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Association between high birth weight and dental caries at 4–5 years of age: a birth-cohort study

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Abstract

Objective Early childhood caries has become a globally crucial oral health problem over the decades. Most studies have discussed the association between low birth weight and early childhood caries; however, studies focusing on high birth weight have been relatively limited. This study aimed to assess the impact of high birth weight on the incidence and severity of dental caries in 4–5-year-old children.

Subjects and methods Study subjects included 491 children from a birth cohort study at 4–5 years of age. Data on dental caries, prenatal and perinatal factors, and socio-demographic determinants were recorded. Logistic regression models adjusted for potential confounders were performed to analyze the data. Two-sided P-value < 0.05 was considered statistically significant.

Results Of the 491 children, the prevalence of dental caries was 48.7%. High birth weight (≥ 4,000 g) was significantly associated with increased incidence of dental caries (OR, 2.000; CI 95% 1.062–3.765), and the relatively enhanced risk OR was further increased in subjects experiencing caries (dmft ≥ 3) (OR, 2.437; CI 95% 1.306–4.549) compared with the normal birth weight (2,500–3,999 g).

Conclusions High birth weight is a risk factor for early childhood caries. Particular attention should be paid to children with birth weight more than or equal to 4,000 g.

Keywords Birth weight, Birth-cohort study, Dental caries, Early childhood caries, Risk factor

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Introduction

Early childhood caries (ECC) is defined as the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child at ≤71 months of age [1]. Based on the data published in recent years, there is a wide variation in ECC prevalence, ranging from 23 to 90% globally. ECC is considered one of the most prevalent chronic diseases in childhood, affecting many children around the world [2–6]. As the fourth most expensive disease to treat, the high morbidity of dental caries increases healthcare costs and the financial burden to families and societies, which are of great concern today [7, 8].

Discomfort or pain can occur when ECC progresses into dentin or involves the dental pulp. Untreated ECC might cause difficulties in sleeping and eating, and possibly affect children's growth and development. Studies have reported that children who suffer from cavitated dentin caries have been found to have lower body weight and height, compared with those without dental caries. In addition, higher rates of absenteeism were found in children with untreated ECC, leading to a negative impact on their school performance. Moreover, hospitalization or emergency dental visits were reported in some severe cases. Such problems could become serious and even life threatening [9]. Index commonly used to characterize ECC is ECC prevalence, dmft index (the decayed, missing due to caries and filled teeth index) and the SiC index (Significant Caries index) [10].

ECC is an infectious disease. Four main etiological factors are well documented: susceptible host, cariogenic bacteria, fermentable carbohydrate substrate, and time for interaction of these factors. The potential risk factors include neumerous environmental and genetic terms such as dental hygiene, excess consumption of sweets, parental socioeconomic status, and support for child rearing [4, 5]. Campus G et al. in their invitation article for the topical collection on 'Prevention and management of dental erosion and decay' in BMC Oral Health, highlight the evolving comprehension of dental caries and erosion as ecological, non-infectious phenomena that necessitate preventive strategies and effective management in public health policies [11].

In recent years, the relationship between children's birth weight and the risk of developing chronic diseases, such as dental caries, has been frequently discussed [12–19]. The relationship between birth weight and oral conditions has been chiefly addressed in infants with low birth weight [20–23]. Most studies indicate no association between low birth weight and the development of dental caries, although conflicting results are reported [24, 25]. Moreover, there are few studies in the literature on children with high birth weight. In those studies, the authors reported a weak association between dental caries and high birth weight in different periods [26–28]. Obviously, previous reports have been unable to end the controversy because of confounding factors. Therefore, we aimed to determine whether high birth weight was associated with the incidence and severity of dental caries later on in a cohort of children and the null hypothesis of the study is that the high birth weight was not the risk factor of ECC.

Materials and methods

Sampling and sample sizes

The sample size was calculated on the basis of early childhood caries prevalence of 5-year-old children derived from the Fourth National Oral Health Survey in China, about 70.9%.[7] According to the formula below and the expected non-response rate of 20%, we estimated that a sample size of approximately 400 subjects would be needed:

$$N = deff\frac{\mu^2(1-p)}{\varepsilon^2 p}/(1 - non - responses)$$

where N is the sample size, deff means design effect, p is the dental caries prevalence of 5-year-old children in the Fourth National Oral Health Survey, μ is the level of confidence, and ε is the margin of error.

