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Risk factors for habitual snoring among children aged 2–14 years in Chengdu, Sichuan

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Abstract

Purpose Habitual snoring (HS) is a prominent symptom of sleep-disordered breathing; thus, it is also important to consider the associated, multidimensional risk factors for HS in children. This study was aimed to identify risk factors for HS in children.

Methods A cross-sectional survey was performed in Chengdu. Children aged 2–14 years from four districts were randomly chosen to participate. Questionnaires were voluntarily completed by the children's guardians.

Results The survey included 926 boys and 622 girls, who were an average of 6.4 ± 3.0 years old. The sample included 463 habitual snorers (30.4%), 683 occasional snorers (44.8%), and 402 nonsnorers (26.4%). HS was found in 51.8% of children under 7 years old and 26.6% of children aged 7 years old or older. The prevalence of pregnancy complications was significantly lower in mothers who bore children with HS ($p = .006$). Among the HS group, 86.6% had an immediate family member who snores. Breastfeeding duration among the HS group was significantly less than among the occasional snoring and nonsnoring groups. History of symptoms of allergic rhinitis, rhinosinusitis, tonsillitis, and pneumonia/bronchitis in the past 6 months was associated with HS. Likewise, maternal smoking during pregnancy, maternal exposure to secondhand smoke during pregnancy, and child exposure to secondhand smoke were also associated with HS.

Conclusion The prevalence of HS was higher in children under 7 years old. Having a mother with more education, a family history of snoring, a shorter period of breastfeeding, upper respiratory tract inflammation, and passive smoking are important risk factors for HS. Pregnancy complications may be associated with lower prevalence of snoring in childhood.

Keywords Risk factors · Habitual snoring · Children

Introduction

Sleep-disordered breathing (SDB) during childhood is common and includes a range of breathing abnormalities from primary snoring (PS) to obstructive sleep apnea (OSA). Also known as simple or non-apneic snoring, PS is regarded as the mildest form of the SDB range and is without severe medical consequences. The most severe manifestation of SDB is OSA, which is characterized by recurrent events of partial or complete upper airway obstruction during sleep leading to abnormal ventilation and sleep patterns [1].

Snoring is the most important and common manifestation of SDB [2]. Habitual snoring (HS) is a prominent symptom of SDB that is usually defined as the presence of loud snoring at least 3 nights per week [3, 4]. Globally, HS is relatively common and has been reported in 2.4–48.4% of children [3–5]. Within the literature to date, different inclusion criteria, age groups, sex ratios, and even research periods have been identified as reasons for inconsistent levels of HS incidence [1–5].

Recent research suggests that HS, even in the absence of OSA, is associated with cognitive, behavioral, and various psychosocial problems [6, 7]. The clinical importance of HS as a potential marker of morbidity for OSA is increasingly recognized. Therefore, it is especially important to identify the multidimensional risk factors for HS among children.

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Many published studies have identified various risk factors for HS [8, 9]. Studies that have investigated the relationship between OSA severity and demographic and clinical risk factors have identified that ethnicity and environmental tobacco smoke are associated with increased severity of SDB [8]. A study by Kim et al. confirmed several risk factors of SDB, namely male sex, overweight, and exposure to tobacco smoking [9]. Lower family income, lower father's education, breastfeeding duration < 6 months, pregnancy maternal smoking, obesity, overweight, several respiratory problems (chronic/allergic rhinitis, asthma, adenotonsillar hypertrophy, and chronic otitis media), and family history of habitual snoring have been associated with an increased risk for habitual snoring [3]. However, from the above studies, we have found that different regions, research groups, inclusion criteria, and methods have led to diverging results.

Therefore, pediatric HS-related risk factors in different regions affect the local epidemiology, as shown in these studies [3–5, 8, 9]. The present study integrated the previous work and collected information on 23 related factors. Using a large population-based sample, we aimed to identify factors predisposing Chengdu's pediatric population to HS from among the previously identified potential risk factors.

