Snoring in Preschool Children*

Prevalence and Association With Nocturnal Cough and Asthma

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Introduction: **The association between snoring, nocturnal cough, and allergic symptoms in young children is not known.**
Objective: **To measure the prevalence of habitual snoring and its association with nocturnal cough, asthma, and hay fever in preschool children.**
Setting: **A cross-sectional study.**
Subjects: **Preschool children aged 2 to 5 years.**
Method: **The data were collected in a cross-sectional study. A total of 974 children were randomly selected from two areas of Lismore and Wagga Wagga in New South Wales, Australia.**
Results: **The prevalence of snoring was 10.5%, with no gender difference ($p = 0.99$) or trend association with age ($p = 0.58$). The association between snoring and nocturnal cough was highly significant (odds ratio [OR], 3.68; 95% confidence interval [CI], 2.41 to 5.63; $p = 0.001$). This association was significant in both the nonasthmatic and asthmatic groups when examined separately. Snoring was also significantly associated with asthma (OR, 2.03; 95% CI, 1.34 to 3.10; $p = 0.001$). In subjects without hay fever, the association between snoring and asthma was also highly significant (41.2% vs 24.8%; OR, 2.12; 95% CI, 1.34 to 3.37; $p = 0.001$).**
Conclusion: **The prevalence of snoring in preschool children was 10.5% for both genders. Snoring was significantly associated with both nocturnal cough and asthma. Because snoring, asthma, and nocturnal cough may have a common etiology, it is possible that effective treatment of one symptom may lead to reductions in the presence or severity of the other symptoms.** ***(CHEST 2003; 124:587–593)***

Key words: allergy; asthma; obstructive sleep apnea syndrome; persistent nocturnal cough; snoring

Abbreviations: CI = confidence interval; 1*df* = one degree of freedom; OR = odds ratio; WLI = weight-for-length index

Previous studies showed that the prevalence of snoring is 11.4% in English children aged 4 to 7 years,[1] 10% in French children aged 5 to 6 years,[2] and 7.3% in Italian children aged 6 to 13 years.[3] Sleep-disordered breathing is common in asthmatics. A case report of the coexistence of sleep apnea and asthma resulting in severe sleep hypoxia was first reported in 1979.[4] In 1988, Guilleminault et al[5] also reported cases of combined obstructive sleep apnea and asthma. In a community-based survey in 1993,[6] asthmatics and young wheezers were found to have a higher prevalence of frequent snoring than nonasthmatics. In the French study,[2] snoring was associated with a history of exercise-induced asthma.

An association between nocturnal cough and upper airway obstruction in sleep has been observed in clinical settings. In a case study, a 3-year-old boy had chronic nocturnal cough secondary to sleep apnea, which suggests that chronic nocturnal cough may result from upper airway obstruction in sleep.[7] To date, the association between snoring, nocturnal cough, and asthma has not been investigated in population samples of young children. The aims of this study were to estimate the prevalence of snoring in preschool children, and to investigate the association between snoring, asthma, and nocturnal cough.

Materials and Methods

The methods of this study have been published in detail[8] and are described briefly below.

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Questionnaire Design

Because no suitable questionnaire was available for measuring sleep symptoms in a cross-sectional study of 2- to 5-year-old children, a new questionnaire was developed in consultation with specialists in sleep-associated breathing disorders in children.

Based on preexisting questionnaires, a parent-administered questionnaire was compiled by including existing questions and by adding a number of newly developed questions. The questionnaire was then reviewed by researchers at the Institute of Respiratory Medicine, by respiratory specialist pediatricians from the New Children's Hospital at Westmead, and by child-care workers and several parents of preschool children. Comments were used to amend the questionnaire. After testing in a pilot study, the questionnaire was further changed to improve the acceptability of the questions. The final questionnaire, which mostly asked about asthma and allergic symptoms, contained 11 pages, of which 1 page included questions about symptoms of sleep-associated breathing disorders.