Study participants

The present study was designed as a retrospective longitudinal register-based cohort study based on information collected from data sources at Xinhua Hospital, including clinical examination and questionnaires.

Women in the 1st -trimester (12–14 gestational weeks) of pregnancy were recruited for the cohort study from June 2012 to March 2013, and all their children were born at Xinhua Hospital, Shanghai Jiao Tong University, in the year 2013. A written consent was obtained from each participant, and each of them were interviewed before participating in the study. Data on dental caries, prenatal and perinatal factors, and socio-demographic determinants were collected by the hospital staff. This cohort was followed up until the children were 4 or 5 years of age. During this period, the subjects received a regular physical examination, including an oral check-up, but no treatment from the local municipality for half a year.

All the mother-offspring pairs were invited over phone for the 4–5-year-old follow-up from June 2017 to November 2017. A total of 539 mother-offspring pairs returned to the hospital and completed the follow-up. The detailed structure and items of the evaluation and questionnaires employed for data collection are performed as supplementary files (Questionnaire1.pdf, Questionnaire2.pdf and Evaluation Form.pdf). During the verification process, our research technicians completed missing answers and/or illegible data by conducting telephonic interviews to avoid errors and invalid data as much as possible. Of the examined subjects ($n = 539$), 491 children had complete and legible clinical examination data and questionnaires at 4 or 5 years of age, thus constituting the final study cohort eventually.

This study was reviewed and approved by the Ethics Committee of Xinhua Hospital affiliated to Shanghai Jiao Tong University (No. XHEC-C-2013-001) in accordance with the ethical guidelines and regulations of the Declaration of Helsinki.

In the study, the groups of high birth weight, normal birth weight, and low birth weight were defined as those with birth weights ≥ 4,000 g, 2,500-3,999 g, and < 2,500 g, respectively, following the standards of the World Health Organization (WHO) [29]. The groups of low-annual household income, middle-annual household income, and high-annual household income were defined as those with an annual household income of < ¥100,000, ¥100,000 - ¥199,999, and ≥ ¥200,000, respectively. The groups of low-maternal educational level, middle-maternal educational level, and high-maternal educational level were defined as maternal educational years < 13, 13–15, and ≥ 16, respectively.

Caries examination

Each child was examined by three trained, licensed dentists, comprising two training examiners and one calibrating examiner. The results were recorded by the research technicians. The mean kappa values for the inter-examiner reproducibility of dental caries were calculated by comparing duplicate examinations with each other and the calibrating examiner. The minimum threshold was set at 0.80.

The diagnostic criteria for caries followed the recommendation of the WHO. Caries experience was measured with the dmft index and the SiC index. In the case of the primary teeth, the dmft index was calculated by deriving information from data codes B, C, D and E in the oral health assessment form [30] and the SiC index was a mean dmft of one-third of the study population with the highest caries score [31]. Examinations were conducted using mobile dental chairs and portable lights. The cavity examinations mainly relied on an ocular inspection with plane mirrors and ball-end Community Periodontal Index (CPI) probes.

Questionnaire

During a face-to-face and one-on-one interview with trained interviewers, the parents or grandparents of each of the participants completed a questionnaire, including data regarding caries-related oral hygiene behaviors, dietary behaviors, and socioeconomic factors. The data were collected to identify the factors related to ECC and were verified to be appropriate, reliable, and valid before commencing the study. During the interview, we started off by enquiring about the children's health and patiently explained the work to dispel the participants' parents/grandparents' doubts so as to minimize potential bias.

Statistical analysis

Data analyses were carried out using the Statistical Package for the Social Sciences software version 21.0. For analyzing the data, frequency tables, crosstables, and logistic regression were used.

For the descriptive analysis of the study population, mean and standard deviations (SDs) were calculated for normally distributed continuous variables, such as age and birth weight. Categorical data, including gender, birth weight categories, and socioeconomic status, were expressed in frequencies and percentages. The normality of distribution for continuous variables was verified using the Shapiro–Wilk test.

Differences between groups for continuous variables with normal distribution were assessed using Student's t-test for two-group comparisons and one-way ANOVA for multiple group comparisons. The Mann-Whitney U test was employed to evaluate the significance of differences between groups for non-normally distributed variables.