Materials and methods

Study sample

This cross-sectional survey was performed in Chengdu, Sichuan Province, in southwestern China. The Chengdu administration was divided into five levels, from low to high, namely city, suburb, county seat, town, and countryside. Each district was divided into three groups: kindergarten, primary school, and junior middle school. We put the number + name of all the schools into fifteen envelopes, respectively. A laboratory colleague who did not participate in the study was invited to draw two number + name of schools from each envelope randomly. Among the 30 selected schools, we distributed 70 questionnaires to each school. School teachers randomly selected 70 students by student ID and distributed the 70 questionnaires. The sample was children aged 2–14 years. Questionnaires were collected from March 22, 2020, to June 13, 2020. A total of 2100 questionnaires were distributed, and 1721 questionnaires were recovered.

Children with a history of tonsillectomy and(or) adenoidectomy, neuromuscular disease, craniofacial syndromes, cerebral palsy, sickle cell disease, mucopolysaccharide storage disease, or immunodeficiency were excluded. Participants were also excluded if they had mental or physical impairment severe enough to cause abnormal behaviors, including congenital disease, intellectual disability, or a psychiatric disorder. The study was approved by the Biomedical Research Ethics Committee of the West China Hospital of Sichuan University. Written informed consent was obtained from each guardian before they completed the questionnaire.

Questionnaire

The investigators explained the purpose of the study and obtained informed consent before administering the questionnaire. The following items from our parent-reported questionnaire were used for the analysis: (1) demographic factors including age, sex, race, weight, height, and district (city, suburb, county seat, town, and countryside); (2) socioeconomic factors, including family income (Chengdu Statistics Bureau's average monthly household income of 2019: < 5000 yuan, 5000–8000 yuan, 8000–12,000 yuan, 12,000–18,000 yuan, 18,000–25,000 yuan, 25,000–35,000 yuan, or ≥ 35,000 yuan) and parental education (junior high school or less, senior high school, junior college/undergraduate course, postgraduate or above); (3) delivery method (natural labor, Cesarean section), gestational age (premature [< 37 weeks], full-term [37–42 weeks], postterm [> 42 weeks]), parental age at delivery, maternal pregnancy disease, and parental history of obstructive sleep apnea hypopnea syndrome; (4) symptoms of upper respiratory tract infection during the past 6 months (including tonsillitis, chronic rhinosinusitis, allergic rhinitis (AR), and asthma); (5) passive smoke exposure (child exposed to secondhand smoke), maternal smoking, and secondhand smoke exposure during pregnancy; (6) and snoring.

Based on the OSA-5 questionnaire [10], the participants were divided into three groups for comparison according to the packet mode of references [3–5] (nonsnorers = "never" or "hardly any," occasional snorers = "rarely" or "sometimes," and habitual snorers = "most of the time," "frequently," or "all the time").

Data analysis

All analyses were performed using SPSS software (version 22.0; IBM SPSS, Armonk, NY, USA). The data are presented as mean ± standard deviation, median (interquartile range), and number (percentage) as appropriate for continuous and categorical data. The differences between normally distributed continuous variables were analyzed using the analyses of variance test, whereas nonnormally distributed variables were compared using the Mann–Whitney *U* test. Categorical variables were compared using Pearson's χ^2 test or Fisher's exact test. Multivariate logistic regression analyses were subsequently performed to further confirm the association between potential correlated factors (sociodemographics, birth and heredity information, history of respiratory inflammation, passive smoking exposure, etc.), with HS and occasional snorers + nonsnorers as a reference.

Results

Participant characteristics and prevalence of habitual snorers

Of the 1721 children enrolled, 197 questionnaires were excluded because of the following: (1) the questionnaire was incomplete; (2) the child had a history of neuromuscular disease, craniofacial syndrome, cerebral palsy, sickle cell disease, mucopolysaccharide storage disease, or immunodeficiency; (3) the child had a mental or physical impairment severe enough to cause abnormal behaviors (including congenital disease, intellectual disability, or psychiatric disorder). The remaining 1524 questionnaires used for analyses represented a response rate of 88.6%. The survey included 926 boys and 622 girls. Overall, there were 463 habitual snorers (30.4%), 683 occasional snorers (44.8%), and 402 nonsnorers (26.4%).