We could not find a practical way to validate our questionnaire. Sleep studies for children are invasive and need to be conducted in specialized clinics. Also, the information collected from sleep studies relates only to the night of study, whereas we used our questionnaire to collect details of sleep problems in the previous year.

Sample Selection

Preschool children who were born between July 1, 1989, and June 30, 1992, and at the time of selection were living in the cities of Wagga Wagga or Lismore were eligible for study. A total of 974 children aged 2 to 5 years at the time of testing were randomly selected from three sources of council immunization records: family day-care records, preschools, and child-care centers and play groups.

Criteria for Exclusion

Children were excluded if their questionnaires were not returned and if their parents' names were not found in the telephone directory, or if children were found not to be living at the addresses copied from above three sources and no forwarding address was available. The total response rate was 61%.

Statistical Analysis

Prevalence rates are presented with 95% confidence intervals (CIs). χ^2 analyses were used to examine associations between categorical variables. Logistic regression was used to calculate odds ratios (ORs), which were adjusted for the effects of other risk factors in the model. The reference group is the children without symptoms with whom the symptomatic group is compared, and in whom the OR is equal to 1.

Definitions

Snoring and nocturnal cough were defined as the presence of these symptoms for ≥ 4 nights per week in the absence of a cold. Asthma and hay fever were defined as positive responses to the questions "Has your child ever having been diagnosed as having asthma (or hay fever) by a doctor or at a hospital?"[8] We relied on the questionnaire for this definition since lung function tests conducted in the community are unreliable in young children.

Obesity was defined by weight-for-length index (WLI), which was used as the most accurate measure of relative body weight in children. WLI is calculated by using the child's actual weight over actual height to the expected 50th percentile of weight for age over the expected 50th percentile height for age and then multiplied by 100. The expected percentiles were derived from the US National Center for Health Statistics data: the normal range of the WLI for children is 90 to 109; children with a WLI ≥ 120 can be considered obese.[9]

Results

In the 516 boys and 458 girls studied, 54 boys (10.5%) and 48 girls (10.5%) had snoring for ≥ 4 nights per week, and 189 boys (36.6%) and 140 girls (30.6%) were reported to have nocturnal cough for ≥ 4 nights per week. In addition, 161 boys (31.2%) and 112 girls (24.5%) had a doctor diagnosis of asthma (Table 1).

There was no difference in the prevalence of snoring between the genders ($p = 0.99$) and no trend association with age (χ^2, one degree of freedom [$1df$] = 0.31, $p = 0.58$). In the sample, 36.6% boys and 30.6% girls had nocturnal cough ($p = 0.05$), but no trend association with age was found (χ^2, $1df = 0.35$, $p = 0.55$). In addition, 31.2% boys had asthma compared to 24.5% girls ($p = 0.02$). The prevalence of asthma dropped slightly from age 2 to 3 years, but rose from age 4 to 5 years (χ^2, $1df = 4.43$, $p = 0.04$) [Table 2].

A total of 656 children had their height and weight measured; however, there was no difference in the prevalence of snoring (10.8% vs 9.8%, $p = 0.61$) or asthma (29.3% vs 25.5%, $p = 0.22$) between children

Table 1—*Characteristics of Study Sample*

	Total Sample, No.		Children With Snoring, %		Children With Nocturnal Cough, %		Children With Asthma, %	
Age, yr	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
2	15	11	6.7	0	53.3	36.4	40.0	18.2
3	202	171	11.9	8.8	37.1	28.1	27.2	22.8
4	235	219	8.9	12.8	35.3	33.3	30.2	24.7
5	64	57	12.5	8.8	35.9	26.3	45.3	29.8
Total	516	458	10.5	10.5	36.6	30.6	31.2	24.5

Table 2—*Prevalence and ORs of Snoring, Nocturnal Cough, and Asthma for Children by Age and Gender*

