Insufficient Sleep and Incidence of Dental Caries in Deciduous Teeth among Children in Japan: A Population-Based Cohort Study

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Objectives To examine whether late bedtime and short nighttime sleep duration at age 18 months are associated with risk of caries in deciduous teeth.

Study design Population-based cohort study using health check-up data of 71 069 children born in Kobe City, Japan, who were free of caries at age 18 months and had information on sleep variables at age 18 months and records of dental examinations at age 3 years. Sleep variables were assessed by standardized parent-reported questionnaires, and the incidence of caries in deciduous teeth was defined as the occurrence of at least 1 decayed, missing, or filled tooth assessed by qualified dentists without radiographs. Logistic regression was used to estimate the effects of late bedtime and short sleep duration on dental caries with adjustment for clinical and lifestyle characteristics.

Results Overall, 11 343 (16.0%) cases of caries were observed at age 3 years. aORs for children with late or irregular bedtimes compared with those with bedtimes before 21:00 were 1.26 (95% CI 1.19-1.33), 1.48 (1.38-1.58), 1.74 (1.58-1.92), 1.90 (1.58-2.29), and 1.66 (1.53-1.81) for bedtimes at 21:00, 22:00, 23:00, 0:00, and irregular bedtime, respectively. aORs for children with short or irregular sleep duration compared with those with sleep duration of ≥11 hours were 1.30 (95% CI 1.15-1.47), 1.16 (1.09-1.24), 1.11 (1.05-1.18), and 1.35 (1.25-1.46) for sleep duration of ≤ 8, 9, 10 hours, and irregular sleep duration, respectively.

Conclusions In this exploratory study, late bedtime and short sleep duration were both consistently associated with increased risk of caries in deciduous teeth. *(J Pediatr 2018;■■:■■-■■).*

Untreated dental caries in deciduous teeth, now present in 7.8% of children worldwide,[1] is a major cause of pain and suffering that may affect children and families' quality of life.[2] Although risk factors for dental caries are well-documented,[3] several unique ones might modify its biology in young children who are in the formative stages of development. These involve the implantation of cariogenic bacteria, immaturity of the host defense systems, and behavioral patterns associated with feeding and oral hygiene.[4] In this regard, sleep might be an important factor, given the vulnerability to the adverse effects of insufficient sleep among the pediatric population.

In humans, sleep–wake timing and circadian timing rhythms are synchronized under normal conditions such that sleep is timed to occur during the night.[5] Young children, however, might face environmental demands that may result in a poor fit with the biological limits imposed by their circadian system, as their time to fall asleep at night is largely determined by their parents or caregivers.[6] Possible pathways by which sleep might affect a child's risk for caries include abnormal salivary flow rate caused by alteration in local circadian timing system in the salivary gland[5,7,8] and susceptibility to infection due to impaired immune function.[9-12] Sleep deprivation is associated with diminished salivary flow rate, diminished IgA secretion rate, and elevated levels of salivary amylase activity in rats.[8] Epidemiologic observation also suggests links between short sleep and increased salivary interleukin-6 production[9] and high levels of *Streptococcus mutans* colony counts,[10] and links between late bedtimes and dental caries in deciduous or permanent teeth.[13,14]

We used data from the Kobe Offspring Study[15] to examine whether late bedtime and short nighttime sleep duration at age 18 months is associated with caries in deciduous teeth to determine whether there is a dose–response relationship and to assess whether associations are consistent across various subgroups related to feeding practices and oral hygiene.

Methods

The Kobe Offspring Study[15] was a population-based cohort study using records of municipal health check-ups for children aged 0-3 years in Kobe City, Japan. Kobe City is the sixth largest city in Japan, with a population of about 1.5 million, and is the capital city of Hyogo Prefecture on the southern side of the main island of Japan. The prefectural income per capita was 23 218 USD in 2002,[16] and about 32% of households had an annual income above the average estimates in Japan (ie, 49 095 USD).[17,18] Nearly 93% of the fathers and 19% of the mothers were employed when their children were born, with professional and engineering workers

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(27.2%) and clerical workers (37.3%) being the most common jobs, respectively.[19] Among household members aged 20-49 years, 42% had a high school education, 21% had junior college or higher professional school education, and 28% completed college, university, or graduate course.[17]

All women of childbearing age and children from pregnancy to 3 years of age residing in Kobe City participated in the health check-up program, which consisted of completion of a standardized pregnancy notification form, neonatal health check-ups, advice provided during home visits, and health check-ups for infants at 4, 9, and 18 months and 3 years of age at healthcare centers of ward offices or designated clinics. Information on lifestyle factors was based exclusively on responses to standardized parent-reported questionnaires, which mothers were required to complete at every health check-up. We had access to deidentified data on health check-ups from March 31, 2004, to April 1, 2014 after approval by the Planning and Coordination Bureau of Kobe. Details of the study design have been reported previously.[15] The Ethics Committee of Kyoto University Graduate School and Faulty of Medicine approved the protocol (Approval Number R0923).