To explore the association between high birth weight and the incidence and severity of dental caries, as well as the potential influence of socioeconomic factors, univariate logistic regression models were first applied. These analyses provided odds ratios (ORs) with 95% confidence intervals (CIs) for each independent variable. This stepwise inclusion helped to control for confounding factors, ensuring that the final model highlighted the most significant predictors of the outcome variables, namely the presence and severity of ECC (dmft ≥ 1 and dmft ≥ 3, respectively).

Results

Demographics

Table 1 showed the demography of subjects in the study. The 539 women and their children selected in this study cohort were followed up until the children were 4 or 5 years of age. At the end of the study, 491 children participated in our study, and the non-response rate was 10.95%. The most common reason for sample attrition was that the individuals had moved out of Shanghai City.

Bivariate analysis

In bivariate analysis, we selected the birth weight, gender, age, preterm birth, mother's age, maternal educational level, and the annual household income as the categorical variables. The analysis showed that the annual household income and birth weight were significantly associated

Table 1 Background characteristics of children and their mothers

Characteristics	Mean (SD) or number (%)
Number of children	491
Number of male children	255 (51.9)
Number of female children	236 (48.1)
Birth weight, g	3415.1 ± 459.7
Age of children, years	4.8 ± 0.2
Number of children with caries	239 (48.7)
dmft	2.0 ± 2.9
dt	1.6 ± 2.6
mt	0.0 ± 0.1
ft	0.4 ± 1.2
Sic index	5.3 ± 3.1
Gestational age, weeks	38.9 ± 1.4
Age of mother when she was pregnant, years	29.4 ± 4.7

with the caries experience ($P<0.05$). In addition, the association between maternal educational level and caries experience was also assessed, which showed a strong trend but no statistical difference (Table 2).

Table 3 Multivariate logistic regression analysis for dental caries (dmft ≥ 1) among children and their mothers

Variable	*P*	OR	95% CI	
			Lower	Upper
Gender (reference, male)	0.735	0.947	0.660	1.340
Age (reference, 4 years old)	0.167	1.422	0.863	2.349
Preterm birth (reference, No)	0.880	0.928	0.351	2.453
Birthweight (g)				
≤ 2,500	0.433	1.810	0.411	7.967
2,500–3,999	—	—	—	—
≥ 4,000	**0.032**	**2.000**	1.062	3.765
Annual household income (In Renminbi)				
< 100,000	**0.016**	**2.003**	1.139	3.524
100,000–199,999	0.280	1.346	0.785	2.308
≥ 200,000	—	—	—	—
Unclear	0.599	1.181	0.635	2.195
Maternal educational level (years)				
< 13	—	—	—	—
13–15	0.572	0.796	0.360	1.757
≥ 16	0.187	0.510	0.187	1.386

Multivariate analysis

The association between birth weight and dental caries experience (dmft≥1, dmft≥3) was assessed using multivariate logistic regression analysis. At the start, all

Table 2 The association between selected characteristics and children's dental caries experience

	n	ECC (*n*,%)	*P*	Mean dmft	*P*	dmft ≥ 3 (*n*,%)	*P*
Birth weight (g)							
< 2500	12	5(41.7)	0.063	1.17 ± 1.90	0.186	3(25.0)	**0.016**
2,500–3,999	431	203(47.1)		1.94 ± 3.00		113(26.2)	
≥ 4,000	48	31(64.6)		2.65 ± 2.98		22(45.8)	
Gender							
Male	255	126(49.4)	0.786	1.89 ± 2.85	0.811	66(25.9)	0.270
Female	236	113(47.9)		2.09 ± 3.12		72(30.5)	
Age (years)							
4.5–4.9	418	198(47.4)	0.204	2.00 ± 3.04	0.487	117(27.9)	0.888
5.0–5.3	73	41(56.2)		1.95 ± 2.66		21(28.8)	
Preterm birth (Gestational weeks < 37)							
No	474	231(48.7)	0.892	2.00 ± 2.98	0.566	135(28.5)	0.329
Yes	17	8(47.1)		1.59 ± 3.02		3(17.7)	
Age of mother (years)							
< 34	446	217(48.7)	0.976	1.98 ± 2.99	0.930	125(28.0)	0.902
≥ 34	45	22(48.9)		2.02 ± 2.90		13(28.9)	
Maternal educational level (years)							
< 13	64	35(54.7)	0.480	2.95 ± 3.69	0.110	26(40.6)	0.050
13–15	379	179(47.2)		1.88 ± 2.92		101(26.6)	
≥ 16	48	25(52.1)		1.52 ± 2.06		11(22.9)	
Annual household income (RMB)							
< 100,000	141	81(57.5)	0.063	2.69 ± 3.49	**0.019**	51(36.2)	0.065
100,000–199,999	185	88(47.6)		1.64 ± 2.39		49(26.5)	
≥ 200,000	77	31(40.3)		1.79 ± 3.31		16(20.8)	
Unclear	88	39(44.3)		1.77 ± 2.78		22(25.0)	

