Assessment of risk factors for early childhood caries at different ages in Shandong, China and reflections on oral health education: a cross-sectional study

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Abstract

Background: The high prevalence of early childhood caries (ECC) is widespread around the world, and oral health education (OHE) plays a vital role in preventing ECC. Numerous studies on ECC risk factor assessment have assisted us enrich the content of OHE. The objective of this study, while, was to further assess independent risk factors for ECC at different ages and provide evidence and insight for OHE.

Methods : Data about oral health status, and oral health knowledge, attitude, practice (KAP) from the questionnaire completed by caregivers among children 3 to 5 years of age (N=1301) in Shandong province were extracted from the 4 th National Oral Health Survey in China. The association between ECC prevalence and various KAP variables was tested in Chi-square test, bivariate analysis and by multivariable logistic regression analyses.

Results: The ECC prevalence in Shandong province was 64.6%, the dmft mean was 3.15. Independent associations with increased risk for ECC were age, feeding method within 6 months of birth, bedtime sugar frequency, the experience of toothache over past one year and dental visit. And feeding methods primarily contribute to the high risk of 3-year-old group, while sugar habits mainly contribute to 5-year-old group. The association between brushing and ECC was not confirmed in this study, and correct cognition was unexpectedly positively correlated with the high risk of ECC.

Conclusion: These data provide evidence to suggest that the ECC-related risk factors at different ages are inconsistent, which give some insights for OHE, that is in addition to promoting preventive dental visit, we should also highlight the effect of feeding methods in the early of deciduous dentition and sugar habits in the late stage of deciduous dentition on ECC and the supplement of practice training.

Background

The high prevalence of early childhood caries (ECC) is a common phenomenon in China and the whole world[1, 2], coupled with its adverse effect on the oral health and even general health[3, 4]. Hence strengthen the prevention of ECC has been the most urgent and significant task for dentists and entire society.

The current prevention of caries is mainly achieved through the following two aspects: i) Professional preventive measures implemented in the hospital: including fluoride coating, pit and fissure sealing, and forth[5–7]; Research dedicating in novel anti-caries materials is one of the hotspots of current basic research. ii) Self-oral health care (S-OHC) behavior: in addition to brushing, gargle, using gloss to remove dental plaque, the control of high-risk factors related to caries such as sugar consumption, feeding habits, etc., is also significant[6, 8, 9]. Access to these information is primarily through the oral health education (OHE), covering hospital, school, community and network platforms[10].

OHE has always contributed to dental caries prevention[11, 12], which brings intuitive guidance and assistance to human beings. The setting of OHE details is mainly based on the researches involving ECC

risk factor assessment, which could provide tough evidence and support for OHE. At present, many high-risk factors associated with dental caries have been evidenced, such as poverty, race, eating habits, family economic status, education level, etc.[13–15]. However, few studies have separately analyzed and assessed the risk factors for each age group, but instead taken the entire preschool children as a whole, which hindered us from preventing dental caries more effectively through the way of optimizing and enriching OHE.

Shandong province located in the lower reaches of the Yellow River, bordering on the Bohai Sea and the Yellow Sea in the east. The local resident primarily takes wheat and its products. Its GDP ranks third in China and it's one of the representative cities in northern China. However, few studies have reported the oral health status of children in Shandong Province.

Therefore, this cross-sectional study intends to explore and analyze the oral health status and independently risk factor for children aged 3–5 years old in Shandong province, China, and pay special attention to the risk factors associated with ECC in different age groups. Those variables involving socio-demographic factors, guardian knowledge, attitude, practice variables and children's oral health status are collected for statistical analyses. We hope that these data would provide guidance and evidence for improving and refining the contents of oral health education.

Methods

This cross-sectional study was conducted in 2015–2016 in Shandong province, which was part of the 4th National Oral Health Survey in China and had been approved by the Ethics Committee of the Chinese Stomatological Association (NO.2014-003).

Sample selection

3–5 years old children lived in Shandong province were our target population. The sample size was determined by the equal allocation of the national plan, at least 1296 sample data should finally be enrolled in this study. Incorporate sample population according to the following multi-stage stratified sampling method:

1. The probability proportion to size sampling (PPS) method determined the two districts and two counties for survey.
2. 3 kindergartens were randomly selected from each region
3. Using cluster sampling, 36 children were selected for each age group in each kindergarten.

