

# BMJ Open Risk factors associated with early childhood caries among Wenzhou preschool children in China: a prospective, observational cohort study

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## ABSTRACT

**Objectives** Early childhood caries (ECC) is a serious health public problem that affects a large proportion of children in China. This study aimed to assess risk factors for the incidence of ECC among Wenzhou (China) preschoolers.

**Design** Prospective, observational cohort study.

**Setting** Kindergartens (n=6) in Wenzhou, China.

**Participants** 606 children who were 3–4 years of age and newly arrived in the kindergartens in September 2011.

**Methods** This was a longitudinal observational study with a 2-year follow-up of preschoolers of 3–4 years of age in Wenzhou (Southeast China). Oral health data were collected annually after the baseline survey. The risk factors associated with visible caries and increment of decayed, missing and filled teeth (dmft) were analysed through univariable and multivariable regression using generalised estimating equations.

**Results** The prevalence of ECC was increasing during the follow-up period (59.8% at enrolment, 71.8% at first year, and 76.4% at second year). Older age (b=0.07; 95% CI: 0.05 to 0.09; p<0.001), caregivers (relatives or nannies) (b=-1.20; 95% CI: -2.23 to -0.16; p=0.023), lower annual family income (¥10 000–¥20 000: b=2.04; 95% CI: 1.04 to 3.04; p<0.001; <¥10 000: b=1.78; 95% CI: 0.65 to 2.92; p=0.002) and more frequent consumption of sugary snacks/drinks at night (sometimes: b=0.88; 95% CI: 0.20 to 1.56; p=0.011; always: b=1.19; 95% CI: 0.13 to 2.25; p=0.028) were independently associated with the increments of dmft. Older age (OR=1.04, 95% CI: 1.03 to 1.05, p<0.001) and more frequent consumption of sweet snacks (OR=1.86, 95% CI: 1.06 to 3.27; p=0.030) were independently associated with a higher risk of visible caries.

**Conclusions** The occurrence and severity of ECC were associated with older age, caregivers (relatives or nannies), lower annual family income and more frequent consumption of sweet snacks. It is imperative to strengthen oral health education for parents and limit sugary foods/snacks.

## INTRODUCTION

Early childhood caries (ECC) is the development of dental caries in primary teeth of children <6 years of age.<sup>1</sup> It is a common disease affecting the oral health-related quality of life

## Strengths and limitations of this study

- This is the first study assessed the impact of dietary lifestyle, oral health behaviours and socioeconomic characteristics on the incidence of early childhood caries in preschoolers of 3–4 years of age in Wenzhou, China.
- Since the age of children would be a significant confounder, participants in this study were preschoolers aged 3–4 years.
- The sample size of this study was sufficient and the rate of lost to follow-up was controlled.
- The study sample was selected from a limited geographical area; therefore, it may not be regarded as representative of the children of that age living in Wenzhou.
- In this study, oral microbiology was not assessed; a study showed that a higher rate of *Streptococcus mutans* was associated with caries in Chinese children.

of young people.<sup>2 3</sup> In the past 10 years, the prevalence of ECC among 5-year-old children has been rising in China, with the rate of caries rising from 66.0% to 71.9%.<sup>4 5</sup>

Dental caries is a chronic and multifactorial-induced infectious disease.<sup>6–8</sup> Evidence from the literature indicates that low family socioeconomic status (SES), consumption of sugary food and beverages, poor oral hygiene status and high level of *Streptococcus mutans* bacteria are associated with ECC.<sup>9–11</sup> Warren *et al*<sup>12</sup> observed that frequent consumption of sugary beverages was a significant risk factor for ECC. Similarly, Johansson *et al*<sup>13</sup> reported that the frequent consumption of sweet snacks increased the occurrence of ECC.

The relationship between SES and ECC has been shown in previous studies, which concluded that low SES was the main risk factor for ECC.<sup>14 15</sup> A cross-sectional study conducted in the United Arab Emirates found that the mean numbers of decayed, missing and filled teeth (dmft) of preschool children

were associated with the parents' perceptions about their child's dental status and maternal education.<sup>16</sup> Kato *et al*<sup>15</sup> found that parental education and family income were inversely associated with the prevalence of ECC in children. According to the National Health and Nutrition Examination Survey, children who lived in poverty had higher rates of caries than those who did not.<sup>17</sup> Nevertheless, children with higher monthly family incomes still have a high risk of caries,<sup>18</sup> suggesting that other multiple factors could be involved in the incidence of ECC.