Assessment of Sleep

Using a standardized questionnaire, parents reported their young child's habitual wake time and bedtime at 18 months in response to 2 questions: "What time does your child usually wake up?" (7 predefined responses: before 7:00, 7:00, 8:00, 9:00, 10:00, 11:00 and later, and irregular), and "What time does your child usually go to bed?" (7 predefined responses: before 20:00, 20:00, 21:00, 22:00, 23:00, 0:00, and irregular). The 2 former categories were combined to form the reference category (ie, before 21:00) based on the recommended sleep hygiene by the National Sleep Foundation,[20] and late bedtime was defined as 21:00 or later. The child's nighttime sleep duration was calculated as the difference between bedtime and wake time and categorized as ≤8 hours, 9 hours, 10 hours, ≥11 hours, and irregular, with sleep duration of ≥11 hours as reference.

Measurement of Dental Caries

Qualified dentists assessed the oral conditions of the children at 18 months and 3 years through visual examination and not radiography. They classified each tooth into 1 of 7 types: normal, decayed, missing, filled, treated by diammine silver fluoride, observation required, or treated by a dental sealant. We counted teeth treated by diammine silver fluoride as well as decayed teeth as decayed. Incidence of dental caries was defined as the occurrence of at least 1 decayed, missing, or filled tooth. Other records of dental examinations included the caries activity test (CARIOSTAT; Dentsply-Sirona, Tokyo, Japan), a colorimetric test designed to measure the pH decrease caused by microorganisms in the plaque sample obtained from the buccal surfaces (0-4 points, 4 points indicating most active); presence of plaque; abnormal conditions of soft tissues and occlusion; and treatment with fluoride varnish.

Statistical Analyses

The primary outcome was incidence of caries in deciduous teeth at 3 years of age. Secondary outcomes were incidence of caries in mandibular or maxillary anterior teeth or molars. The Cochran–Armitage test for trend was used to assess trends in the incidence of caries. We present risk estimates separately for bedtime and sleep duration, as having a late bedtime does not necessarily equate to short sleep duration, although studies do suggest links between these 2 sleep variables.[20] Also, bedtime correlated modestly with sleep duration in our study (Pearson correlation coefficient, –0.48), and their effects on caries may be confounded and should be handled separately. We used binary logistic regression to estimate ORs and 95% CIs with adjustment for clinical and lifestyle characteristics (**Table I**). We tested the linearity assumption between the log odds of the outcome and continuous variables by using a scatterplot smoothing method and observed no significant deviations.[21]

In a sensitivity analysis, we further adjusted the following postexposure covariates at age 3 years as covariates: tooth brushing alone (yes/no), tooth brushing by parents before sleep

Table I. Potential confounders

Background characteristics
Maternal age at delivery (continuous; y)
Gestational age (22-27, 28-36, 36-43 wk)
Maternal alcohol consumption during pregnancy (none, occasional, daily)
Maternal smoking during pregnancy (yes/no)
Pre-eclampsia (yes/no)
Anemia (yes/no)
Threatened abortion (yes/no)
First-born child (yes/no)
Child' sex (boy, girl)
Birth year (continuous; y)
Birth weight (continuous; g)
Birth height (continuous; cm)
Oral hygiene
Number of teeth at 9 mo (continuous)
Treated by fluoride varnish (yes/no)
Tooth brushing by own self (yes/no)
Tooth brushing by parents before going to bed (yes/no)
Absence or presence of plaque (yes/no)
Lifestyle factors
Exposure to tobacco smoke at 4 months (none, exposed to only household smoking, exposed to tobacco smoke)
Age of introduction of solids (continuous; mo)
Weaning at 9 mo (yes/no)
Bottle-feeding at 9 mo (yes/no)
Bottle-feeding at 18 mo (yes/no)
Breastfeeding at 18 mo (yes/no)
Eating sweets irregularly (yes/no)
Frequency of eating sweets (1, 2, or ≥3 times per day)
Daily juice consumption (yes/no)
Use of babysitter or nursery at 4 mo
Use of babysitter or nursery at 18 mo (yes/no)
Mental status of the mother (continuous; 1-5 scores)
Support by family, friends, and neighbors (yes/no)
Common comorbidities at 18 mo
Atopic dermatitis (yes/no)
Asthma (yes/no)
Asthmatic bronchitis (yes/no)
Food allergy (yes/no)
Varicella (yes/no)
Pneumonia (yes/no)
Severe diarrhea (yes/no)
History of familiar allergenic disease (yes/no)

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