Examiners selection and training

Three examiners from the Hospital of Stomatology were selected and trained. In order to ensure the consistency of clinical practice inter- and intra- examiners, each examiner randomly enrolled three participants to examination. Before calculating the Kappa value, every examination result must be calibrated with a qualified examiner. The mean Kappa value of intra-examiners was determined through re-examine the samples, the mean Kappa value of inter-examiners was calculated through mutual examine samples. Clinical practice training would be ended until the Kappa value is greater than 0.8.

Informed consent and questionnaire

After informed all kindergartens enrolled in this research the survey procedure and got support, our team would ask guardians to sign informed consent form. When the oral examination for children was performing, a questionnaire would be simultaneously completed by the guardians, the questionnaire contents mainly include:

- i) Personal and family information.
- ii) OHC knowledge, mainly involved in the effect of brushing, bacteria, sugar, pit and fissure sealing, fluoride and other factors on the teeth and gums.
- iii) OHC attitude, mainly to investigate whether the guardian believes that oral health is extremely important.
- iv) Guardians-guided OHC practice for children, mainly get information about feeding, sugar consumption, brushing, toothache, dental visit and some details information of children.

Caries assessment

A ball-end community periodontal index probe was used to assess dental status according to the WHO guidelines[16]. In addition, the written version of the examination results and treatment recommendations would be sent to guardians to increase the significance of the survey.

Statistical analysis

The IBM SPSS Statistics version 17.0 was used to perform the statistical analyses. The prevalence of preschool children with ECC, and mean dmft count was calculated to assess the association of caries with selected KAP variables. analyses of variance, Chi-square test, Fisher's test and z test for post hoc comparisons were performed to assess statistical significance. Multivariate logistic regression models were carried out based on the outcomes of ECC (any versus none) to evaluate the independent risk factors while controlling for latent confounders found in the bivariate analyses ($P \leq 0.10$). All variables included in the models were categorical variables. Some count variables were adjusted to categorical variables if necessary, such as income variable. Differences were considered significant at $P < 0.05$.

Results

A total of 3 cities including 2 districts and 2 counties in Shandong were selected. 1330 preschool children had been invited. But due to the loss of 29 individual information, the remaining 1301 children's data were included in the final statistical analysis. 64.6% of 3-5-year-old children had ECC, and mean dmft was 3.15. The rates of 3, 4, and 5 age group were respectively 51.1%, 67.8%, 73.9%, the mean dmft were 2.16, 3.21, 4.01 (see Table 1). 96.4% of decayed teeth were waiting to be treated.

Table 1
Distribution and statistical significance by demographic variables for ECC. (n, (%))

Variables	Health	ECC	P
gender			
male	235 (36.1)	416 (63.9)	0.616
female	226 (34.8)	424 (65.2)	
Age			
3	203 (48.9) ^a	212 (51.1) ^a	0.000
4	142 (32.2) ^b	299 (67.8) ^b	
5	116 (26.1) ^b	329 (73.9) ^c	
Region			
urban	227 (34.9)	424 (65.1)	0.343
weihai	111 (34.3)	213 (65.7)	
hedong, linyi	116 (35.5)	211 (64.5)	
rural	234 (36.0)	416 (64.0)	
weifang	106 (32.7)	218 (67.3)	
pingyi, linyi	128 (39.3)	198 (60.7)	
Education			
Elementary school and below	88 (34.9)	164 (19.5)	0.699
junior high school	192 (36.8)	330 (39.3)	
Senior high school and above	181 (34.3)	346 (41.2)	
Income			
less than 30,000	111 (34.0)	215 (27.4)	0.357
40,000–60,000	166 (38.0)	271 (34.5)	
more than 70,000	153 (33.8)	300 (38.2)	
^{a, b, c} : Differences of caries prevalence between row variables, the same mark represents no difference between the two variables.			

Statistical analyses of ECC-related variables

The demographic characteristics are shown in Table 1, ECC rates increased with age ($P = 0.000$), whereas the gender, region, education background and income in this study had no association with the rates of ECC.