Due to the difficulty of conducting longitudinal studies, there is relatively few available data describing the relationship between risk factors and the incidence of ECC. Zhou *et al*<sup>18</sup> stated that the incidence of ECC could be related to socioeconomic, behavioural and biological factors. A cohort study conducted in African-American preschoolers aged 3–22 months indicated that an increased incidence of ECC was associated with more frequent consumption of sweets, lower frequency of toothbrushing, occasionally or no fruit juice and a history of a visit to a dentist.<sup>19</sup>

Longitudinal studies represent the study design of choice to analyse the risk of dental caries for the exposure factors during an individual's lifetime. Therefore, this longitudinal study aimed to assess the impact of dietary lifestyle, oral health behaviours and socioeconomic characteristics on the occurrence and severity of ECC in preschool children.

## METHODS

### Study design and population

This was a longitudinal observational study that started in October 2011 and with a 2-year follow-up in Wenzhou (Southeast China). The study was led by the Department of Preventive and Pediatric Dentistry, School and Hospital of Stomatology, Wenzhou Medical University. There are three districts in Wenzhou: Lucheng, Longwan and Ouhai. Each district was divided into developed and developing regions according to the per capita income. A kindergarten was sampled randomly from one developed and one developing region in each district, and finally, six kindergartens were included in this study.

Children who were 3–4 years of age and newly arrived in the kindergarten in September 2011 were enrolled after discussion with their parents, who accepted the oral cavity examination for up to 2 years. Exclusion criteria were children who were not resident or had systemic disease (such as cardiovascular and cerebrovascular disease, epilepsy and leukaemia), which has an impact on the data integrity and/or the safety of the participant.

Written informed consent was obtained from all children's parents.

### Sample size

The prevalence of ECC in 5-year-old children was 66% in China.<sup>4</sup> Since the subjects were 3–4 years old, the estimated prevalence of dental caries would be less than 66%. The calculation of the sample size was based on an

estimate of the prevalence of ECC 50%.<sup>20</sup> It resulted in 500 children, considering a power of 90%, a significant difference level of 5% and attrition of 20%.

### Dental examination and diagnostic criteria

The oral examinations were conducted by a single examiner under natural light in a bright classroom in the kindergarten. The examinations were performed annually for 2 years. In well-lit premises, the dental examination was performed with a dental mirror and probe after drying the teeth with a sterile dry cotton ball. The number of dmft and the number of dmft surface (dmfs) were recorded. The examiner evaluated caries using dmft and dmfs according to the WHO criteria.<sup>21</sup> Dental caries was found by visual examination without an X-ray. The examiner was trained and calibrated against a gold-standard examiner. Every examination period, 10% of the participants were re-examined. Kappa scores for the reproducibility of the single examiner for each wave of exams were 0.96, 0.98 and 0.96, respectively.

### Data collection

Oral examination was conducted by a single examiner and recorded by another dentist in the kindergarten (online supplemental appendix 1). Data on caries-related factors were collected by structured questionnaires (online supplemental appendix 2/online supplemental appendix 3). Questionnaires were distributed to parents or other guardians annually after the oral examination and were collected the following day. The collected data included dietary habits (consumption of carbonated beverage, sweet snacks, and candies/chocolate, and consumption of sugary snack/drinks at night), feeding habits (breastfed or not and sleeping with a bottle), children's oral hygiene behaviours (age tooth brushing started and frequency of toothbrushing), parental oral health practices (parents helped with tooth brushing and checked after tooth brushing), caregivers (who took care of the child, such as parents, grandparents, relatives or nannies), dental services and SES (annual family income and mother's education level). Moreover, a 5-item knowledge survey on dental caries was used to assess parental knowledge on oral health. The score of each correct answer is 1 point, and the score of oral health knowledge was calculated by the sum of the scores of the five questions. The scores on oral health knowledge were classified as poor (score 0–2), intermediate (score 3) or good (score 4–5). The design of the questionnaire was based on the national Third Oral Health Questionnaire.

