

Research Progress on the Association Between Children's Sleep and Oral Diseases

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Abstract: This paper systematically reviews epidemiological empirical studies on the association between children's sleep problems (such as insufficient sleep, sleep-disordered breathing, and circadian rhythm disorders) and common oral diseases (dental caries, malocclusion, periodontal diseases, etc.). Starting from potential biological mechanisms, it deeply analyzes the correlation from dimensions including salivary secretion rhythm disturbance, oral microbiota imbalance, abnormal inflammatory response, and abnormal circadian rhythm gene regulation. The limitations of existing research and future development directions are discussed, providing references for clinical interventions and subsequent studies on children's sleep and oral health.

Keywords: Children; Sleep problems; Dental caries; Malocclusion; Oral diseases

Online publication: Mar 11, 2026

1. Introduction

Children are in a critical period for establishing sleep patterns and oral health. In recent years, the interaction and mechanism between children's sleep problems and common oral diseases have become an interdisciplinary research hotspot. Physiologically, good sleep is key for children's metabolism, immune regulation, and nervous system development. However, with global economic growth and improved living standards, childhood sleep problems and oral diseases have risen sharply. The Fourth National Oral Health Epidemiological Survey shows that 70.9% of 5-year-olds in China have deciduous tooth caries, 34.5% of 12-year-olds have permanent tooth caries, and malocclusion incidence is also increasing^[1]. In pediatrics and stomatology, children's sleep health has gained wide attention. Medical professionals and experts use experimental methods to explore links between sleep issues (irregular circadian rhythm, sleep-disordered breathing, insufficient sleep) and oral diseases. Tests confirm sleep problems increase risks of caries, malocclusion, and periodontitis via multiple pathways. Conversely, oral diseases cause discomfort or breathing difficulties, worsening sleep and forming a vicious cycle. In-depth analysis of their mutual influence and mechanisms is crucial for building intervention/prevention systems and improving intervention effectiveness.

2. Association between children's sleep problems and major common oral diseases

2.1. Sleep problems and dental caries

Dental caries is the most common chronic infectious oral disease in childhood, associated with bacteria, food, host, and time. Epidemiological studies and systematic reviews confirm sleep problems are key risk factors for childhood caries.

Insufficient or poor-quality sleep increases caries risk. Sardana et al. developed a scale for preschool children, finding insufficient sleep raises caries risk, each 1-hour reduction in sleep duration boosts the probability ^[2]. Ogasawa et al. verified this correlation in a large-sample study of Japanese preschoolers, accounting for other influencing factors ^[3]. Sleep-disordered breathing also impacts caries prevalence: Mehdipour et al. found children with snoring or sleep apnea have higher caries and oral disease risks than those with normal sleep ^[4].

Circadian rhythm disorder, a major sleep problem, is linked to childhood caries. KURTOVIC et al. noted it may increase caries risk by disrupting oral microecological balance and salivary secretion ^[5]. Population studies support this: Alqaderi et al.'s longitudinal study of Kuwaiti children found late sleepers (after 23:00) had significantly higher caries incidence, independent of diet and oral hygiene; FOLAYAN et al. confirmed chronotype is a caries risk indicator in Nigerian children, with night owls facing higher risks ^[6,7].

2.2. Sleep-disordered breathing and malocclusion

Sleep-disordered breathing (common childhood forms: snoring, obstructive sleep apnea/OSA) involves abnormal sleep breathing rhythm and ventilation. Studies show an interactive relationship between childhood sleep-disordered breathing and malocclusion, threatening physical and mental health.

On one hand, sleep-disordered breathing increases malocclusion risk. Aroucha et al. found affected children are more prone to overjet, overbite, and Class II malocclusion ^[8]. Mechanistically, sleep-related breathing difficulties lead to chronic oral breathing, unbalancing facial/oral muscle forces, impairing maxillary development, and causing mandibular retrusion ^[9]. Hansen et al. confirmed children with maxillary stenosis or mandibular retrusion face higher sleep-disordered breathing risks, forming a vicious cycle of aggravated dentofacial abnormal forces. Villa et al. added that a short lingual frenulum limits tongue movement, hindering jaw development and worsening sleep airway obstruction, increasing oral breathing and malocclusion incidence ^[10].

On the other hand, malocclusion induces sleep-disordered breathing. Li et al.'s study of Shanghai children found malocclusion correlates with higher sleep-disordered breathing incidence, with severity positively correlated ^[11]. BRUUN et al. confirmed severe malocclusion is linked to greater daytime sleepiness, suggesting impaired daytime function from poor nighttime sleep ^[12].

2.3. Sleep problems and other oral diseases

Children's sleep problems are also related to periodontal diseases or other oral diseases. Sleep-disordered breathing affects the incidence of periodontal diseases. A study by Mehdipour et al. found that children with poor sleep breathing habits or sleep-disordered breathing are prone to gingival bleeding and increased periodontal pocket depth, and their periodontal health level is lower than that of normal children.