The distribution characteristic of KAP variables shows in Appendix Table S1. 80.9% of the questionnaires were completed by parents and the rest were done by older people ($P > 0.05$, data not shown). Analysis from perspective of OHC knowledge (Q22a-h) and attitude (Q21a-f), 66.0%-98.8% individuals could answer most of the questions correctly. While only 30.7% known that gum bleeding is not a normal phenomenon when brushing teeth (Q22a), 16.0% and 27.7% known that fit and fissure sealing or fluoride can protect teeth (Q22g, h), 35.8% believe that mother's oral health affects child's oral health (21f). Those who known that bacteria (Q22d) and sugar (Q22e) can induce the caries, pit and fissure sealing can protect teeth (Q22g), and those who believed that teeth health is related to your own protection (Q21c) were unexpectedly more likely to experience ECC ($P < 0.05$). Analysis from perspective of OHC practices (Q3-13). Children with completely artificial feeding within 6 months of birth had the lowest rates of ECC compared to other feeding methods (Q3, 45.0% vs 65.3%~66.5%; $P = 0.005$). And the frequency of eating sugary before going to bed at night was associated with increased rates of ECC (Q5, 58.6% vs 66.8% vs 73.8%; $P = 0.002$). In addition, 53.1% of all children ($n = 691$) had tooth-brushing habits with 98.8% using toothpaste, but only 8.8% ($n = 60$) known they were using fluoride toothpaste, and these children were unexpectedly having the highest rates of ECC compared to other ones who don't know (Q11, $n = 683$, 80.0% vs 62.2%, $P = 0.016$), and the earlier you start brushing your teeth, the lower rate of dental caries (Q7, $n = 691$, $P = 0.033$). Children who have frequent toothache or discomfort in the past 12 months (Q12) or who ever visited dentist (Q13) generally have a higher caries rate (88.1%-100.0% and 81.0%, $P = 0.000$). While the frequency and the number of brushing times per day in current study were not associated with increased numbers of caries.

Statistical analyses of ECC related variables at different ages

Considering that age was a significant difference variable, the differences of ECC rates across variables in each age group were analyzed to eliminate the potential effects of age. The results of bivariate analyses for different ages are shown in Table 2. In the 3-year-old group, children raised by parents who believe that sugar can induce dental decay and those who were primarily breastfed within 6 months of birth, had toothache recently or had visited a dentist were more likely to suffer from dental caries ($P < 0.05$). In the 4-year-old group, girls generally had higher rates of caries (72.9% vs 62.5%; $P = 0.025$), and children who had ever a toothache or dental visit still had the highest rates of ECC ($P < 0.05$). In the 5-year-old group, the frequency of eating sweets before going to bed, toothache experience or dental visit experience and cognitive status in which bacteria can cause dental caries were associated with increased rates of ECC ($P < 0.05$). Overall, the experience of toothache and dental visit (Q12 and 13) at each age were all correlated with the high risk of ECC.

Table 2
Differential KAP variables in different age groups. (n, (%))

Groups and variables	Health	ECC	P
For 3-year-old group (n = 415)			
Knowledge			
Q22e Does eat sugar cause dental caries?			
correct answer	160 (46.2) ^a	186 (53.8) ^a	0.017
wrong answer or do not know	43 (62.3) ^b	26 (37.7) ^b	
Practice			
Q3_group Feeding method within 6 months of birth			
complete breastfeeding	122(46.6) ^a	140(53.4) ^a	0.028
mainly breastfeeding	34(47.9) ^{a,b}	37(52.1) ^{a,b}	
complete artificial feeding	23(74.2) ^b	8(25.8) ^b	
mainly artificial feeding	9(64.3) ^{a,b}	5(35.7) ^{a,b}	
half breastfeeding and half artificial feeding	15(40.5) ^{a,b}	22(59.5) ^{a,b}	
Q12 Has your child had a toothache or discomfort in the past 12 months?			
Never	179(54.4) ^a	150(45.6) ^a	0.000
Sometimes	11(18.0) ^b	50(82.0) ^b	
Often	0(0) ^{a,b}	4(100.0) ^{a,b}	
Not clear	13(61.9) ^a	8(38.1) ^a	
Q13 Did your child go to the hospital to see the teeth?			
Yes	24(35.8) ^a	43(64.2) ^a	0.023
Never	179(51.4) ^b	169(48.6) ^b	
For 4-year-old group (n = 441)			
Gender			

a, b: Differences of caries prevalence between row variables, the same mark represents no difference between the two variables.