### Statistical analysis

All collected data were entered in EpiData software, V.3.1. Continuous variables were described using means and SDs. Categorical data were presented as counts and percentages. EmpowerStats (X&Y Solutions, Wilmington, Delaware, USA) and R software V.2.11.1 (The R Project for Statistical Computing, [www.r-project.org](http://www.r-project.org)) were used for statistical analysis. Considering the non-independent

characteristic of the repeated measurements on the same subject over time, the correlates of possible risk factors and the outcome of visible caries and dmft were examined with univariable and multivariable regression using generalised estimating equations. The ORs with 95% CIs are reported. Two-sided values of  $p < 0.05$  were considered statistically significant.

### Patient and public involvement statement

Not applicable.

## RESULTS

### Characteristics of the participants

A total of 606 resident children of 3–4 years of age were enrolled, and 87 non-resident children who did not complete at least two oral examinations were excluded in the study, resulting in a participation rate of 87.4%. There were 278 girls (47.9%) and 328 boys (52.1%). The response rates of annual dental examination were 445 (73.4%), 584 (96.4%) and 560 (92.4%). The reason for not completing the oral examination was that the child was absent on the examination day or had odontophobia. The recovery rates of annual valid questionnaires were 362 (59.7%), 389 (64.2%) and 370 (61.1%), respectively. Of the 606 participants, 57 children without questionnaire data were not included in the risk factor analysis. Combining dental examination data and questionnaire data, the final risk factor analysis was based on a total of 549 children.

Table 1 presents the characteristics of the children and their parents. The questionnaires were mostly filled by the mothers (70.2%–73.8%). Most mothers had <12 years of education (44.8%–54.8%). The prevalence of ECC in the children of 3–4 years of age was 59.8%. After 1 year

of follow-up, the prevalence increased to 71.8%. After 2 years of follow-up, the prevalence increased to 76.4%.

### Univariable analyses

Univariable analyses (tables 2 and 3) on the incidence density of a tooth developing caries showed that children who were taken care of by others (relatives or nannies) had lower increments of dmft ( $b = -1.27$ ; 95% CI:  $-2.28$  to  $-0.26$ ;  $p = 0.014$ , table 2). Lower annual family income (¥10 000–¥20 000:  $b = 1.97$ ; 95% CI: 0.94 to 2.99;  $p < 0.001$ ; <¥10 000:  $b = 1.79$ ; 95% CI: 0.65 to 2.93;  $p = 0.002$ , table 2), consumption of sweet snacks >1 time/day ( $b = 1.12$ ; 95% CI: 0.08 to 2.16;  $p = 0.035$ , table 3), more frequent consumption of sugary snack/drinks at night (sometimes:  $b = 0.97$ ; 95% CI: 0.31 to 1.64;  $p = 0.004$ ; always:  $b = 1.56$ ; 95% CI: 0.50 to 2.62;  $p = 0.004$ , table 3) and parental checking after toothbrushing (sometimes) ( $b = 0.69$ ; 95% CI: 0.10 to 1.28;  $p = 0.021$ , table 2) were associated with higher increments of dmft.

Univariable analyses for visible caries showed that children whose mother had more than 15 years of education experience had a lower risk of dental caries (OR=0.59, 95% CI: 0.37 to 0.96;  $p = 0.033$ , table 2). Children who consumed sweetened snacks more than once a day had a higher risk of dental caries (OR=2.02, 95% CI: 1.15 to 3.55;  $p = 0.015$ , table 3). Children who consumed sugary snacks/drinks at night frequently had a higher risk of dental caries (OR=1.78, 95% CI: 1.09 to 2.90;  $p = 0.020$ , table 3).

### Multivariable analyses

The multivariable model (table 4) for the increments of dmft showed that older age ( $b = 0.07$ ; 95% CI: 0.05 to 0.09;  $p < 0.001$ ), caregivers (relatives or nannies) ( $b = -1.20$ ; 95% CI:  $-2.23$  to  $-0.16$ ;  $p = 0.023$ ), lower annual family income

**Table 1** Characteristics of the children and parents

Variables	Baseline	First follow-up	Second follow-up
Questionnaire completers, n (%)			
Father	84 (23.1)	79 (20.3)	74 (20.0)
Mother	267 (73.8)	273 (70.2)	266 (71.9)
Others	11 (3.0)	37 (9.5)	30 (8.1)
Mother's educational level (years), n (%)			
<12	162 (44.8)	213 (54.8)	195 (52.7)
13–15	97 (27.8)	91 (23.4)	82 (22.2)
>15	103 (28.5)	85 (21.9)	93 (25.1)
Children			
Sex, n (%)			
Male	237 (53.3)	313 (53.6)	305 (54.5)
Female	208 (46.7)	271 (46.4)	255 (45.5)
Caries, n (%)			
Without caries	179 (40.2)	165 (28.3)	132 (23.6)
With caries	266 (59.8)	419 (71.8)	428 (76.4)