Risk factors for HS

Sociodemographics

Sociodemographic risk factors were tabulated for each group and are shown in Table 1. HS morbidity was significantly higher in children under 7 years old than in children aged 7 years old or older. Although boys had a slightly higher rate of HS than girls, this difference was not statistically significant.

Fewer minority race children than Han participated, though there was no racial difference in HS prevalence. Nor did HS morbidity differ based on living district (Table 1).

From Table 1, the BMI percentile in four categories had no statistical significance between the incidence of HS. Body mass index (BMI) scores were 16.62 (15.12–19.80), 16.63 (15.08–19.72), and 16.59 (15.15–19.96) for the HS, occasional snoring, and nonsnoring groups, respectively. After adjusting for age and gender, BMI did not differ among the snoring groups.

Socioeconomic factors

According to the average household income statistics for Sichuan Province in 2019, we divided family monthly earning into six groups. No significant difference was found between the prevalence of HS and family monthly earning ($p = 0.21$).

Paternal education did not differ between snoring groups ($p = 0.119$). Higher maternal education was associated with greater prevalence of HS ($p = 0.023$) and maternal college and undergraduate degrees were related to an increase in HS morbidity (2.3; 95% *CI*, 1.1–4.7).

Table 1 Social demographic factors were compared among non-snoring, occasional snoring, and habitual snoring groups

Social demography	Non-snorers ($n = 402$)	Occasional snorers ($n = 683$)	Habitual snorers ($n = 463$)	p
Age				**0.002**
< 7 Y	159 (39.6)	310 (45.4)	240 (51.8)	
≥ 7 Y	243 (60.4)	373 (54.6)	223 (48.2)	
Sex				**0.089**
Boys	207 (51.5)	427 (62.5)	292 (63.1)	
Girls	195 (48.5)	256 (37.5)	171 (36.9)	
Race				**0.326**
Han	382 (96.5)	649 (97.6)	450 (97.2)	
Other race	14 (3.5)	16 (2.4)	9 (2.8)	
BMI				0.376
< 5th perc	16 (4.0)	39 (5.7)	24 (5.2)	0.117
5th–75th perc	285 (70.9)	475 (69.9)	320 (69.1)	
75th–95th perc	75 (18.7)	132 (19.4)	102 (22.0)	
> 5th perc	26 (6.5)	34 (5.0)	17 (3.7)	
Living districts				**0.141**
City	169 (42.0)	330 (48.3)	231 (49.9)	
Suburb	67 (16.7)	131 (19.2)	84 (17.5)	
County seat	67 (16.7)	150 (22.0)	97 (21.0)	
Town	51 (12.7)	38 (5.6)	30 (6.5)	
Countryside	48 (11.9)	34 (5.0)	21 (4.5)	

Birth and heredity information

Neither delivery method (natural labor vs. cesarean section) nor gestational age (premature, full-term, or post-term birth) was related to HS prevalence ($p = 0$ 0.75 and 0.11, respectively). Nor were maternal or paternal ages at the child's birth related to HS prevalence ($p = 0.123$ and 0.373, respectively).

The average breastfeeding duration for the overall sample was 6.9 ± 5.5 months. The between-groups difference in average breastfeeding duration was statistically significant ($p = 0.019$). Breastfeeding duration (6.1 ± 5.2 months) in the HS group was significantly shorter than in the occasional snoring group (8.25 ± 5.91 months) and the nonsnoring group (7.92 ± 6.12 months).

In our sample, 77 mothers had pregnancy complications, including four highly prevalent diseases: diabetes, hypertension, hypothyroidism, and cholestasis. Interestingly, the prevalence of pregnancy complications was significantly lower in mothers who bore children with HS (16.6%) compared with occasional snoring (24.6%) and nonsnoring (18.9%) ($p = 0.006$).

Parental loud snoring (considered a hereditary factor) was related to the HS prevalence ($p < 0.001$) (1.16; 95% *CI*, 1.29–1.61).