Variables	Total No.	Prevalence of Snoring (95% CI)	OR (95% CI)	Prevalence of Nocturnal Cough (95% CI)	OR (95% CI)	Prevalence of Asthma (95% CI)	OR (95% CI)
Age, yr							
2	26	3.9 (0–11.3)	0.3 (0.1–2.7)	46.2 (27.0–65.4)	1.7 (0.8–3.8)	30.8 (13.1–48.6)	1.3 (0.6–3.2)
3	373	10.5 (7.4–13.6)	1.0	33.0 (28.2–37.8)	1.0	25.2 (20.8–29.6)	1.0
4	454	10.8 (7.9–13.7)	1.0 (0.7–1.6)	34.4 (30.0–38.8)	1.1 (0.8–1.4)	27.5 (23.4–31.6)	1.1 (0.8–1.5)
5	121	10.7 (5.2–16.2)	1.0 (0.6–2.0)	31.4 (23.1–39.7)	0.9 (0.6–1.5)	38.0 (29.4–46.7)	1.8 (1.2–2.8)
Gender							
Boys	516	10.5 (7.9–13.2)	1.0	36.6 (32.4–40.8)	1.0	31.2 (27.2–35.2)	1.0
Girls	458	10.5 (7.7–13.3)	1.0 (0.7–1.5)	30.6 (26.4–34.8)	0.8 (0.6–1.0)	24.5 (20.6–28.4)	0.7 (0.5–1.0)

who did or did not have these measurements, but there was a higher prevalence of nocturnal cough in children with weight and height measured (36.0% vs 29.3%, $p = 0.04$). We therefore included the children without weight and height measured into the nonobesity group in our analyses.

The prevalence of nocturnal cough was examined in relation to snoring (Table 3). In the total sample, 30.5% of the nonsnorers reported nocturnal cough, compared to 61.8% of the children with snoring. The association between snoring and nocturnal cough was highly significant (OR, 3.68; 95% CI, 2.41 to 5.63; $p = 0.001$). Because nocturnal cough was strongly associated with asthma, the association between nocturnal cough and snoring was re-examined in children with or without asthma. In the nonasthmatic group of children without snoring, the prevalence of nocturnal cough was 22.6%; however, this increased to 44.1% when children were also reported with snoring (OR, 2.70; 95% CI, 1.56 to 4.66; $p = 0.001$). Similarly, in the asthmatic group, the prevalence of nocturnal cough was also significantly higher among children who snored (86.1% vs 52.6%; OR, 5.56; 95% CI, 2.26 to 13.67; $p = 0.001$) [Fig 1].

The prevalence of obesity in children who snored (12.2%) was slightly higher than in nonsnorers

Table 3—*Prevalence and ORs of Nocturnal Cough in Groups of Children Defined According to Snoring, Asthma, Sleep Symptoms, and Parental Smoking*

Variables	Total No.	Prevalence of Nocturnal Cough, No. (95% CI)	p Value	OR (95% CI)	Adjusted OR (95% CI)
Snoring in total sample					
No	872	30.5 (27.4–33.6)		1.0	1.0
Yes	102	61.8 (52.4–71.2)	0.001	3.7 (2.4–5.6)	2.3 (1.4–3.8)
Snoring in nonasthmatics					
No	642	22.6 (19.4–25.8)		1.0	
Yes	59	44.1 (31.4–56.8)	0.001	2.7 (1.6–4.7)	
Snoring in asthmatics					
No	230	52.6 (46.2–59.1)		1.0	
Yes	43	86.1 (75.8–96.4)	0.001	5.6 (2.3–13.7)	
Asthma					
No	701	24.4 (21.2–27.6)		1.0	1.0
Yes	273	57.9 (52.0–63.8)	0.001	4.3 (3.2–5.7)	3.7 (2.7–5.1)
Restless sleep					
No	839	29.9 (26.8–33.0)		1.0	1.0
Yes	135	57.8 (49.5–66.1)	0.001	3.2 (2.2–4.7)	1.9 (1.3–3.0)
Choking episode					
No	878	29.3 (26.3–32.3)		1.0	1.0
Yes	96	75.0 (66.3–83.7)	0.001	7.3 (4.5–11.8)	4.8 (2.8–8.1)
Frequent waking					
No	929	32.5 (29.5–35.5)		1.0	1.0
Yes	45	60.0 (45.7–74.3)	0.001	3.1 (1.7–5.7)	2.0 (1.0–3.9)
Parents smoking					
No	846	32.5 (29.3–35.7)		1.0	
Yes	128	42.2 (33.6–50.8)	0.03	(0.04–2.2)	