**Table 2** Univariable analyses between sociodemographic status, parental oral health behaviour, parental oral health knowledge level and ECC

Variables	dmft		Experience of caries	
	b (95% CI)	P value	OR (95% CI)	P value
Mother's education level (years), n (%)				
<12*	262 (23.4)	0	1	
13–15	578 (51.6)	−0.36 (−1.19 to 0.47)	0.93 (0.61 to 1.40)	0.717
>15	281 (25.1)	−0.48 (−1.53 to 0.56)	0.59 (0.37 to 0.96)	0.033
Annual family income (¥), n (%)				
>¥20 000*	33 (2.9)	0	1	
¥10 000–¥20 000	833 (74.3)	1.97 (0.94 to 2.99)	1.43 (0.63 to 3.26)	0.392
<¥10 000	255 (22.8)	1.79 (0.65 to 2.93)	1.35 (0.57 to 3.21)	0.493
Caregiver, n (%)				
Parents	776 (69.2)	0	1	
Grandparents	304 (27.1)	0.51 (−0.31 to 1.33)	1.09 (0.75 to 1.59)	0.658
Relatives or nannies	41 (3.7)	−1.27 (−2.28 to −0.26)	0.91 (0.39 to 2.13)	0.834
Parents help with tooth brushing, n (%)				
Once a day*	204 (18.2)	0	1	
Once a week	126 (11.2)	0.37 (−0.54 to 1.28)	1.13 (0.68 to 1.90)	0.630
Sometimes	662 (59.1)	0.23 (−0.48 to 0.95)	1.08 (0.75 to 1.55)	0.673
Never	129 (11.5)	0.52 (−0.54 to 1.59)	1.07 (0.63 to 1.81)	0.807
Parental check after tooth brushing, n (%)				
≥1 time/week*	289 (25.8)	0	1	
<1 time/week	832 (74.2)	0.69 (0.10 to 1.28)	1.24 (0.90 to 1.70)	0.192
Parental oral health knowledge level, n (%)				
Poor*	221 (19.7)	0	1	
Intermediate	557 (49.6)	−0.11 (−0.87 to 0.65)	0.87 (0.61 to 1.24)	0.436
Good	344 (30.7)	0.28 (−0.55 to 1.10)	1.21 (0.80 to 1.84)	0.370

\*Reference group.

dmft, decayed, missing and filled teeth; ECC, early childhood caries.

(¥10 000–¥20 000:  $b=2.04$ ; 95% CI: 1.04 to 3.04;  $p<0.001$ ; <¥10 000:  $b=1.78$ ; 95% CI: 0.65 to 2.92;  $p=0.002$ ) and more frequent consumption of sugary snacks/drinks at night (sometimes:  $b=0.88$ ; 95% CI: 0.20 to 1.56;  $p=0.011$ ; always:  $b=1.19$ ; 95% CI: 0.13 to 2.25;  $p=0.028$ ) were independently associated with the increments of dmft.

The multivariable model (table 4) for visible caries showed that older age (OR=1.04, 95% CI: 1.03 to 1.05;  $p<0.001$ ) and more frequent consumption of sweet snacks (OR=1.86, 95% CI: 1.06 to 3.27;  $p=0.030$ ) were independently associated with a higher risk of visible caries.

## DISCUSSION

ECC is a serious health public problem that affects a large proportion of children in China.<sup>4 5</sup> This study aimed to assess risk factors for the incidence of ECC among Wenzhou (China) preschoolers. The results showed that the occurrence and severity of ECC were associated with older age, caregivers (relatives or nannies), lower annual

family income and consumption of sweet snacks. Those results are supported by other studies on ECC.<sup>22 23</sup>

Most studies reported an association between ECC and frequent consumption of sweets.<sup>12 13 24</sup> This study reported that children who ate sweet snacks frequently or consumed sugary snacks/drinks at night had a higher risk of dental caries. The results are supported by previous studies.<sup>6 7 12 13 24</sup> Watanabe *et al*<sup>25</sup> reported that the incidence of ECC was associated with the consumption of sweet snacks and sweetened beverages. The findings suggest that it is necessary to strengthen oral health education for parents and to limit the intake of sugary foods/snacks.