History of respiratory inflammation

The prevalence of AR, nasosinusitis, and tonsillitis symptoms in the past 6 months for the HS, occasional, and nonsnoring groups is listed in Table 2. AR symptoms (1.24; 95% *CI*, 1.10–1.77), nasosinusitis symptoms (17.62; 95% *CI*, 6.41–48.80), tonsillitis symptoms (19.66; 95% *CI*, 9.51–55.38), and pneumonia/bronchitis symptoms (14.22; 95% *CI*, 5.42–38.01) within the past 6 months were related to HS incidence. However, only 20 (1.3%) of the children had been diagnosed with asthma, which was unrelated to HS prevalence.

Passive smoking exposure

In the HS group, the proportion of mothers with a history of smoking during pregnancy (43.1%) was markedly higher than that in the nonsnoring (4.7%) and occasional snoring (2%) groups. Both maternal exposure to secondhand smoke during pregnancy and child exposure were related to HS prevalence ($p < 0.001$) (Table 3). To further investigate the relationship between passive smoking and other factors and snoring, multivariate logistic regression analysis was undertaken, controlling for the potential confounders of age, gender, and upper respiratory inflammation in the fully adjusted model. Maternal smoking during pregnancy (1.95; 95% *CI*, 1.63–2.34), maternal exposure to secondhand smoke during pregnancy (1.61; 95% *CI*, 1.08–2.39), and child exposure to secondhand smoke (1.89; 95% *CI*, 1.56–2.23) were significant risk factors for HS.

Discussion

This is the first epidemiological study to explore pediatric HS risk factors in Chengdu. HS was present among 30.4% of our study sample. We also explored 23 potential HS risk factors to find that sex, race, living district, family income, BMI, birth mode, and time of pregnancy did not predict HS. However, age, family history of HS, maternal education, respiratory tract infection, exposure to second-hand smoke, and breast-feeding duration are important risk factors for HS.

The prevalence of 30.4% of HS that we found in our study is higher than the 10.5–27.4% previously reported in other Chinese studies [3, 11, 12]. A possible reason for this inconsistency may be heterogeneity between studies in participant

Table 3 Passive smoking exposure were compared among non-snoring, occasional snoring, and habitual snoring groups

Passive smoking exposure	Habitual snorers		*P*
	Yes	No	
Smoking during pregnancy	25	438	**0.025**
Exposure to secondhand smoke during pregnancy	76	387	**< 0.001**
Exposure to secondhand smoke	72	391	**< 0.001**

Table 2 The upper respiratory disease within 6 months were compared among non-snoring, occasional snoring, and habitual snoring groups

Respiratory disease	Non-snorers ($n = 402$)	Occasional snorers ($n = 683$)	Habitual snorers ($n = 463$)	*P*
Yes	63 (15.7)	1189 (27.7)	196 (42.3)	< 0.001
No	339 (87.6)	494 (72.3)	264 (57.7)	
Tonsillitis	19 (4.7)	82 (12.0)	115 (24.8)	< 0.001
Chronic rhinosinusitis	30 (7.5)	73 (10.7)	62 (13.6)	0.023
Allergic rhinitis	23 (5.7)	71 (10.4)	62 (13.4)	0.005
Pneumonia (bronchitis)	21 (5.2)	76 (14.3)	98 (21.2)	0.012
Asthma	4 (1.0)	11 (1.6)	5 (1.1)	0.629

age and area of residence. We speculate that another principal reason may be that our questionnaire was completed voluntarily. Guardians of children who snore habitually and have related symptoms may have been more likely to participate and complete the questionnaire.

There was an increased prevalence of HS in younger children. The prevalence rate in children under age 7 years was 51.8%, and 26.6% in children 7 years and older. Two studies using large samples of children, by Li et al. [3] and Anuntaseree et al. [13], also showed interesting age differences in HS prevalence: a significant initial increase from ages 5–6 to 7 years and then a gradual decline. HS prevalence tended to decrease with age because of an increase in pharyngeal cross-sectional area with growth. This is consistent with the fact that lymphoid tissues in the larynx (i.e., adenoids, tonsils) gradually degenerate after age 7 years [13, 14]. Children < 7 years old commonly have a higher proportion of co-sleep, which might result in higher rates of reported snoring by their parents compared with the parents of children > 7 years.