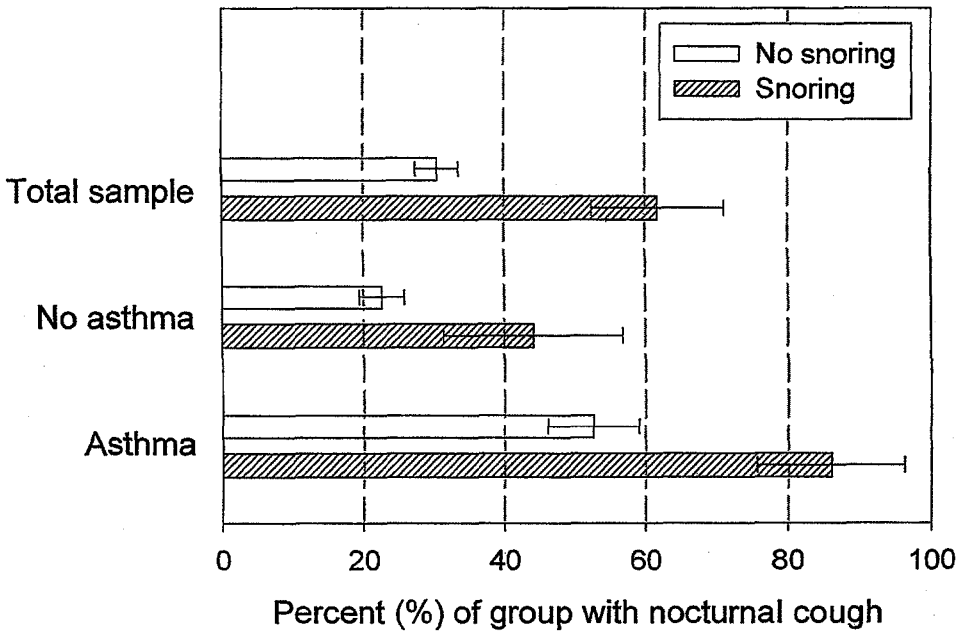

FIGURE 1. Prevalence of nocturnal cough shown with 95% CI in the total sample and in children with or without asthma and classified into groups according to the presence or absence of snoring.

(10.3%); however, this difference was not significant (p = 0.57). The association between snoring and hay fever was also not significant (9.9% vs 14.3%, p = 0.15). The prevalence of asthma in children with hay fever was 39.5%, compared to 26.4% in children with no hay fever (OR, 1.82; 95% CI, 1.22 to 2.70; p = 0.003) [Table 4].

Logistic regression analysis showed that asthma was a significant confounder in the relation between snoring and nocturnal cough (adjusted OR, 3.73; 95% CI, 2.73 to 5.09) [Table 3]. This suggests that the high prevalence of nocturnal cough in children who snore cannot be explained by the coexistence of asthma and nocturnal cough, but is explained by both factors acting independently.