Groups and variables	Health	ECC	P
male	81(37.5) ^a	135(62.5) ^a	0.025
female	61(27.1) ^b	164(72.9) ^b	
Practice			
Q12 Has your child had a toothache or discomfort in the past 12 months?			
Never	130(38.2) ^a	210(61.8) ^a	0.000
Sometimes	10(13.5) ^b	64(86.5) ^b	
Often	0(0) ^b	13(100.0) ^b	
Not clear	2(14.3) ^{a, b}	12(85.7) ^{a,b}	
Q13 Did your child go to the hospital to see the teeth?			
Yes	14(18.4) ^a	62(81.6) ^a	0.004
Never	128(35.1) ^b	237(64.9) ^b	
For 5-year-old group (n = 445)			
Knowledge			
Q22d Can bacteria cause dental caries?			
correct answer	79(25.0) ^a	237(75.0) ^a	0.010
wrong answer	9(60.0) ^b	6(40.0) ^b	
do not know	28(24.6) ^a	86(75.4) ^a	
Practice			
Q5 Frequency of eating sweet before going to bed at night			
often	4(12.1) ^a	29(87.9) ^a	0.005
occasionally	56(22.5) ^a	193(77.5) ^a	
never	56(34.4) ^b	107(65.6) ^b	
Q12 Has your child had a toothache or discomfort in the past 12 months?			
a, b: Differences of caries prevalence between row variables, the same mark represents no difference between the two variables.			

Groups and variables	Health	ECC	P
Never	102(35.3) ^a	187(64.7) ^a	0.000
Sometimes	10(7.9) ^b	116(92.1) ^b	
Often	0(0) ^b	15(100) ^b	
Not clear	4(26.7) ^{a, b}	11(73.3) ^{a,b}	
Q13 Did your child go to the hospital to see the teeth?			
Yes	9(8.7) ^a	95(91.3) ^a	0.000
Never	107(31.4) ^b	234(68.6) ^b	
a, b: Differences of caries prevalence between row variables, the same mark represents no difference between the two variables.			

Logistic regression analyses

The results of multivariable logistic regression analyses for ECC are shown in Table 3. Overall, the association between increasing age and accumulation of ECC was still significant (OR: 2.44, 95% confidence interval (CI):1.79–3.31 for 5-year-old group; OR: 2.07, 95% CI: 1.55–2.78 for 4-year-old group). Factors independently associated with an augmented risk for ECC include the experience of breastfeeding completely within 6 months of birth, the high frequency of bedtime sweet (OR: 1.81, 95% CI: 1.09–3.02), the experience of toothache over the past 1 year (OR: 4.7, 95% CI: 3.11–7.11) and dental visit (OR: 1.75, 95% CI: 1.19–2.55). Unexpectedly, those family who known that sugar can induce caries were more likely to experience ECC (OR: 1.49, 95% CI:1.07–2.06). However, tooth-brushing was not associated with increased rates of ECC.

Table 3

Multivariable logistic regression model for ECC: children aged 3–5 years old.

Variables	OR	95% CI	P
age			
5 years old	2.44	1.79–3.31	0.000
4 years old	2.07	1.55–2.78	0.001
3 years old	1.00	NA	NA
22e_group Does eat sugar cause dental caries?			
Yes	1.49	1.07–2.06	0.017
No or do not know	1.00	NA	NA
Q3 Feeding method within 6 months of birth			
mainly breastfeeding	0.86	0.62–1.18	0.339
complete artificial feeding	0.42	0.25–0.69	0.001
mainly artificial feeding	0.81	0.45–1.47	0.488
half breastfeeding and half artificial feeding	0.84	0.56–1.25	0.378
complete breastfeeding	1.00	NA	NA
Q5 Frequency of eating sweet before going to bed at night			
often	1.81	1.09–3.02	0.023
occasionally	1.32	1.03–1.74	0.027
never	1.00	NA	NA
Q12 Does your child have toothache or discomfort within the past 12 months?			
Sometimes or often	4.70	3.11–7.11	0.000
Not clear	1.24	0.67–2.23	0.487
Never	1.00	NA	NA
Q13 Has your child ever seen a dentist?			
Yes	1.75	1.19–2.55	0.024
Never	1.00	NA	NA
OR: odd rates; CI: confidence interval; NA: not applicable.			