We found a higher prevalence of HS in boys than in girls; however, this difference was not significant in our sample of 1524 children. In adults, HS is more common in men, for which the influence of sex hormones on respiratory control and/or body fat distribution has been suggested to play a crucial role. Clearly, these factors would be much less prominent in prepubertal children [15]. Papaioannou and colleagues have also reported that growing adenotonsillar tissue narrows the upper airway during early life, and adenotonsillar hypertrophy has been reported as a major determinant of OSA in children but not in adolescents [16]. Lumeng has suggested that studies showing sex differences often include children over age 13 years, so there may be a potential mediating effect of puberty-related hormonal changes on the higher SDB prevalence in boys [17].

Obesity has long been thought to be an important cause of snoring, but in our study, we did not find any significant difference in BMI among those three groups. Two potential reasons for this result may be as follows: (1) obesity-related anatomic risk factors, other than BMI, including enlargement of parapharyngeal fat pads, lateral pharyngeal walls, the tongue, and total upper airway soft tissue[18]; (2) some studies have shown that waist circumference (abdominal and hip fat), not BMI, are the most important causes of snoring in children [19, 20]. Ours was an epidemiological survey study for which BMI was calculated based on parents' answers (height and weight values), and we were unable to measure abdominal and hip fat.

We found that the HS group had a higher proportion of children whose mother had a college-level or more education. In China, it is often the case that mothers are more focused on their children's growth and living habits compared with fathers. We speculate that mothers with a higher education had more access to information about HS-related diagnoses and symptoms and may have been more concerned about the impact of HS on their children's cognition and behavior.

Breastfeeding duration was significantly shorter within the HS group compared with the other groups. A meta-analysis by Sun et al. [21] indicated that breastfeeding was associated with reduced risk of HS in children. There are two potential explanations underlying an impact of breastfeeding on HS risk. First, breastfeeding has a beneficial effect on mandibular development. Oral cavity features such as high palates, retruded chin, and narrow dental arches are additional risk factors for snoring in children which may be partly prevented by breastfeeding. Second, breast milk may provide immunoglobulins that may help prevent viral respiratory infections and thus reduce the chronic upper airway inflammation and adenotonsillar hypertrophy which facilitate snoring [22]. Breastfeeding is an important way to prevent the occurrence of HS, especially in the first months of life [23]. However, how long breastfeeding can effectively prevent snoring needs to be clarified by future prospective research.

In this study, the prevalence of pregnancy complications was significantly lower in mother who born children with HS than in two other groups. The Barker hypothesis proposes that fetal development within a hostile gestational environment may predispose/program future sensitivity. Each variable such as different environments likely plays a subtle role in the epigenetic manipulation of the embryo [24]. Maternal low-protein diet could change the metabolism of single carbon amino acids, thus changing the epigenetic modification of histone and DNA. Therefore, the mother suffering from pregnancy complications may lead to abnormal metabolism of protein, genes of the fetus. Then, those changes of protein or genes are related to the lower incidence of HS. This analysis was our conjecture based on "Barker Hypothesis" and "Epigenetics." More epidemiology, big data, and basic medical science are needed to verify our conjecture in the future.

Family history of HS was another strong risk factor for childhood HS. Li et al. found that having one habitually snoring parent increased the child's HS risk by nearly 3.4-fold [15]. Genetic factors contribute to craniofacial structure, body composition, and neuromuscular control of the upper airway and interact to produce a phenotype [25]. A potential association has been suggested between the presence of a child's tonsillar hypertrophy and the presence of pharyngeal lymphoid tissue hypertrophy in their siblings and parents [25]. Guardian should pay more attention to the sleep condition and quality of children and guide the child to eat a healthy diet and exercise more to avoid obesity. When guardian find the children snoring, open mouth, and sleep apnea during sleep, they should seek medical treatment in time. The guardian can appropriately adjust the child's sleep posture, such as changing from supine position to lateral position.