In the children studied, 26.4% of children who did not snore were reported to have had asthma, compared with 42.2% of children who snored (OR, 2.03; 95% CI, 1.34 to 3.10; p = 0.001) [Table 4]. Nasal obstruction of any kind is known to cause snoring. The association between snoring and asthma was assessed separately according to nasal obstruction

Table 4—*Prevalence of Asthma and ORs in Children Classified Into Groups According to a History of Snoring, Hay Fever, and Obesity*

Variables	Total No.	Prevalence of Asthma, No. (95% CI)	p Value	OR (95% CI)	Adjusted OR (95% CI)
Snoring in total sample					
No	872	26.4 (23.5–29.3)		1.0	1.0
Yes	102	42.2 (32.6–51.8)	0.001	2.0 (1.3–3.1)	1.7 (1.1–2.7)
Snoring and no hay fever					
No	770	24.8 (21.8–27.9)		1.0	
Yes	85	41.2 (30.7–51.7)	0.001	2.1 (1.3–3.4)	
Snoring and hay fever					
No	102	38.2 (28.8–47.6)		1.0	
Yes	17	47.1 (23.4–70.8)	0.49	1.4 (0.5–4.0)	
Hay fever					
No	855	26.4 (23.5–29.4)		1.0	1.0
Yes	119	39.5 (30.7–48.3)	0.003	1.8 (1.2–2.7)	1.7 (1.2–2.6)
Obesity					
No	884	26.5 (23.6–29.4)		1.0	1.0
Yes	90	43.3 (33.1–53.5)	0.001	2.1 (1.4–3.3)	2.2 (1.4–3.4)

(hay fever). The prevalence of asthma was significantly higher in children who snored than in nonsnorers in the group without hay fever (41.2% vs 24.8%; OR, 2.12; 95% CI, 1.34 to 3.37; p = 0.001); however, in the group with hay fever, the difference was not significant (47.1% vs 38.2%, p = 0.49) [Table 4, Fig 2].

Using logistic regression, the effect of hay fever was found to have a significant association with snoring and asthma (adjusted, OR 1.74; 95% CI, 1.15 to 2.61) [Table 4]. However, there was no evidence that the effect of snoring was modified by hay fever ($p > 0.5$).

Discussion

This is the first community survey in preschool children in which associations between snoring, nocturnal cough, and asthma have been investigated. This study extends previous studies of snoring in childhood in suggesting that habitual snoring is common in preschool children. The prevalence of 10.5% for both genders was similar to the 10% found in French children aged 5 to 6 years,[2] and 11.4% in English children aged 4 to 7 years.[1] The somewhat lower prevalence estimated in the Italian study[3] might reflect the inclusion of children in older age groups who are expected to have a lower prevalence of snoring.

The prevalence of reported asthma in our study population was high at 28%. This is the first study to measure the prevalence of asthma by parent-completed questionnaire in this age group[8]; however, Australian children in older age groups have a similarly high prevalence of asthma and wheeze.[10] The selection criteria in the current study could have led to an overestimation of the prevalence rate in preschool children; however, sampling bias is unlikely to have influenced the relationships that we found between asthma, snoring, nocturnal cough, and allergic symptoms.

In adults, male subjects report snoring more frequently than female subjects, and snoring is related to body weight. The lack of a gender difference in snoring in preschool children suggests that the increased prevalence of snoring in male subjects occurs after puberty, and may be related to the influence of sex hormones; however, our finding of no clear link between body weight and snoring in our study sample may be a type II error, in that few children in our sample were obese.

An aim of this study was to measure potential links between snoring, nocturnal cough, and asthma. We found that both nocturnal cough and asthma were highly correlated with habitual snoring. In adults, it is common in clinical practice to find bouts of coughing at the termination of apneic events; however, a specific link between snoring and cough has not been made, although a case study[7] showed that nasal continuous positive airway pressure alleviated