Table 4 shows results of multivariable logistic regression analyses to identify risk factors independently associated with ECC in different age groups. For 3-year-old group, a history of ever having been completely artificial fed within six months of birth was less likely to experience ECC compared to completely breastfed (OR: 0.59, 95% CI: 0.19–1.83), yet a history of toothache over the last year (OR: 5.83, 95% CI: 2.89–11.77) and the positive cognitive in which bacteria can cause dental caries (OR: 1.77, 95% CI: 1.02–3.07) would more likely to suffer from dental caries. The independent risks for 4-year-old group were only gender and toothache experience over the past year. For 5-year-old group, factors independently associated with an ascended risk for ECC included increased frequency of bedtime sweets, the experience of toothache over the past year and dental visit. Brushing was still not an independent risk factor for ECC.

Table 4
Multivariable logistic regression model for ECC at different age groups.

model 1 (For 3-year-old group)			
Variables	OR	95% CI	P
22e_group Does eat sugar cause dental caries?			
Yes	1.77	1.02–3.07	0.043
No or do not know	1.00	NA	NA
Q3 Feeding method within 6 months of birth			
mainly breastfeeding	0.88	0.50–1.53	0.646
complete artificial feeding	0.28	0.12–0.69	0.005
mainly artificial feeding	0.59	0.19–1.83	0.360
half breastfeeding and half artificial feeding	1.27	0.60–2.66	0.53
complete breastfeeding	1.00	NA	NA
Q12 Does your child have toothache or discomfort within the past 12 months?			
Sometimes or often	5.83	2.89–11.77	0.000
Not clear	0.66	0.26–1.68	0.386
Never	1.00	NA	NA
model 2 (For 4-year-old group)			
Variables	OR	95% CI	P
gender			
male	0.62	0.41–0.94	0.024
female	1.00	NA	NA
Q12 Does your child have toothache or discomfort within the past 12 months?			
Sometimes or often	4.73	2.36–9.49	0.000
Not clear	3.90	0.85–17.80	0.079
Never	1.00	NA	NA
model 3 (For 5-year-old group)			

OR:odd rates; CI: confidence interval; NA: not applicable.

model 1 (For 3-year-old group)			
Variables	OR	95% CI	P
Q5 Frequency of eating sweet before going to bed at night			
often	3.22	1.03–10.06	0.045
occasionally	1.64	1.03–2.61	0.036
never	NA	1.00	NA
Q12 Does your child have toothache or discomfort within the past 12 months?			
Sometimes or often	4.93	2.39–10.14	0.000
Not clear	1.25	0.38–4.14	0.716
Never	NA	1.00	NA
Q13 Did your child go to the hospital to see the teeth?			
Yes	2.54	1.17–5.53	0.018
Never	NA	1.00	NA
OR:odd rates; CI: confidence interval; NA: not applicable.			

Discussion

As a populous province, Shandong province has a population of nearly 100 million people. The current study collected eligible samples to represent the oral health status of this province and cover areas with different dietary habits. Finally, out of a total of 1330 children aged 3-5-year-old, 1301 families provide complete and reliable data information, the response rate is as high as 97.8%, this is very satisfying.

The caries prevalence for 3-5-year-old children in Shandong province are 51.1%, 67.8–73.9% respectively, which all higher than the national level (50.8%, 63.6%, 71.9%), while the dmft mean and the untreated rate of dental caries are lower than the national data (3.15 vs 3.35; 96.4% vs 96.9%)[17]. Compared to some other developing countries in Asia, Thailand (age 5: 78.5%)[18], Indonesia (age 0–5: 70.0%)[19], Myanmar (age 5–6: 81.3%) and Cambodia (age 3: 84.9%) [20], all have higher rates of ECC. While in developed countries like Japan and Singapore, the ECC rates are down to 44.4% and 49% respectively[21, 22], which is significantly lower than the results of 63% obtained by statistics worldwide[23] and has already achieved the goal of less than 50% prevalence of ECC for the year of 2020 raised by WHO [24]. These data alert us there is still a long and tough way to go to reduce the prevalence of ECC in Shandong, China.

