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Feeding Practices and Early Childhood Caries in Korean Preschool Children

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ABSTRACT

Objectives: This study aimed to investigate the association between feeding practices and early childhood caries using representative Korean national survey data.**Methods:** Data of 2772 children (aged 1-3 years) from the fourth to seventh Korean National Health and Nutrition Examination Surveys (2007-2018) were analysed. Data on decayed-filled teeth (dft) were obtained, and early childhood caries was determined as $dft \geq 1$. Chi-squared test was performed to examine the experiencing of dental caries by participant characteristics, whilst analysis of variance was performed to compare the difference in dft values amongst the 3 groups (breast-feeding, mixed-feeding, and formula-feeding groups). Logistic regression analysis was performed to evaluate the association between feeding practice and early childhood caries.**Results:** Comparison of the mean dft values amongst the 3 groups showed the highest value in the breast-feeding group. Multiple logistic regression analysis results showed that the likelihood of experiencing dental caries was significantly lower in the mixed-feeding group than in the breast-feeding group, whereas no significant difference was seen between the formula-feeding and breast-feeding groups. The likelihood of early childhood caries was higher in the group that introduced weaning food at ≥ 6 months than that at 4- to 6-month age, whilst the introduction of cow's milk and use of nutritional supplements had no significant association with the likelihood of early childhood caries.**Conclusions:** Breast-feeding and delayed introduction of weaning food were associated with a higher likelihood of early childhood caries.

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Introduction

A healthy oral environment during early childhood is very important for lifelong oral health.¹ Early childhood caries (ECC) is one of the most prevalent oral diseases during early childhood that causes discomfort, pain, and nutritional imbalance, ultimately leading to a decline in the quality of life of the child.² ECC is defined as the presence of 1 or more decayed, missing, or filled tooth surfaces in any primary tooth in a child younger than 6 years.³ According to a Korean survey in 2018,⁴ 68.5% of children aged 5 years had experienced ECC. The prevalence of ECC was 33.9%, and the average number of decayed and filled primary teeth (dft) was 3.43. The

percentage of children with ECC showed a sharp decreasing trend until the early 2000s, but since 2016 this decrease has stopped. Moreover, the average dft has shown an increasing trend, which is very concerning.⁴

Factors associated with ECC that have been studied include genetic factors,⁵ birth weight,⁶ socioeconomic status,⁷ familial factors,⁸ level of parental oral health care knowledge,⁹ and exposure to environmental tobacco smoke.¹⁰ Feeding practices also have a very important influence on the incidence of ECC, as does sugar intake, frequency of consuming ultra-processed foods,¹¹ mode of feeding,¹² and feeding frequency.¹³ However, the conclusions reached have not been consistent amongst studies; for example, various studies on the effects of breast-feeding on ECC have reported contradictory conclusions. Whilst some studies reported that ECC occurred more frequently with breast-feeding,¹⁴⁻¹⁷ some reached a contradictory conclusion,¹⁸⁻²⁰ whilst others reported no significant difference in ECC between the breast-

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fed and formula-fed groups.^{21,22} A recent systematic review on the association between breast-feeding and ECC reported that a definitive conclusion could not be reached since existing studies reporting results that differed markedly from each other.²³

Therefore, a consensus has not been reached on the factors associated with ECC, and this may be due to difficulties in obtaining high-quality data from young children regarding their oral health. The Korea National Health and Nutrition Examination Survey (KNHANES) data are representative of the population and are important for studying ECC. However, there have been very few studies on the association between ECC and feeding practices based on these data. Therefore, this study aimed to investigate the feeding practices associated with ECC using the KNHANES data.

Methods

Participants

KNHANES is conducted every 3 years; it uses a 2-stage stratified cluster sampling method based on census data to select 20 sample households per enumeration district, and the members of the selected households are the study population. The present study selected data of young children aged 1 to 3 years amongst the study population of the fourth through the seventh KNHANES (2007-2018). From a total of 3284 children, 512 with missing study variables were excluded, leaving data from a total of 2772 children for analysis. Written informed consent was obtained from all KNHANES participants and/or their legal guardians. All data analyses and study procedures were performed with approval from the Public Institutional Review Board committee designated by the Ministry of Health and Welfare, Korea (P01-202,002-21-002) and conducted according to the World Medical Association Declaration of Helsinki.