Table 4 Multivariate logistic regression analysis for dental caries (dmft ≥ 3) among children and their mothers

Variable	*P*	OR	95% CI	
			Lower	Upper
Gender (reference, male)	0.245	1.264	0.848	1.866
Age (reference, 4 years old)	0.856	1.052	0.606	1.827
Preterm birth (reference, No)	0.326	0.531	0.150	1.880
Birth weight (g)				
≤ 2,500	0.683	0.709	0.136	3.699
2,500–3,999	—	—	—	—
≥ 4,000	**0.005**	**2.437**	1.306	4.549
Annual household income (In Renminbi)				
< 100,000	**0.020**	**2.160**	1.129	4.134
100,000–199,999	0.331	1.374	0.724	2.605
≥ 200,000	—	—	—	—
Unclear	0.521	1.271	0.611	2.642
Maternal educational level (years)				
< 13	—	—	—	—
13–15	0.053	0.448	0.199	1.001
≥ 16	**0.020**	**0.326**	0.121	0.911

variables listed in Table 2 were included in the model. In the final model, only significant covariates persisted.

After adjustment for the confounding factors under study, the results showed that high birth weight (≥4,000 g) was significantly associated with the prevalence of ECC (OR, 2.000; 95% CI=1.062–3.765, Table 3) and the outcome of severe caries experience (dmft≥3) (OR, 2.437; 95% CI=1.306–4.549, Table 4) compared with the normal birth weight group (2,500 g – 3,999 g).

The remaining significant variables in the final model, except for high birth weight, were annual household income and maternal educational level (Tables 3 and 4). Low annual household income (< ¥100,000) was associated with the prevalence of ECC (OR, 2.003; 95% CI=1.139–3.524, Table 3) and the outcome of severe caries experience (dmft≥3)(OR, 2.160; 95% CI=1.129–4.134, Table 4) compared with the group with annual household income more than or equal to ¥200,000. In contrast, high maternal educational level was only indicated in the outcome of severe caries experience (dmft≥3) as a protective factor compared with the group with low maternal educational level (OR, 0.326; 95% CI=0.121–0.911) (Table 4).

Discussion

ECC has a significant impact on oral health, general health, growth, and the children's quality of life, their families, and the communities [32, 33]. In this study, ECC prevalence was 48.7% and showed a non-homogeneous distribution of dental caries like most previous studies conducted in mainland China [34]. According to the study results, the null hypothesis, which stated that high birth weight was not a risk factor for ECC, was rejected.

The Significant Caries (SiC) index has been proposed focusing on individuals with the highest caries values in every population [27] Thus, the SiC index was also chosen to assess the caries risk indicators that are associated with the one-third of individuals experiencing severe caries in this study. According to the study's outcome, the SiC index was approximately 5.3. Less than one-third of the children with dmft index more than 2 contributed 83.4% of the total decayed, missing, or filled deciduous teeth. Thus, caries experience (dmft≥1) and severe caries experience (dmft≥3) were both used as the logistic regression analysis outcomes.