Age has been evidenced to be an independent risk factor of ECC by many studies [13, 20, 25], and this finding was corroborated in current study. Most researches, however, evaluate 3-5-year-old children as whole with few studies access the risk factors for each age. Therefore, we speculated that although the

age span is small, different ages may have different risk factors. Exactly, both the Chi-square test and the logistic regression model in present study confirm this speculation (Table 2–4). Despite different age groups share a caries-related risk factors—the experience of toothache over the past year, the increased risk for ECC in children aged 3 is independently associated with the feeding method within 6 months after the birth, while the 5-year-old children are primarily associated with the frequency of bedtime sweets. This heterogeneity indicates that we should have different priorities when it comes to OHE for preschool children of different ages.

The association between feeding method and ECC is pretty intricate and involves in a variety of factors including the frequency, duration, numbers, time and formula of the feeding. Previous studies ever reported that the breastfeeding and its duration is not associated with the ascended risk of ECC [13], yet studies also found that both prolonged breastfeeding and high-frequency feeding in late infancy augments the risk of having dental caries[26, 27]. Van Palenstein et al[28], interestingly, reported that breastfeeding during the daylight beyond the age of 12-month was not associated with ECC for 25- to 30-month old infants, the relevant factor is breastfeeding at night > 2 times, and exposing > 15 minutes per nocturnal feeding. Although the current study also provides evidence that breastfeeding has a greater adverse impact on ECC than artificial feeding, similar to the results of national studies 10 years ago[29], no more details information about the duration, frequency, time, formula were collected, so it's hard to analyze and attain those specific factors that have caused such outcomes. After all, the high cariogenic of bottle feeding has also been confirmed by many studies[30]. One latest research contributes evidence for the nonlinear association between breastfeeding duration and ECC and the auxiliary role of fluoridated water in reducing the negative effects of feeding on ECC[31]. That reminds us more relevant variables need to be considered in future studies to elucidate the correlation between feeding methods and ECC.

Frequent exposure to dietary sugar and refined carbohydrates is well recognized to be associated with ECC[32–35], bedtime sweet is particularly serious[33, 36]. Excessive sugar consumption provides abundant nutrients for the supragingival microorganisms and induces acid production, enamel-dentine demineralization, and then caries formation[11, 37]. The limitation of sugar consumption has therefore been listed in the Declaration that gained worldwide support[38]. Interestingly, the data from this present study found that the increase in the frequency of bedtime sweets did not become an independent risk factor for ECC in children aged 3 and 4, but only work for children aged 5 years. It is not possible from these data to conclude that there is no need to pay attention to sugar consumption habits under 4 years old, because sweet preference has also been evidenced to be a high risk factors of ECC for children under 23 months in Japan[36]. Scholar Leroy et al. [39]and Schluter et al.[40] also respectively confirmed that bedtime sweet is significantly associated with ECC for children aged 3 and 4. Accordingly, it is possible that the outcomes of previous undesirable sugar consumption habits exactly show up at 5 years old and become an independent risk factor for the current study sample. This is in full compliance with the action of time factors in the pathogenesis of dental caries[11]. Therefore, even though the sugar habits in this study were only risk factors for the 5-year-old group, knowledge transmission and behavioral intervention definite should be carried out early in life.

Previous studies ever found that infrequent dental visits were correlated with an augmented risk for untreated caries[41, 42]. Some studies, however, reported a positive association between the number of dental visits and ECC prevalence[13, 43]. This finding is consistent with the results of the current study. Unfortunately, this result goes against the goal of oral prevention. The design of the dental visit is expected to play a positive and energetic role in caries prevention[44], while 51.8% of families in present study sought help from a dentist for treatment compared to only 7.8% came for prevention. An Australian study reported that dental visit actually contributes 30.3% in explaining inequalities in ECC[15]. This indicates that our awareness of prevention is still insubstantial, the purpose of dental visit is incorrectly implemented as more for treatment, and rarely for prevention. This definite is one of the priorities we need to improve.

Tooth brushing has always been considered as the primary and most effective way to clean plaque microbes and prevent dental caries. Many studies have confirmed the association between tooth-brushing and ECC[45, 46]. While plenty of studies have also verified that there is no correlation between these two variables[47, 48], which is consistent with the results of the present study. Abdelaziz et al.[49] ever reported that brushing was not an independent risk factor of ECC and S-ECC for preschool children. Edward Lo even found that supplemental training in parental toothbrushing would not be benefit to the reduction of ECC for those children under 3 years of age who lived in a water fluoridated area and had been provided the OHE sufficiently[50]. To be sure, however, the earlier of oral preventive intervention, the lower risk of ECC[14, 29], the present study also confirms this trend in bivariate analyses, but not to be an independent risk factor. Honestly, interpretation of the results relevant to such issues is further limited in the deficiency of information about brushing details. For example, brushing duration, brushing compliance, floss assistance, and especially brushing efficiency assessment are not available in our data, it is therefore difficult to objectively assess the association between tooth-brushing and ECC in the scenario of many factors being masked or even neglected. Further studies should include these variables so we can attain a clearer picture for the role of toothbrushing on ECC prevention.

