ± 0.7	10.1		+					+		
Frequently	1,494	United States ²⁹	4-11	10.5									
≥ 6 times/wk	3,047	Hong Kong ¹⁰	6-12	10.9	+		+		+				
≥ 3 times/wk	5,728	United States ²¹	5-7	11.7			+					+	
≥ 2 times/wk	1,650	Australia ¹⁵	0-17	14.2	+	+				+			
Often	806	Ecuador ²⁵	6-12	15.1				+					
> 4 times/wk	985	Australia ¹⁹	4-12	15.2			+						
Frequently	998	Brazil ²²	9-14	27.6				+	+			+	

NA = not applicable. See Table 2 for expansion of other abbreviation.

relationship between prevalence of such outcomes (namely poor temper, hyperactivity, and poor academic performance) and snoring frequency. Furthermore, HS was demonstrated to be a significant risk factor for these surrogate markers of neurocognitive deficit.

There are limitations to our study. First, the response rate was 70% of all students invited to participate. This could have introduced a degree of selection bias whereby parents whose child had sleep symptoms or problems were more likely to return the questionnaire. This might have resulted in an overestimation of the prevalence. On comparing the demographic and socioeconomic data of respondents and nonrespondents, we could not find any significant differences between the two groups. We believe that our studied cohort was a good overall representation of the sample population. Second, the survey questionnaires were completed by parents, and very often they do not rest in the same room as their child and therefore would not know their actual sleep behavior. This is a known intrinsic problem associated with the use of postal questionnaire survey. Nonetheless, a recent publication on preschool children showed a significant and independent association between parentally reported and objectively measured HS.⁴¹ Furthermore, the reliability of sleep-disordered

breathing questionnaires, including ours, has been demonstrated previously.^{26,42}

In summary, we found the prevalence of HS to be 7.2% in Hong Kong. Male sex, BMI *z* score, parental HS, AR and asthmatic symptoms, and URTI in the past 12 months were independent risk factors of HS. HS was also demonstrated to be associated with various OSA symptoms and neurobehavioral outcomes.

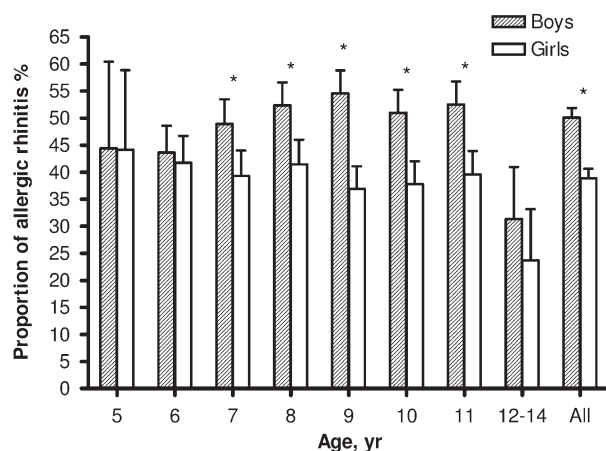


FIGURE 2. Prevalence of allergic rhinitis by age and sex. *Significant difference between boys and girls ($P < .05$).

ACKNOWLEDGMENTS

Author contributions: Drs Li and Wing accept full responsibility for the work and conduct of the study, had access to the data, and controlled the decision to publish.

Dr Li: contributed to the planning and design of the study, recruiting subjects, collecting data, revising the article, and approving the final manuscript.

Mr Au: contributed to the planning and design of the study, recruiting subjects, collecting data, analyzing data, revising the article, and approving the final manuscript.

Dr So: contributed to the planning and design of the study, recruiting subjects, collecting data, analyzing data, revising the article, and approving the final manuscript.

Dr Lau: contributed to the planning and design of the study, analyzing data, revising the article, and approving the final manuscript.

Dr Ng: contributed to the planning and design of the study, revising the article, and approving the final manuscript.

Dr Wing: contributed to the planning and design of the study, recruiting subjects, collecting data, revising the article, and approving the final manuscript.

Financial/nonfinancial disclosures: The authors have reported to *CHEST* the following conflicts of interest: Dr Wing has lectured in scientific meeting under the sponsorship of Eli Lilly. He also has received grant sponsorship from the government of HKSAR and sanofi-aventis. Drs Li, So, Lau, and Ng and Mr Au have reported no conflicts.

Other contributions: We thank all participating schools, parents, and children for their dedication. This work was performed at the Department of Pediatrics, The Chinese University of Hong Kong.

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Chest 2010;138; 519-527; Prepublished online February 19, 2010;
DOI 10.1378/chest.09-1926

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