Numerous disorders have been associated with HS, including respiratory tract infection (asthma, AR, sinusitis, tonsillitis, and pneumonia/bronchitis) [14, 26]. These may narrow the airway, causing inflammation that increases flow resistance and hence snoring propensity. Inflammatory mediators including histamine, CysLTs, IL 1, and IL-4, found in high levels in AR, have also worsen sleep quality in those with OSA[27]. Montelukast sodium and mometasone furoate have obvious anti-inflammatory effects, which has indirectly confirmed upper respiratory tract infection as an important cause of HS [28]. However, we could not detect a significant association between asthma and HS prevalence, likely due to the small number of positive cases. The guardian shall pay attention to improving the child's body immunity and preventing respiratory tract infection. In case of respiratory tract infection, treatment should be taken on time.

In relation to the domestic environment, passive smoking was identified as a major risk factor for HS, consistent with other studies. Maternal smoking during pregnancy, maternal exposure to secondhand smoke during pregnancy, and child exposure to secondhand smoke all result in child smoke exposure. Parent-reported smoking, particularly maternal smoking, has been associated with increased child snoring, and nighttime respiratory symptoms are exacerbated by such exposure [14, 29]. Multivariate analyses by Subramanyam et al. show that children aged 3–18 years with severe OSA and tobacco smoke exposure have a 1.48 increased odds of developing obstructive apnea hypopnea index than do those unexposed to tobacco smoke[30]. Studies by Urschitz et al. [14] and Zhu [31] have shown a positive association between household smoking and incidence of sleep-related hypoxia and HS, respectively. Cigarette smoke exposes the nasal and respiratory mucosa to large amounts of endotoxin, resulting in a potent inflammatory reaction [32]. It is likely that cessation of secondhand smoke exposure may also reduce oropharyngeal mucosal inflammation. Cigarette smoke causes ciliary dysfunction and proliferation of goblet cells with increased mucus production, in addition to mucosal inflammation [33]. Thus, inflammatory reactions and mucus production lead to respiratory tract narrowing and HS. In summary, the best way to prevent children from HS caused by secondhand smoke is for mothers and people living together not to smoke at any time.

In conclusion, our epidemiological investigation showed that the prevalence of HS is higher in children under 7 years old. Family history of snoring, passive smoking, upper respiratory tract inflammation, and shorter breastfeeding durations are important HS risk factors. In addition, pregnancy complications may be associated with lower occurrence of snoring in childhood.

This was a questionnaire and observational survey based on reports of guardians, and these were prominent limitations. The data collected by the questionnaire lacked objective measurement such as polysomnography. HS severity, the prevalence of respiratory tract infections, exposure time of passive smoking, and maternal pregnancy disease were based on parental reports. In the future, with the support of big data and polysomngraphy, we will make more detailed groupings of possible risk factors in order to minimize the bias caused by the questionnaire survey method.

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Author contribution JZ completed research design, questionnaire design, questionnaire distribution, and collection. LL completed research design, questionnaire design, questionnaire distribution and collection, data statistics, and article writing. ZJ and YZ and LY completed questionnaire distribution and collection. PZ completed the statistics and analysis of the data.

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Data availability The key identity information of participants was deleted from the data, and other parts are presented in the submission attachment.

Declarations

Ethics approval This study was approved by the Biomedical Research Ethics Committee of the West China Hospital of Sichuan University. This study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent to participate Written informed consent was provided by parents before they began completing the questionnaire.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