It must also be said that the current status and issues of oral health education are well demonstrated in present study. First of all, a sharp contrast between the high awareness of oral health routine knowledge (66%-98.8%) and the low access to oral prevention knowledge (16%-35.8%), the negative association between correct cognition and ECC risk (Appendix table S1, Table 2–4), and the positive correlation between frequency of toothache and dental visit and ECC all reflect that human information behavior[51] seems to be underperforming in impelling people's practice for ECC prevention, and oral health promotion, related policies, and even the dentist itself also seems to be underperforming. However, many studies have confirmed that when a more systematic, proactive oral health intervention involving brushing training, referral and dental care is implemented for a family with children, even if implemented by non-dental professionals[52], it generally has a greater preventive effect against ECC[44, 53–56]. Therefore, a systematic and sound oral health care program is imperative[57], which involves in clinical care, brushing training, referral and so on, rather than just oral health education, only this way can make sure the consistency between theoretical knowledge and actual action as much as possible, thus reducing the incidence of ECC. In addition, the risk factors for ECC at different ages (3-5-year-old) are not completely

consistent. In current study, the early stage of deciduous dentition(3 years old) is mainly related to feeding methods, the late stage of deciduous dentition(5 years old) is mainly associated with sugar-eating habits, which indicate that a more strategic and more targeted OHE method and content are supposed to be designed for children of different ages, this would be more cost-effective. Finally, although the positive association between the tooth-brushing, using of fluoride and the low risk of dental decay was not obtained in this study, its role in caries prevention is indeed indelible[14, 58, 59]. Therefore, assisting children to master these knowledge and skills early in life is the responsibility of dentist and parents.

The main advantage of this study is its large representative sample of children and its high response rate. Limitations include the issues in the OHC knowledge and attitude designed for the questionnaire are relatively basic and traditional. Several major risk factors are incorporated in current study, but unlike those monographic researches which excavated and explored sufficient detailed information about one certain targeting factor associated with ECC[27, 31, 50]. We have to say that some data on detailed information is limited, such as frequency of bedtime feeding, brushing efficiency, floss assist status, cariogenic microbial flora, each of which is reported to be associated with ECC. Therefore, more information is waiting to be collected to further analyze the risk factors associated with ECC for each age group.

Conclusion

These data provide evidence that different risk factors at different age are independently associated with an augmented risk for ECC, feeding methods primarily contribute to the early stage of deciduous dentition, yet sugar habits mainly contribute to the late stage of deciduous dentition. While the contribution of toothbrushing and fluoride to caries prevention has not been confirmed. Of course, there is a need for more research to identify detailed characteristics of above variables that cause ECC and make a guideline for children with different age. In addition, the apparent gap between theoretical knowledge and actual behavior in this study suggests that we need a more systematic oral health care program that involves behavioral guidance and effect evaluation, rather than just OHE, to reduce the ECC prevalence.

Abbreviations

ECC:early childhood caries; KAP:knowledge, attitude and practice; OHC:oral health care; OHE:oral health education; WHO:world health organization; dmft:decayed, missing and filled teeth; RCT:randomized controlled trial; OR:odd rates; CI:confidence interval.

Declarations

Ethics approval and consent to participate: This study had been approved by the Ethics Committee of the Chinese Stomatological Association (NO.2014-003) and the informed consent was obtained from a legal guardian for participants under 16 years old.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: ZF W, J Land SJ X conceptualized and designed the study, reviewed and revised the manuscript. M Z collected and organized data, carried out the statistical analyses, drafted and revised the manuscript. Y Z instructed the methods and strategies of statistical analyses and reviewed and revised the manuscript. XY Z and YN L collected, organized and input data. CC S conducted the statistical analysis of the data. *All authors read and approved the final manuscript.*

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