It demonstrated that a high birth weight (≥4,000 g) is associated with the development of caries later in life during childhood. The risk of caries experience (dmft≥1) and severe caries experience (dmft≥3) for children born with a birth weight of 4,000 g or higher was 2.000 (OR) and 2.437 (OR), respectively, adjusted for potential confounders. At this time, we cannot definitively explain the mechanisms behind the observed association between high birth weight and dental caries. Possible mechanisms may include a reduction in the salivary flow rate and an alteration of the oral microflora due to decreased salivary flow. Several studies have shown that children with high birth weight (≥4,000 g) are reported to exhibit a higher prevalence of being overweight with increased risk for obesity [35]and diabetes [36] later in life. Another cohort study [37] found that increased weight at birth was associated with a small increased risk of caries at 61 months. While the researchers of this study did not find more conclusive data in support of growth rates and caries risk in children. It cannot be considered causal. Therefore, the relationship between the variables warrants further investigation.

For children with low birth weight (<2,500 g), there was no enhanced risk for dental caries development, which was consistent with the majority of studies reporting no associations between dental caries and gestational age or low birth weight [20–23]. One explanation could be the sample size of children with low birth weight is too small for the calculating power. The other explanation could be closer monitoring and more frequent antibiotic use in children with low birth weight, which, in the long-term, influence the oral colonization of caries-related microorganisms. Unfortunately, information regarding antibiotic use was not available and is therefore a limitation of this study. Notably, some studies mentioned the positive association between very low birth weight (<1,500 g) and caries experience [24, 25], due to the small sample size of the children with low birth weight of this study, we did not design an analysis for this part.

In recent years, increased attention has been paid to parental socioeconomic status because the prevalence of ECC was influenced by parental oral health knowledge and their attitudes on oral health practices [38]. Our finding that annual household income was inversely associated with the prevalence of ECC and severe caries experience (dmft≥3) was consistent with the previously reported findings [3, 39]. Indeed, a lower annual household income can significantly influence dietary habits, where increased sugar consumption emerges as a critical pathway linking reduced family income with a higher prevalence of ECC and more severe instances of caries. The low maternal educational level was found to be a prospective factor for the severe caries experience (dmft≥3), which was also widely supported [40, 41]. The level of education serves as a crucial socioeconomic marker, encapsulating the knowledge and skills essential for making informed health-related decisions. Often, the mother, as the primary caregiver, plays a pivotal role in this dynamic. Mothers with higher education levels tend to exhibit more positive attitudes and a stronger determination to regulate their children's sugar consumption compared to those with lower educational attainment.

This study was based on data from the ongoing prospective cohort study of children born at Xinhua Hospital in 2014 and 2015. Compared to traditionally designed studies, this cohort study design with data collection at several time points during pregnancy and early childhood had the advantage of reduced recall bias. Logistic regression models were used which can effectively handle potential confounding factors. This study also has some weaknesses, and the results need to be interpreted with care. First, despite having adjusted for several potential confounding factors, there is the possibility that unmeasured factors influenced our results. These factors may be responsible for the positive associations we discovered. Another limitation was that information about parental dental conditions was not collected, which may have directly affected the incidence of caries in their children. However, because parental lifestyles and dental hygiene are somehow reflected in socioeconomic status, this potential confounding factor might have been reduced by adjusting for information regarding the parental socioeconomic status aspects. The third potential limitation of this study is its regional restriction and small range of subjects; therefore, the results may not apply to other regions of China.

In conclusion, a high birth weight of more than or equal to 4,000 g is correlated with increased risk of caries. Although the underlying mechanisms of the observed associations are unclear, high birth weight can be regarded as a predictor for dental caries and should be taken into consideration in the risk assessment. It may be essential to pay more attention to children with high birth weight in an effort to prevent dental caries. Future studies with a larger sample size clarifying the roles of birth conditions on dental caries and the underlying mechanisms are needed.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-024-04651-6.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions
Lisu Huang, Xinxin Zeng and Qian Chen were charge for the whole birh-cohort study. Jin Yu, Yiwei Jiang and Dongxin Da conducted the data analysis and prepared all the tables. Huning Wang and Hao Zhang were responsible for the primary manuscript writing, while Xiaoli Zeng and YingZhang contributed to the research design and methodology. All authors have reviewed and approved the final manuscript.

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Data availability
The datasets generated and analysed during the current study are not publicly available due to the undergoing progress but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was reviewed and approved by the Ethics Committee of Xinhua Hospital affiliated to Shanghai Jiao Tong University (No. XHEC-C-2013-001) in accordance with the ethical guidelines and regulations of the Declaration of Helsinki. A written informed consent was obtained from each participant and children's legal guardians, and each of them was interviewed before participating in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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