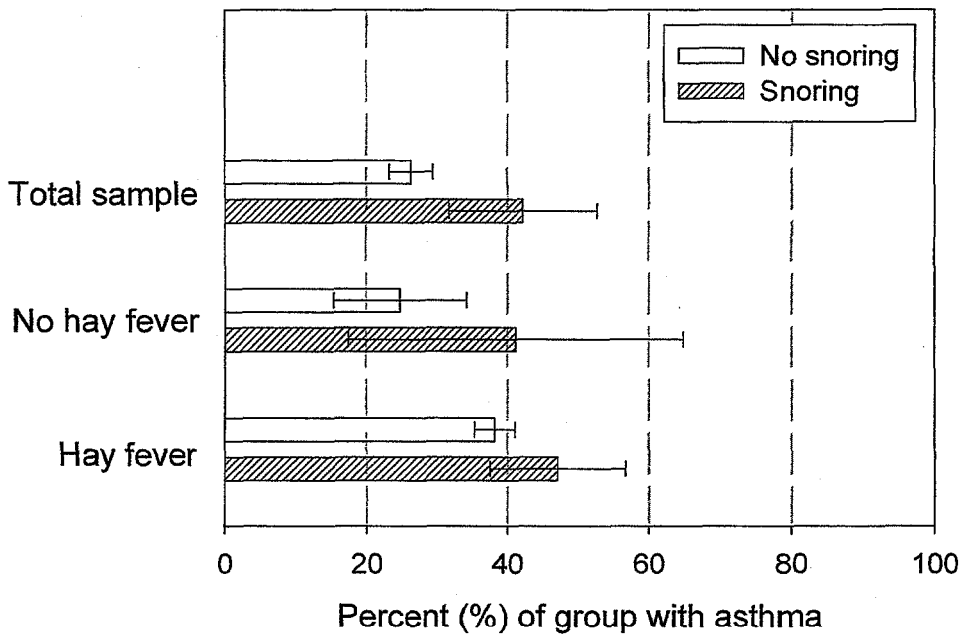

Figure 2. Prevalence of asthma shown with 95% CI in the total sample and in children with or without hay fever and classified into groups according to the presence or absence of snoring.

persistent nocturnal coughing in a child with obstructive apnea. In the current study, persistent nocturnal cough was a common symptom reported in 31% of nonsnorers. This high prevalence doubled to 62% in children who snored, suggesting a close link between habitual snoring and nocturnal cough.

Nocturnal cough is a symptom that can be indicative of asthma in young children, and is often the first sign of asthma in this age group; therefore, the reporting of both nocturnal cough and asthma may be the reporting of different symptoms of the same underlying allergic illness. In addition, nasal obstruction is often secondary to allergic rhinitis and may also contribute to snoring and involve the same underlying pathology that is associated with asthma, and, thus, there are many ways in which nocturnal cough and asthma may be linked. However, our results show that children who snore have a higher occurrence of nocturnal cough, even when asthma is excluded.

There are many potential factors that could lead to nocturnal cough. Rhinitis, postnasal drip, asthma, and gastroesophageal reflux are all recognized causes of cough that worsen during the night. The mechanisms by which snoring occurs together with nocturnal cough are unknown; however, there are a number of factors, including vibration-induced irritation of the glottic inlet by the snoring process. Snoring is one of the primary symptoms of sleep-disordered breathing that may lead to oxygen desaturation if followed by partial or complete cessation of airflow. The increased effort in snoring may be secondary to chemoreceptor stimulation, which induces vibration of the upper airway. It is clear that increased nasal obstruction during sleep and subsequent increased resistance increases the likelihood of snoring. The present data provide support for the hypothesis that snoring may play a significant role in producing nocturnal cough.

Clinical studies suggest that there is a link between snoring, obstructive apnea, and asthma. There is evidence that the treatment of snoring and otherwise mild obstructive sleep apnea with nasal continuous positive airway pressure can lead to improvements in asthma both during the night and while awake.[11] We examined the potential interaction between snoring and asthma and found a clear relationship between reported snoring and asthma, even when likely confounding factors such as rhinitis were removed. Asthma remained twice as common in snorers than nonsnorers despite the removal of subjects with reported nasal symptoms. Allergic rhinitis and asthma commonly occur together because they share a common underlying allergic inflammatory pathology. Nasal obstruction is known to be a cause of snoring, and snoring increases during the pollen season in some patients with seasonal allergic rhinitis. Our finding that snoring in young children remained significantly linked to asthma even when reported rhinitis was removed suggests that other potential causative links beyond that of nasal obstruction exist between snoring and asthma. In contrast, there was no significant difference between snorers and nonsnorers in the asthmatics who had rhinitis, although the snoring group had a higher prevalence of asthma.