Variables

Based on the responses to the questionnaire, the included demographic characteristics were age, sex, and household income, whilst tooth brushing frequency and regular dental checkup were the oral hygiene care-related characteristics. Data on the mode of feeding, introduction of weaning food, introduction of cow's milk, and use of nutritional supplements were included as feeding practice-related variables from the responses to the questionnaire. The mode of feeding was divided into breast-feeding, mixed-feeding, and formula-feeding, whilst the introduction of weaning food was divided into timely introduction (4-6 months old) and delayed introduction (≥ 6 months old) groups.²⁴ Introduction to cow's milk was divided into <12 , 12-17, and ≥ 18 months old,²⁵ whilst the use of vitamin/mineral, probiotic, and other nutritional supplements was divided based on the response into "yes" or "no" groups. The participants' dental caries status was determined based on the results of the oral health examination performed by dentists who participated as investigators. The

participants were divided into non-ECC (dft = 0) and ECC experience (dft ≥ 1) groups.

Data analysis

Chi-squared test was performed to examine the distribution of ECC according to the characteristics of the participants, whilst analysis of variance (ANOVA) and independent t test were performed to compare the difference in dft values between the groups. Simple logistic regression analysis was performed to determine whether feeding practice or other potential risk factors were related to the presence or absence of ECC experience. In addition, a multiple logistic regression model was constructed using the presence or absence of ECC experience as a dependent variable and all other variables used in this study as independent variables, whilst subgroup analyses were performed stratified by sex. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc.) with a statistical significance level of $\alpha = 0.05$.

Results

Amongst the participants with dft ≥ 1 , the percentages of children aged 1, 2, and 3 years were 5.7%, 30.9%, and 63.4%, respectively, and most (57.9%) were boys (Table 1). In addition, 37.6% of the ECC experience group were breast-fed, whilst 26.0% of the non-ECC group were breast-fed ($P < .001$).

The mean dft values amongst children aged 3 years were higher than those of children aged 1 and 2 years ($P < .001$; Table 2), and those of boys were significantly higher than those for girls ($P < .01$). The mean dft differed significantly, with 0.62 ± 1.56 , 0.35 ± 1.28 , and 0.48 ± 1.33 in the breast-fed, mixed-fed, and formula-fed groups, respectively ($P < .001$), and was lower when weaning food was introduced between 4 and 6 months of age than when introduced later ($P < .01$). Significant differences also occurred with the introduction of cow's milk at 12 to 17 months, with a lower mean dft than in the other groups ($P < .001$). By use of vitamin/mineral supplements, a higher mean dft value was observed amongst those who used nutritional supplements than those who did not ($P < .01$).

Comparison of differences in the distribution by mode of feeding amongst participants (Table 3) showed that boys were less frequently breast-fed than girls ($P < .01$); the formula-fed group experienced the most delayed introduction of weaning food compared with the other 2 groups ($P < .001$), and in this group, children were more likely to be introduced to cow's milk at ≥ 18 months of age ($P < .01$).

Simple (Figure 1) and multiple logistic regression analyses (Figure 2) showing factors associated with ECC experience showed similar results. According to the multiple regression model (Figure 2), the likelihood of ECC experience was lower in girls than in boys (adjusted odds ratio [aOR], 0.78; 95% confidence interval [CI], 0.62-0.97). Those who received regular dental checkups showed a higher likelihood of ECC (aOR, 1.75; 95% CI, 1.39-2.20) than those who did not. The mixed-fed group showed a significantly lower risk of ECC than the breast-fed group (aOR, 0.53; 95% CI, 0.41-0.67), whilst the formula-fed

Table 1 – Demographic characteristics, oral hygiene care, and feeding practices related to early childhood caries experience.

Variables		dft ≥ 1 (n = 404)		dft = 0 (n = 2368)		P value*
		n	%	n	%	
Age, y	1	23	5.7	817	34.5	<.001
	2	125	30.9	854	36.1	
	3	256	63.4	697	29.4	
Sex	Boys	234	57.9	1206	50.9	.009
	Girls	170	42.1	1162	49.1	
Household income	Low	36	8.9	134	5.7	.025
	Low-medium	136	33.7	751	31.7	
	High-medium	131	32.4	901	38.0	
	High	101	25.0	582	24.6	
Tooth-brushing frequency	≤1/d	97	24.0	765	32.3	.004
	2/d	151	37.4	812	34.3	
	≥3/d	156	38.6	791	33.4	
Dental checkup	No	215	53.2	1674	70.7	<.001
	Yes	189	46.8	694	29.3	
Mode of feeding	Breast-feeding	152	37.6	616	26.0	<.001
	Mixed-feeding	205	50.7	1518	64.1	
	Formula-feeding	47	11.6	234	9.9	
Introduction of weaning food	4-6 months old	271	67.1	1788	75.5	<.001
	≥6 months old	133	32.9	580	24.5	
Introduction of cow's milk	<12 months old	25	6.2	145	6.1	<.001
	12-17 months old	280	69.3	1846	78.0	
	≥18 months old	99	24.5	377	15.9	
		311	77.0	1899	80.2	
Vitamin and mineral supplement	No	93	23.0	469	19.8	.138
	Yes	314	77.7	1755	74.1	
Probiotic supplement	No	90	22.3	613	25.9	.123
	Yes	379	93.8	2188	92.4	
Other nutritional supplement	No	25	6.2	180	7.6	.316
	Yes					

dft, decayed-filled teeth.