In this study, the multivariable analysis showed a lower increment of dmft among children who were taken care of by relatives or nannies. It was reported that children who were taken care of primarily by grandparents had higher dmft increments.<sup>26</sup> Children whose mother worked in professional and engineering or service had

**Table 3** Univariable analyses between dietary information, oral hygiene practices and ECC

Variables	dmft		P value	Experience of caries	
	b (95% CI)			OR (95% CI)	P value
<b>Breastfed or not, n (%)</b>					
Breastfed*	248 (22.1)	0		1	
Breastfed mainly	199 (17.8)	-0.16 (-1.07 to 0.76)	0.738	0.98 (0.63 to 1.53)	0.946
Mixed feed	248 (22.1)	-0.73 (-1.63 to 0.16)	0.107	0.92 (0.59 to 1.44)	0.724
Formula feed mainly	162 (14.5)	-0.34 (-1.42 to 0.74)	0.538	0.99 (0.59 to 1.67)	0.977
Formula feed	264 (23.6)	-0.07 (-1.07 to 0.93)	0.886	1.25 (0.77 to 2.03)	0.359
<b>Consumption of carbonated beverage, n (%)</b>					
<1 time/day*	981 (87.5)	0		1	
1 time/day	100 (8.9)	0.21 (-0.71 to 1.14)	0.651	1.19 (0.70 to 2.02)	0.523
>1 time/day	40 (3.6)	0.45 (-0.89 to 1.79)	0.510	1.77 (0.81 to 3.89)	0.155
<b>Consumption of sweet snacks, n (%)</b>					
<1 time/day*	513 (45.8)	0		1	
1 time/day	506 (45.1)	0.36 (-0.25 to 0.98)	0.246	1.30 (0.97 to 1.74)	0.082
>1 time/day	102 (9.1)	1.12 (0.08 to 2.16)	0.035	2.02 (1.15 to 3.55)	0.015
<b>Consumption of candies/chocolate, n (%)</b>					
<1 time/day *	848 (75.7)	0		1	
1 time/day	215 (19.2)	0.64 (-0.09 to 1.38)	0.087	1.37 (0.92 to 2.03)	0.119
>1 time/day	58 (5.2)	0.48 (-0.85 to 1.84)	0.479	1.54 (0.76 to 3.10)	0.233
<b>Sugary snack/drinks at night, n (%)</b>					
Never*	225 (20.1)	0		1	
Sometimes	712 (63.5)	0.97 (0.31 to 1.64)	0.004	1.40 (0.98 to 2.00)	0.063
Always	184 (16.4)	1.56 (0.50 to 2.62)	0.004	1.78 (1.09 to 2.90)	0.020
<b>Slept with bottles, n (%)</b>					
Never*	942 (84.1)	0		1	
Sometimes	110 (9.8)	0.95 (-0.07 to 1.97)	0.069	1.47 (0.91 to 2.38)	0.118
Always	68 (6.1)	0.42 (-1.04 to 1.88)	0.573	1.13 (0.57 to 2.25)	0.725
<b>Age toothbrushing started, n (%)</b>					
1 year old*	48 (4.3)	0		1	
2 years old	152 (13.6)	-0.01 (-1.82 to 1.81)	0.993	0.93 (0.46 to 1.88)	0.837
3 years old	836 (74.6)	0.81 (-0.99 to 2.61)	0.379	1.38 (0.68 to 2.81)	0.371
Never	85 (7.6)	1.01 (-1.08 to 3.11)	0.343	1.39 (0.57 to 3.37)	0.469
<b>Frequency of toothbrushing, n (%)</b>					
≥2 time/day*	209 (18.6)	0		1	
1 time/day	419 (37.4)	0.11 (-0.68 to 0.90)	0.793	0.95 (0.63 to 1.45)	0.825
<1 time/day	450 (40.1)	0.36 (-0.53 to 1.25)	0.430	0.94 (0.61 to 1.46)	0.792
Never	43 (3.8)	0.50 (-1.42 to 2.42)	0.611	0.84 (0.37 to 1.91)	0.677

\*Reference group.

dmft, decayed, missing and filled teeth; ECC, early childhood caries.

lower rates of dental caries than those whose mother was unemployed.<sup>15</sup> When the caregiver was not a parent or grandparent but someone else (a relative or a nanny), the family had to bear the cost of hiring that person, indicating that the family had sufficient income. Compared with the elderly, relatives or nannies might have higher

compliance and better service awareness, and they might be more responsible for children's oral health.