There are a number of potential mechanisms by which asthma and snoring might be linked. For example, an increased drive to breathe asleep during active asthma could lead to increased upper airway suction pressures and thus to snoring. Alternatively, worsening of gastroesophageal reflux induced by snoring may also trigger asthma. We did not collect information about gastroesophageal reflux in the present study. The upper airway vibration can stimulate upper airway cough receptors and induce reflex bronchoconstriction, which has been demonstrated in an animal model.[12] Also, snoring might play a more direct role in the underlying pathology of asthma. The upper airway vibration and increased suction pressures in the pharynx are powerful mechanisms that promote the transfer of nasal mucus into the lower airway. Clearly, transfer of such material onto the glottic inlet can induce cough by the stimulation of glottic cough receptors; however, this same mechanism has the potential to deliver relatively large quantities of mucus laden with key allergens, such as house dust mite, into the airways. Longitudinal cohort studies are needed to collect further information of the etiology of respiratory symptoms in early childhood, and to identity the sequence of development of snoring, asthma, and nocturnal cough.

In conclusion, the prevalence of snoring in preschool children in the two communities in our study was 10.5% with no gender difference. Snoring was significantly associated with both nocturnal cough and asthma. Because snoring, asthma, and nocturnal cough may have a common etiology, it is possible that effective treatment of one symptom may lead to reductions in the presence or severity of the other symptoms. Before any treatment options can be recommended, it is important that experimental studies to test the efficacy of different treatment combinations in this age group are undertaken.

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References

1 Ali NJ, Pitson D, Stradling JR. Natural history of snoring and related behaviour problems between the ages of 4 and 7 years. Arch Dis Child 1994; 71:74–76

2 Teculescu DB, Caillier I, Perrin P, et al. Snoring in French preschool children. Pediatr Pulmonol 1992; 13:239–244

3 Corbo GM, Fuciarelli F, Foresi A, et al. Snoring in children: association with respiratory symptoms and passive smoking. BMJ 1989; 299:1491–1494

4 Hudgel DW, Shucard DW. Coexistence of sleep apnea and asthma resulting in severe sleep hypoxemia. JAMA 1979; 242:2789–2790

5 Guilleminault C, Quera-Salva MA, Powell N, et al. Nocturnal asthma: snoring, small pharynx and nasal CPAP. Eur Respir J 1988; 1:902–907

6 Fitzpatrick MF, Martin K, Fossey E, et al. Snoring, asthma and sleep disturbance in Britain: a community-based survey. Eur Respir J 1993; 6:531–535

7 Teng AY, Sullivan CE. Nasal mask continuous positive airway pressure in the treatment of chronic nocturnal cough in a young child. Respirology 1997; 2:131–134

8 Haby MM, Peat JK, Marks GB, et al. Asthma in preschool children: prevalence and risk factors. Thorax 2001; 56:589–595

9 Mahan LK. Family focussed behavioral approach to weight control in children. Pediatr Clin North Am 1987; 34:983–996

10 Faniran AO, Peat JK, Woolcock AJ. Prevalence of atopy, asthma symptoms and diagnosis, and the management of asthma: comparison of an affluent and a non-affluent country. Thorax 1999; 54:606–610

11 Chan CS, Woolcock AJ, Sullivan CE. Nocturnal asthma: role of snoring and obstructive sleep apnea. Am Rev Respir Dis 1988; 137:1502–1504

12 Plowman LP, Edwards H, Lauff DC, et al. Tracheal smooth muscle responses to upper airway pressure in conscious dogs. J Appl Physiol 1990; 68:1555–1561