References

1. Olsen M, Mignot E, Jennum PJ, Sorensen HBD (2020) Robust, ECG-based algorithm for sleep disordered breathing detection in large population-based cohorts using an automatic, data-driven approach. Sleep 12:zsz276
2. Sateia MJ (2014) International classification of sleep disorders, third edition: highlights and modifications. Chest 146(5):1387–1394
3. Li S, Jin X, Yan C, Wu S, Jiang F, Shen X (2010) Habitual snoring in school-aged children: environmental and biological predictors. Respir Res 11(1):114
4. Sahin U, Ozturk O, Ozturk M, Songur N, Bircan A, Akkaya A (2009) Habitual snoring in primary school children: prevalence and association with sleep-related disorders and school performance. Med Princ Pract 18(6):458–465
5. Duman S, Vural H (2020) Evaluation of the relationship between malocclusions and sleep-disordered breathing in children. Cranio. https://doi.org/10.1080/08869634.2020.1779508
6. Nafiu OO, Burke CC, Chimbira WT, Ackwerh R, Reynolds PI, Malviya S (2011) Prevalence of habitual snoring in children and occurrence of peri-operative adverse events. Eur J Anaesthesiol 28(5):340–345

7. Luo R, Galland BC, Gill AI, Dawes P, Schaughency E (2018) Habitual snoring at age 3 years: links with parent-rated remembering in daily life and academic achievement at age 7 years. J Dev Behav Pediatr 39(2):144–153
8. Tamanyan K, Walter LM, Davey MJ, Nixon GM, Horne RS, Biggs SN (2016) Demographic risk factors for obstructive sleep apnoea in Australian children. J Paed Child Health 52(5):512–517
9. Kim KM, Kim JH, Kim D, Lim MH, Joo H, Yoo SJ, Kim E, Ha M, Paik KC, Kwon HJ (2020) Associations among high risk for sleep-disordered breathing, related risk factors, and attention deficit/hyperactivity symptoms in elementary school children. Clin Psychopharmacol Neurosci 30 18(4):553–561
10. Soh HJ, Rowe K, Davey MJ, Horne RSC, Nixon GM (2018) The OSA-5: development and validation of a brief questionnaire screening tool for obstructive sleep apnea in children. Int J Pediatr Otorhinolaryngol 113:62–66
11. Li Y, Gao Q, Li L, Shen Y, Lu Q, Huang J, Sun C, Wang H, Qiao N, Wang C, Zhang H, Wang T (2019) Additive interaction of snoring and body mass index on the prevalence of metabolic syndrome among Chinese coal mine employees: a cross-sectional study. BMC Endocr Disord. 19(1):28
12. Lu LR, Peat JK, Sullivan CE (2003) Snoring in preschool children: prevalence and association with nocturnal cough and asthma. Chest. 124(2):587–693
13. Anuntaseree W, Sangsupawanich P, Mo-suwan L, Ruangnapa K, Pruphetkaew N (2014) Prospective cohort study on change in weight status and occurrence of habitual snoring in children. Clin Otolaryngol 39(3):164–168
14. Urschitz MS, Guenther A, Eitner S, Urschitz-Duprat PM, Schlaud M, Ipsiroglu OS, Poets CF (2004) Risk factors and natural history of habitual snoring. Chest 126(3):790–800
15. Li AM, Au CT, So HK, Lau J, Ng PC, Wing YK (2010) Prevalence and risk factors of habitual snoring in primary school children. Chest 138(3):519–527
16. Papaioannou G, Kambas I, Tsaoussoglou M, Panaghiotopoulou-Gartagani P, Chrousos G, Kaditis AG (2013) Age-dependent changes in the size of adenotonsillar tissue in childhood: implications for sleep-disordered breathing. J Pediatr 162(2):269-274.e4
17. Lumeng JC, Chervin RD (2008) Epidemiology of pediatric obstructive sleep apnea. Proc Am Thorac Soc 5:242–252
18. Larsson LG, Lindberg A, Franklin KA, Lundbäck B (2003) Gender differences in symptoms related to sleep apnea in a general population and in relation to referral to sleep clinic. Chest 124:204–211