Our findings showed that children with a lower family income had a higher increment of dmft and children whose mother had more than 15 years of education experience had a lower risk of dental caries, as supported by

**Table 4** Risk factors associated with the increment of dmft and the experience of caries analysed by generalised estimating equation

Factors	dmft			Experience of caries		
	b	95% CI	P value	OR	95% CI	P value
(Intercept)	-2.97	-4.94 to -1.00	0.003	0.09	0.02 to 0.34	<0.001
Age (months)	0.07	0.05 to 0.09	<0.001	1.04	1.03 to 1.05	<0.001
Sex (girls)	-0.14	-0.84 to 0.57	0.708	1.26	0.87 to 1.83	0.215
Mother's education level (years)						
<12*	0			1		
13–15	-0.34	-1.16 to 0.47	0.411	0.94	0.62 to 1.44	0.789
>15	-0.29	-1.32 to 0.74	0.580	0.63	0.38 to 1.04	0.074
Caregiver						
Parents*	0			1		
Grandparents	0.53	-0.28 to 1.33	0.201	1.13	0.77 to 1.65	0.538
Relatives or nannies	-1.20	-2.23 to -0.16	0.023	0.98	0.40 to 2.43	0.967
Annual family income						
>¥20 000*	0			1		
¥10 000–¥20 000	2.04	1.04 to 3.04	<0.001	1.44	0.63 to 3.29	0.384
<¥10 000	1.78	0.65 to 2.92	0.002	1.34	0.56 to 3.19	0.510
Consumption of sweet snacks						
<1 time/day*	0			1		
1 time/day	0.28	-0.33 to 0.89	0.374	1.21	0.90 to 1.63	0.215
>1 time/day	0.89	-0.15 to 1.94	0.095	1.86	1.06 to 3.27	0.030
Sugary snack/drinks at night						
Never*	0			1		
Sometimes	0.88	0.20 to 1.56	0.011	1.29	0.90 to 1.84	0.163
Always	1.19	0.13 to 2.25	0.028	1.42	0.86 to 2.36	0.168
Parental check after toothbrushing (sometimes)	0.47	-0.12 to 1.06	0.0116	1.14	0.82 to 1.59	0.427

\*Reference group.

dmft, decayed, missing and filled teeth.

the previous studies.<sup>15 27</sup> Nevertheless, the underlying mechanism of the influence of the SES on dental caries still needs to be defined. Parental SES might affect the prevalence of ECC through parental oral health knowledge and practices.<sup>28</sup> Educated mothers are more likely to know how to protect their children from dental caries. Patients with special needs and difficulty accessing oral health services seems to have higher rates of dental caries.<sup>29</sup> Clearly, these issues warrant further research, including further analyses of the present study's data. Whether there is a relationship between parental SES and oral health behaviours remains unknown.

There were some limitations to this study. First, some information bias and recall bias were inevitable in this investigation. Second, some people might sometimes respond to questionnaires based on general social norms rather than actual situations because they attempt to adhere to what is socially desirable. Third, there was some selection bias. The study sample was selected from a limited geographic area. Therefore, it may not be

regarded as representative of the children of that age living in Wenzhou. Fourth, oral microbiology was not assessed; a study showed that high rates of plaque mutans streptococci were associated with caries in Chinese children.<sup>30</sup> Finally, due to the high prevalence of dental caries among 3–4 years old children, further research in younger children was necessary.

## CONCLUSIONS

The occurrence and severity of ECC were associated with older age, caregivers (relatives or nannies), lower annual family income and more frequent consumption of sweet snacks. The findings indicated that lower SES and more frequent consumption of sweet snacks had a significant impact on the occurrence and severity of ECC.

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**Contributors** LM designed the study, carried out the dental examinations and drafted the manuscript. HS performed the statistical analysis and helped draft the manuscript. ZW participated in the study design and helped carry out the examinations. QL collected the data and helped draft the manuscript. XW carried out the examinations, collected data and drafted the manuscript. All authors read and approved the final manuscript.

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**Patient consent for publication** Not required.

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