* P value derived using the Chi-squared test.

Table 2 – Comparison of dft values according to the characteristics of participants.

Variables		n	dft		P value*
			Mean	SD	
Age, y	1	840	0.08	0.55	<.001
	2	979	0.34	1.19	
	3	953	0.85	1.86	
Sex	Boys	1440	0.52	1.54	.001
	Girls	1332	0.35	1.16	
Household income	Low	170	0.52	1.31	.328
	Low-medium	887	0.49	1.49	
	High-medium	1032	0.39	1.33	
	High	683	0.41	1.30	
Tooth-brushing frequency	≤1/d	862	0.33	1.19	.012
	2/d	963	0.45	1.26	
	≥3/d	947	0.52	1.62	
Dental checkup	No	1889	0.32	1.18	<.001
	Yes	883	0.69	1.69	
Mode of feeding	Breast-feeding	768	0.62	1.56	<.001
	Mixed-feeding	1723	0.35	1.28	
	Formula-feeding	281	0.48	1.33	
Introduction of weaning food	4-6 months old	2059	0.39	1.26	.001
	≥6 months old	713	0.58	1.65	
Introduction of cow's milk	<12 months old	170	0.46	1.48	<.001
	12-17 months old	2126	0.37	1.20	
	≥18 months old	476	0.72	1.92	
Vitamin and mineral supplement	No	2210	0.40	1.29	.004
	Yes	562	0.59	1.67	
Probiotic supplement	No	2069	0.46	1.44	.103
	Yes	703	0.36	1.17	
Other nutritional supplement	No	2567	0.44	1.40	.260
	Yes	205	0.33	1.07	

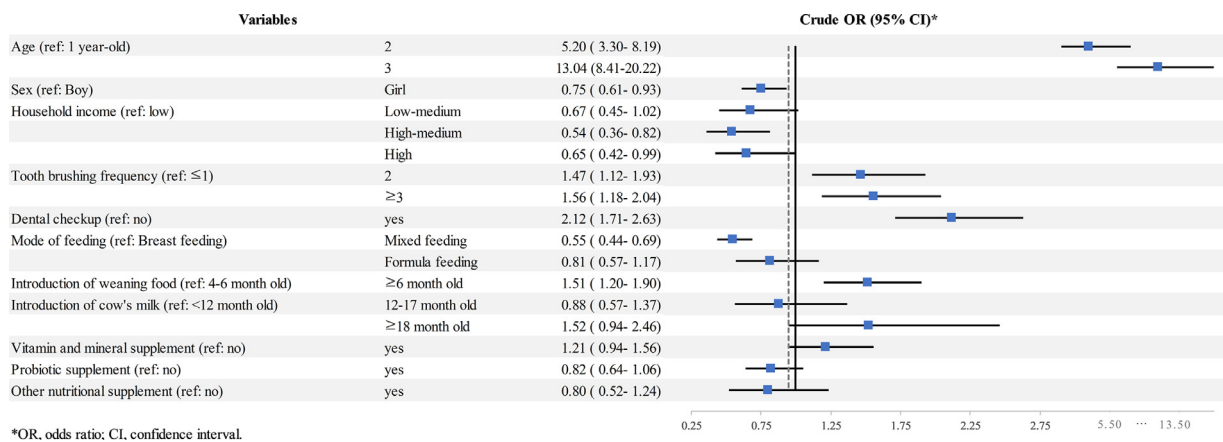
dft, decayed-filled teeth; SD, standard deviation.

* P value derived using the analysis of variance and independent t test.

Table 3 – Mode of feeding according to the characteristics of participants.