Sleep habits are correlated with oral diseases such as bruxism during sleep and temporomandibular disorders (TMD). Topaloglu-Ak et al. selected children with dental caries, poor sleep habits, bruxism during sleep, TMD, etc., as the observation group ^[13]. The observation results showed that compared with normal children, the observation group had a significantly higher risk of developing TMD. The mechanism is that bad sleep habits can

disrupt children's autonomic nervous function, leading to the inability of masticatory muscles to contract and relax normally, which in turn causes bruxism and abnormal temporomandibular joint function.

3. Potential mechanisms of children's sleep problems affecting oral health

3.1. Salivary secretion rhythm disturbance

Saliva maintains oral health by regulating pH, cleaning the oral cavity, and inhibiting microorganisms. Nighttime saliva secretion is reduced but rich in antibacterial and buffering components, adapting to nocturnal oral environment changes. Sleep-disordered children have abnormal nighttime saliva secretion, failing to maintain oral health.

Irregular circadian sleep or insufficient duration reduces nighttime saliva, leading to bacterial and food residue accumulation on periodontium or tooth surfaces, increasing caries risk. Dry oral mucosa impairs acid neutralization, causing hard dental tissue demineralization. Shang et al. noted salivary glands have immune functions, reversed sleep disrupts secretion rhythm, reducing immune factors and increasing infection risk ^[14]. Human salivary microbiota has a circadian alternation; irregular sleep breaks this rhythm, exacerbating infection risks.

3.2. Oral microbiota imbalance

The oral microbiota is a microecosystem; balanced beneficial and harmful bacteria maintain oral health. Imbalance (e.g., increased harmful bacteria reproduction) raises risks of caries and periodontal diseases. Children's sleep problems disrupt this balance in multiple ways.

Firstly, insufficient or irregular sleep disrupts salivary secretion, reduced saliva alters oral oxygen and nutrient levels, promoting harmful bacterial growth. Mehdipour et al. found irregular sleep correlates with higher salivary fungi and cariogenic bacteria (e.g., *Streptococcus mutans*), lower pH, and reduced buffering capacity, indicating sleep duration affects microbiota composition via saliva and oral environment ^[15]. Secondly, irregular sleep directly impacts microbiota circadian rhythm: Chellappa et al. confirmed disrupted day-night rhythm changes microbiota composition, increasing harmful bacteria ^[16]. Ciurli et al. added that sleep disorders imbalance oral metabolism, indirectly disrupting microbiota ^[17].

3.3. Abnormal inflammatory response

Inflammatory response is a defensive response of the body to external stimuli. However, when the body's inflammatory response is excessive or abnormal, it will cause tissue damage. Children's sleep problems can activate the body's inflammatory response pathways, leading to abnormal local inflammatory responses in the oral cavity, thereby increasing the risk of oral diseases.

Insufficient sleep duration or sleep-disordered breathing can put the body in a state of chronic stress, gradually activating the hypothalamic-pituitary-adrenal (HPA) axis, resulting in increased cortisol secretion. Angelhoff et al. selected children with severe dental caries and found through a comparative study that compared with normal children, children with severe dental caries often experienced insomnia, had significantly higher hair cortisol concentrations, and lower quality of life ^[18]. This experiment reflects that sleep problems can increase the body's cortisol level through chronic stress, exacerbating oral inflammatory responses. In addition, short sleep duration can also lead to decreased immune function in children and disrupt the secretion rhythm of inflammatory

molecules. A study by Xue et al. found that after corneal injury, sleep-deprived mice exacerbated inflammatory responses through the IL-17 signaling pathway; Chen et al. obtained multi-omics experimental research results and found that chronic sleep deprivation can disrupt the homeostasis in the oral cavity of rats, increase the expression of inflammatory factors, and increase the risk factors for oral health ^[19,20]. A systematic review and Meta-analysis by Alarcón-sánchez et al. found that the levels of inflammatory factors such as TNF- α , IL-6, and IL-8 in the saliva of children with dental caries were significantly higher, and sleep problems may promote the occurrence and development of dental caries and periodontal diseases by exacerbating the abnormal expression of these inflammatory factors ^[21].

3.4. Abnormal circadian rhythm gene regulation

Circadian rhythm genes (such as CLOCK, BMAL1, PER, CRY, etc.) are the core of regulating the body's circadian rhythm. Abnormal expression of these genes can lead to circadian rhythm disorders, thereby affecting various physiological functions. In recent years, studies have found that abnormal regulation of circadian rhythm genes may be an important molecular mechanism associated with children's sleep problems and oral diseases.