19. Verhulst SL, Schrauwen N, Haentjens D, Suys B, Rooman RP, Van Gaal L, De Backer WA, Desager KN (2007) Sleep-disordered breathing in overweight and obese children and adolescents: prevalence, characteristics and the role of fat distribution. Arch Dis Child 92(3):205–208
20. de Sousa Caixêta JA, Saramago AM, de Cácia Pradella-Hallinan ML, Moreira GA, Tufik S, Fujita RR (2015) Waist to height ratio distinguish obstructive sleep apnea from primary snoring in obese children. Sleep Breath 19(1):231 237
21. Sun K, Guo Y, Zhang Y, Jiang X (2019) Breastfeeding and risk of habitual snoring in children: a meta-analysis. Matern Child Nutr 15(3):e12799. https://doi.org/10.1111/mcn.12799
22. Bentley JP, Burgner DP, Shand AW, Bell JC, Miller JE, Nassar N (2018) Gestation at birth, mode of birth, infant feeding and childhood hospitalization with infection. Acta Obstet Gynecol Scand 97(8):988–997. https://doi.org/10.1111/aogs.13371
23. Storari M, Yanez-Regonesi F, Denotti G, Paglia L, Viscuso D (2021) Breastfeeding and sleep disordered breathing in children systematic review and proposal of underlying interaction models. Eur J Paediatr Dent 22(4):314–322. https://doi.org/10.23804/ejpd.2021.22.04.10
24. Carpinello OJ, DeCherney AH, Hill MJ (2018) Developmental origins of health and disease: the history of the Barker hypothesis and assisted reproductive technology. Semin Reprod Med 36:177–182. https://doi.org/10.1055/s-0038-1675779
25. Kalampouka E, Moudaki A, Malakasioti G, Panaghiotopoulou-Gartagani P, Chrousos G, Kaditis AG (2014) Family history of adenotonsillectomy as a risk factor for tonsillar hypertrophy and snoring in childhood. Pediatr Pulmonol 49(4):366–371. https://doi.org/10.1002/ppul.22830
26. Kukwa W, Guilleminault C, Tomaszewska M, Kukwa A, Krzeski A, Migacz E (2018) Prevalence of upper respiratory tract infections in habitually snoring and mouth breathing children. Int J Pediatr Otorhinolaryngol 107:37–41. https://doi.org/10.1016/j.ijporl.2018.01.022
27. Zheng M, Wang X, Zhang L (2018) Association between allergic and nonallergic rhinitis and obstructive sleep apnea. Curr Opin Allergy Clin Immunol 18(1):16–25. https://doi.org/10.1097/ACI.0000000000000414
28. Ras AE, Hamed MH, Abdelalim AA (2020) Montelukast combined with intranasal mometasone furoate versus intranasal mometasone furoate a comparative study in treatment of adenoid hypertrophy. Am J Otolaryngo l41(6):1–5. https://doi.org/10.1016/j.amjoto.2020.102723
29. O'Callaghan F, O'Callaghan M, Scott JG, Najman J, Al Mamun A (2019) Effect of maternal smoking in pregnancy and childhood on child and adolescent sleep outcomes to 21 years: a birth cohort study. BMC Pediatr 19(1):70. https://doi.org/10.1186/s12887-019-1439-1
30. Subramanyam R, Tapia IE, Zhang B, Mensinger JL, Garcia-Marcinkiewicz A, Jablonka DH, Gálvez JA(2020)Secondhand smoke exposure and risk of obstructive sleep apnea in children. Int J Pediatr Otorhinolaryngol. https://doi.org/10.1016/j.ijporl.2019.109807
31. Zhu Y, Au CT, Leung TF, Wing YK, Lam CW, Li AM (2013) Effects of passive smoking on snoring in preschool children. J Pediatr 163:1158–1162. https://doi.org/10.1016/j.jpeds.2013.05.032
32. Hsu WY, Chiu NY, Chang CC, Chang TG, Lane HY (2019) The association between cigarette smoking and obstructive sleep apnea. Tob Induc Dis 17:27. https://doi.org/10.18332/tid/105893
33. Weinstock TG, Rosen CL, Marcus CL, Garetz S, Mitchell RB, Amin R, Paruthi S, Katz E, Arens R (2014) Predictors of obstructive sleep apnea severity in adenotonsillectomy candidates. Sleep 37(2):261–269. https://doi.org/10.5665/sleep.3394