Variables	Breast-feeding (n = 768)		Mixed-feeding (n = 1723)		Formula-feeding (n = 281)		P value*	
	n	%	n	%	n	%		
Age, y	1	238	31.0	527	30.6	75	26.7	.338
	2	253	32.9	621	36.0	105	37.4	
	3	277	36.1	575	33.4	101	35.9	
Sex	Boys	360	46.9	936	54.3	144	51.2	.003
	Girls	408	53.1	787	45.7	137	48.8	
Household income	Low	41	5.3	103	6.0	26	9.3	.001
	Low-medium	249	32.4	526	30.5	112	39.9	
	High-medium	308	40.1	637	37.0	87	31.0	
	High	170	22.1	457	26.5	56	19.9	
Tooth-brushing frequency	≤1/d	240	31.3	520	30.2	102	36.3	.246
	2/d	274	35.7	595	34.5	94	33.5	
	≥3/d	254	33.1	608	35.3	85	30.2	
Dental checkup	No	496	64.6	1192	69.2	201	71.5	.033
	Yes	272	35.4	531	30.8	80	28.5	
Introduction of weaning food	4-6 months old	592	77.1	1291	74.9	176	62.6	<.001
	≥6 months old	176	22.9	432	25.1	105	37.4	
Introduction of cow's milk	<12 months old	64	8.3	94	5.5	12	4.3	.001
	12-17 months old	595	77.5	1325	76.9	206	73.3	
	≥18 months old	109	14.2	304	17.6	63	22.4	
Vitamin and mineral supplement	No	587	76.4	1399	81.2	224	79.7	.024
	Yes	181	23.6	324	18.8	57	20.3	
Probiotic supplement	No	661	86.1	1201	69.7	207	73.7	<.001
	Yes	107	13.9	522	30.3	74	26.3	
Other nutritional supplement	No	726	94.5	1584	91.9	257	91.5	.054
	Yes	42	5.5	139	8.1	24	8.5	

* P value derived using the Chi-squared test.

**Fig. 1 – Simple logistic regression analysis of potentially related factors of early childhood caries experience.**

group showed a nonsignificant result (aOR, 0.71; 95% CI, 0.48-1.04). The group with delayed introduction of weaning food showed a higher likelihood of ECC than the group with timely introduction of weaning food (aOR, 1.37; 95% CI, 1.07-1.75), whilst the introduction of cow's milk and the use of nutritional supplements did not show a significant association. The area under the receiver operating characteristic curve, which indicates the accuracy of the model, was 0.77 (Appendix Figure S1). In the subgroup analyses performed separately for boys and girls, the same tendency was found with the breast-fed group showing a significantly higher risk of ECC than the mixed-fed group (Appendix Tables S1 and S2).

Discussion

To investigate the epidemiological association between feeding practice and ECC amongst young children, the present study analysed the 2007-2018 KNHANES data of children aged 1 to 3 years. Tinanoff et al.²⁶ extracted data from 72 worldwide studies between 1998 and 2018, and mean ECC prevalence from these 72 reports for 1-, 2-, and 3-year-olds was 17%, 36%, and 43%, respectively. The rates of children with dft ≥1 in our study participants of the same age were 2.7%, 12.8%, and 26.9%, which were low compared to the results of Tinanoff et al. This may be a regional difference, but as ECC is

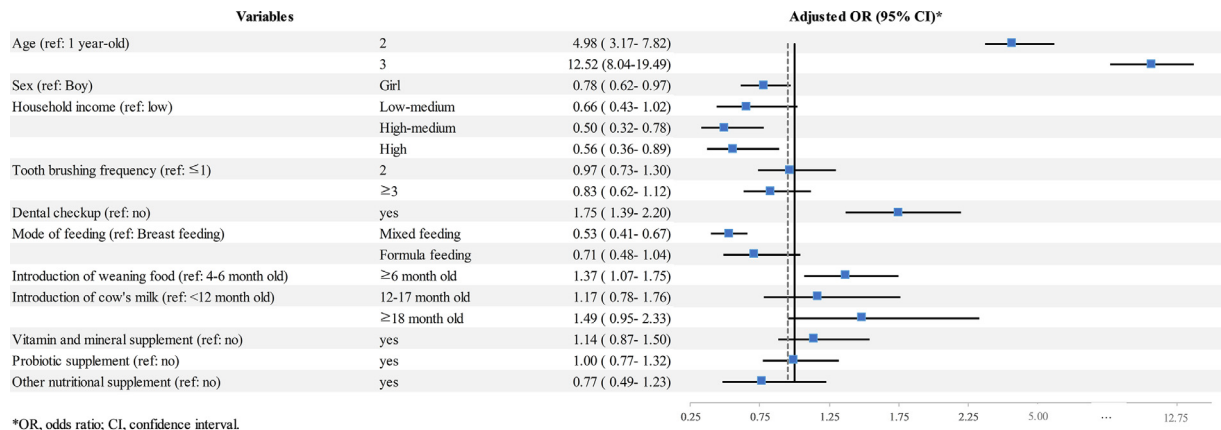


Fig. 2 – Multiple logistic regression analysis of potentially related factors of early childhood caries experience.

decreasing, our results may be lower than those based on 1998-2018 data.