On the one hand, abnormal circadian rhythm genes may affect the development and repair of oral tissues. A study by FENG et al. pointed out that the circadian clock is a promising scientific target in oral science, and circadian rhythm genes are involved in regulating oral physiological processes such as dentin formation and alveolar bone metabolism ^[22]. A study by Huang et al. found that the PER2 gene promotes the odontoblastic/osteogenic differentiation of dental pulp stem cells by regulating mitochondrial metabolism, and abnormal expression of the PER2 gene may affect the repair function of dental pulp tissue ^[23]. A study by Wu et al. confirmed that the circadian clock is involved in enamel development, and abnormal circadian rhythm genes may lead to enamel hypoplasia, increasing the risk of dental caries ^[24]. On the other hand, abnormal circadian rhythm genes may affect inflammatory responses and immune functions. A study by Schrader et al. found that circadian rhythm disorders and clock gene abnormalities are closely related to metabolic health, and may affect overall health through inflammatory response pathways ^[25]. A study by Sehirli et al. pointed out that the circadian rhythm gene Bmal1 is associated with the occurrence of periodontitis, and abnormal Bmal1 expression may affect periodontal health by regulating inflammatory responses ^[26]. In addition, a study by MAJEWSKA et al. found that abnormal clock gene function is associated with various health problems, and may indirectly increase the risk of oral diseases by affecting the cell cycle, metabolism, and immune function ^[27].

3.5. Other potential mechanisms

Children's sleep problems can affect oral health through eating habits. Adolescent night owls are more likely to eat at night, especially high-fat and high-sugar foods. With the increase in nighttime eating frequency, the risk of dental caries increases accordingly. Children with insufficient sleep have decreased self-management ability and attention span, and cannot brush their teeth on time or clean their oral cavity thoroughly, forming bad oral hygiene habits, leading to an increased risk of oral diseases.

Sleep-disordered breathing can affect oral health by changing the oral oxygen supply environment. A study by ZHU et al. found that the oral cavity in a hypoxic environment will produce ROS/TXNIP/NLRP3 inflammasomes, leading to inflammation of periodontal tissues and aggravating periodontal inflammation ^[28]. A study by Yu et al. found that the level of HIF-1 α in hypoxic dental pulps of teeth with severe periodontitis is significantly higher, and hypoxia may affect the repair and regeneration function of dental pulp tissue through the HIF-1 α pathway ^[28]. At

the same time, the hypoxic environment may also affect the metabolic activities of oral microbiota, promoting the growth and reproduction of harmful bacteria.

4. Discussion

There is a close association between children's sleep problems and common oral diseases (dental caries, malocclusion, periodontal diseases, etc.). Different types of sleep problems, such as insufficient sleep, sleep-disordered breathing, and circadian rhythm disorders, may increase the risk of oral diseases through various mechanisms, including salivary secretion rhythm disturbance, oral microbiota imbalance, abnormal inflammatory response, and abnormal circadian rhythm gene regulation.

Although research on the association between children's sleep problems and oral diseases has made some progress, there are still many limitations. Firstly, many studies adopt a cross-sectional research design, which is difficult to prove a causal relationship between the two, only that there is an association between sleep problems and dental problems. It is difficult to determine the mechanism of mutual influence between them, such as whether insufficient sleep affects dental caries, whether dental caries pain affects sleep, or other factors affect both. In this regard, it is necessary to cooperate with communities, hospitals, and schools to carry out large-sample, multi-center studies, and use big data technology and systems to in-depth analyze the mutual influence between children's sleep problems, oral diseases, and other confounding factors from the perspective of time and causal relationship, so as to improve the reliability of research results.

Secondly, the evaluation standards and methods for sleep problems have not been unified. Researchers use a combination of objective monitoring, parental questionnaires, student questionnaires, and other methods. Inconsistent evaluation methods will affect the heterogeneity of research results. In this regard, invite experts in clinical medicine and sleep medicine to formulate a standardized sleep evaluation standard system, and adopt a combination of objective monitoring and subjective investigation to more comprehensively understand and evaluate children's sleep status, reducing the heterogeneity of research results.

In addition, the research scope is narrow and the sample representativeness is not strong. Current studies are mostly concentrated in foreign regions or specific age groups of children, and the classification of sleep problems and oral diseases is not detailed and diverse enough. Research on the association mechanism is mostly *in vitro* observations or animal experiments. Differences in oral service levels and dietary cultures in different regions limit the extrapolation of research results. In this regard, it is necessary to expand the coverage of research populations, attach importance to studies on children's samples from different regions and age groups in China, explore the population differences in the association between sleep problems and oral diseases, propose clinical intervention plans from an overall perspective, explore the improvement effect of oral interventions on children's sleep problems or sleep health interventions on oral health problems, improve the extrapolation of research results, and provide new ideas and methods for the physical and mental health development of children.

5. Conclusion

In summary, compelling evidence underscores a significant bidirectional association between children's sleep problems, including insufficient sleep, sleep-disordered breathing, and circadian rhythm disorders, and common oral diseases such as dental caries and malocclusion. The interplay is mediated through complex mechanisms

involving disturbances in salivary secretion, oral microbiota, inflammatory responses, and circadian gene regulation. Moving forward, future research should prioritize longitudinal and multi-center studies to establish causality and translate these findings into integrated, preventative clinical strategies that concurrently address sleep health and oral hygiene in pediatric populations.

Disclosure statement

The author declares no conflict of interest.

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