Tooth brushing is an important related factor in the development of ECC; therefore, it was selected as a confounding variable in this study. A Swedish study²⁷ surveyed tooth-brushing behaviour in 336 children and reported that 77.3% of the 2-year-olds had their teeth brushed more than twice a day; this is similar to the 68.9% observed in our study. One study³⁶ of 633 Saudi preschool children (age, 36-71 months) reported that 57.4% of the respondents had their teeth brushed more than once a day, whilst yet another study²⁹ of 395 Chinese children (age, 24-71 months) reported that only 29.1% of the participants had their teeth brushed more than twice a day; these data indicate large regional differences in tooth-brushing behaviours.

According to the multiple logistic regression model with the inclusion of all variables, girls showed a lower likelihood of ECC than boys, and higher household income was associated with a lower likelihood of ECC, which was consistent with the results of a previous study.¹⁴ Tooth brushing frequency did not have a significant association with ECC, whilst those who had regular dental checkups had a higher likelihood of experiencing ECC. However, it would be inappropriate to interpret these results to mean that tooth brushing frequency was not associated with ECC experience or that frequent dental checkups increase the likelihood of ECC. In fact, children who experienced dental caries may have been more receptive to tooth brushing and undergoing dental checkups, and there is a very strong likelihood that this assumption may be reflected in the findings of the present study. A previous study²⁸ showed a higher percentage of dental visits for checkups in the ECC group than in the caries-free group.

Those with a timely introduction to weaning food (4-6 months old) showed a lower likelihood of ECC than those with a delayed introduction, which is consistent with the results of a previous study.³⁰ On the other hand, the introduction of cow's milk and the use of nutritional supplements showed no significant association with ECC experience. The mixed-feeding group showed a significantly lower likelihood of ECC than the breast-feeding group. Moreover, the mean dft

value was also highest in the breast-fed group, followed by the formula-fed and mixed-fed groups. Previous studies have reported varying conclusions about the association between breast-feeding and ECC and, recently, some epidemiological studies have reported that breast-feeding is associated with a higher likelihood of dental caries.¹⁴⁻¹⁷ A Chinese national survey conducted in 2018 revealed a higher prevalence of dental caries amongst breast-fed children than amongst the mixed-fed group.¹⁴ Similarly, a longitudinal study conducted in Japan in 2015 revealed a higher risk of dental caries in young children who were exclusively or predominantly breast-fed.¹⁵ Other recent studies pointed out that prolonged breast-feeding of ≥12 months could be a risk factor for dental caries.^{16,17} Based on this evidence, the British Society of Paediatric Dentistry published its position statement in 2018, which included content about the potential link between dental caries and prolonged breast-feeding of ≥12 months, especially nighttime breast-feeding.³¹

Breast-feeding is beneficial to the systemic health of young children; thus, it is actively recommended by the WHO.³² A previous experimental study reported that the cariogenicity of breast milk was lower than that of formula³⁴ and, according to this, breast milk itself does not have a negative effect on dental hard tissues. Nevertheless, our study found that breast-feeding groups had a higher risk of ECC. This may be because the time spent breast-feeding is longer than bottle-feeding, and the daily feeding frequency was more than with bottle-feeding.^{13,34} Moreover, children often fall asleep during breast-feeding, which could also be a cause of increased risk of ECC. Therefore, it is necessary for clinicians to recommend education on proper feeding and oral hygiene care methods as well as regular dental checkups for parents of breast-fed children.

The limitations of the present study included its cross-sectional design; the causal relationship between feeding practice and ECC could therefore not be inferred. The variables investigated were limited; therefore, not controlling for some confounding factors (such as sugar intake, fluoride intake, use of fluoride toothpaste, systemic disease, and medication status) could also be a limitation. Despite such limitations, the significance of the present study was that it investigated

the association between feeding practice and ECC using highly representative national survey data. Prospective studies using big data are needed in the future to identify the causal relationship between these two factors. In addition, consideration should be given to measures that can promote the prevention of ECC by developing appropriate guidelines for the feeding practices of young children.

Conclusions

The findings in the present study showed that the breast-fed group had a higher likelihood of experiencing ECC. The group with delayed introduction of weaning food showed a higher rate of dental caries experience, whilst the introduction of cow's milk and the use of nutritional supplements did not show a significant association with ECC.

Conflict of interest

None disclosed.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at [doi:10.1016/j.identj.2021.07.001](https://doi.org/10.1016/j.identj.2021.07.001).

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