HHS Public Access

Author manuscript

Pediatr Dent. Author manuscript; available in PMC 2017 August 23.

Published in final edited form as:

Pediatr Dent. 2014 ; 36(4): 342–347.

Infant Breast-feeding and Childhood Caries: A Nine-year Study

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Abstract

Purpose—This study's purpose was to assess the association between infant breast-feeding and caries experience of primary second molars in a nine-year longitudinal cohort study.

Methods—Study sample was 509 subjects recruited at birth. Information about breast-feeding duration and other factors was collected through parents' responses to periodic questionnaires. Primary teeth were examined for dental caries at five years old and nine years old by calibrated dentist examiners. Caries experience (yes/no) and number of decayed and/or filled surfaces (dfs) were determined for five- and nine-year-olds.

Results—For primary second molars at five years old, 18 percent of children who were breast-fed less than six months had caries (mean dfs=0.55) while only 9 percent of children who were breast-fed at least six months had caries (mean dfs=0.33). From five to nine years old, caries incidence was 32 percent and 31 percent, respectively, for children breast-fed less than six months and at least six months. In multivariable regression analyses, shorter breast-feeding duration was positively associated with caries experience of primary second molars at five years old (P=.005), both before and after controlling for other important factors.

Conclusions—Shorter duration of breast-feeding is suggested to be associated with increased risk for early childhood caries, but its impact might diminish with age.

Keywords

DENTAL CARIES; BREAST-FEEDING; PRIMARY TEETH

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Human milk is identified as the ideal nutrient for infants, and breast-feeding is recommended to be continued for at least the first year of life.[1,2] However, several studies have reported prolonged and unrestricted breast-feeding as a potential risk factor for primary tooth caries.[3–6] A recent animal study found human breast milk to be more cariogenic than bovine milk.[7] On the other hand, other studies reported no association between various aspects of breast-feeding and early childhood caries (**ECC**) or longer duration of breast-feeding with lower caries risk.[8–11]

Reports examining US national sample data from both the 1988–1994 and 1999–2002 National Health and Nutrition Examination Surveys did not find an association.[12,13] Using a more detailed categorization of breast-feeding duration and type, Iida et al.[13] found that breast-feeding and its duration, whether overall, full, or exclusive, was not associated with increased risk for ECC or severe-ECC.

However, decreased family income and prenatal maternal smoking, both strongly associated with decreased breast-feeding, were found to be independently associated with increased risk of caries. Collectively, epidemiologic evidence linking infant breast-feeding and childhood caries is limited, and more studies are needed to provide a clearer answer. Most previous studies were cross-sectional and retrospective in study design and usually examined dental caries of primary teeth by three years old. There is a lack of prospective, longitudinal studies to assess such an association.

Therefore, utilizing data previously collected among children recruited at birth for the Iowa Fluoride Study (**IFS**), the purpose of the present study was to assess the longitudinal effects of breast-feeding duration on caries experience at five years old and nine years old.

Methods

Subjects

All children were participants in the IFS,[14–17] which is a longitudinal study of the relationships among fluoride exposures, biological and environmental factors, and children's dental health. A total of 1,390 newborns recruited (at birth) from March 1992 to February 1995 from eight Iowa hospitals participated in the study. The Institutional Review Board at the University of Iowa, Iowa City, Iowa, approved all IFS components, and written informed consent was obtained from mothers at recruitment and again at the time of examinations. Demographic characteristics at baseline were collected and described previously.[14,15] Briefly, this cohort was: predominantly Caucasian (approximately 98 percent); 51 percent female; from families of relatively high socioeconomic status ([**SES**] 71 percent having baseline family income of equal to or greater than $30,000 or more and 46 percent of mothers having completed four years of college); 44 percent were first children; only four percent had low birth weight; and three percent had developmental disorders.[17] There were 698 subjects who received dental examinations of the primary dentition at five years old and 579 who again received dental examinations at nine years old. This report utilized 509 subjects who had complete data for both dental exams, baseline demographics, and breast-feeding duration through 12 months.

Data collection

Parents were mailed IFS questionnaires at three- to six-month intervals from birth. Questionnaires included a series of items concerning children's fluoride exposures and ingestion from various sources during the preceding time period. Information regarding breast-feeding, formula use, beverage intakes, general health/illnesses, and oral health behaviors was also obtained. Fluoride intake in mg per day was estimated from water, formula, other beverages, selected foods, dietary fluoride supplements, and fluoride dentifrice, based on parents' responses to a series of questions. Fluoride levels (in parts per million [**ppm**]) of nonfiltered municipal water sources were obtained from state reports. Other water sources and other beverages were assayed for fluoride content. Parents' responses were not validated, but reliability was assessed for selected questionnaire items.[14,15] Parental educational levels were assessed at recruitment, and, for this study, were defined for two-parent households as the level of the least-educated parent.

Children's dental examinations

Dental examinations were conducted, using a portable chair and exam light (DenLite, Welch-Allyn Medical Products, Inc, Skaneateles, N.Y., USA) at the General Clinical Research Center at the University of Iowa or one of several community locations, by one of three trained and calibrated dentist examiners.[18,19] Teeth were dried, transillumination with the DenLite mirror system, and a dental explorer was utilized only to confirm questionable caries findings. The D1–D3 caries exam criteria[18] were adapted and modified from those of Pitts et al.[20,21] and Ismail et al.[22] In brief, these criteria define: D1 lesions as having evidence of demineralization, but no loss of enamel structure; D2 lesions as having a loss of enamel structure confined to the enamel layer; and D3 lesions as having loss of enamel structure that penetrates into dentin.

However, our study did not differentiate between cavitated enamel (**d_2**) and dentin (**d_3**) lesions. For this report, caries experience was considered in two ways. First, caries experience (yes/no) was defined based on whether a subject had any decayed (cavitated $d_{2–3}$ lesions) and/or filled surfaces on primary second molars. Second, the number of decayed (cavitated $d_{2–3}$ lesions) and/or filled surfaces was counted (**dfs**). These caries measures were determined for both the five- and nine-year-old exams. Also, caries incidence from five to nine years old was computed as the percentage of subjects having a dfs increment. Since many primary teeth exfoliated prior to the nine-year-old examinations, this study focused on the primary second molars, which were most consistently present for both the five-and nine-year-old examinations.

Presence or absence of enamel hypoplasia was recorded separately for each tooth. Deficiency in enamel formation, such as pits and linear grooves, was recorded as enamel hypoplasia, while localized opacities of white, yellow, or brownish color were recorded as demarcated opacities. Enamel hypoplasia was differentiated from fluorosis[23] and other nonfluoride enamel defects using Russell's criteria.[19,24]

Statistical analysis

Interexaminer reliability was assessed from duplicate examinations. Percent agreement and kappa statistics are reported at the person level for diagnoses on the primary second molars. For caries examinations, percent agreement was 94 percent for dfs at five years old (weighted kappa=0.90) and 88 percent at nine years old (weighted kappa=0.90). For enamel hypoplasia, there was 100 percent agreement (five years old, kappa=1.0), and for demarcated opacities there was 85 percent agreement (five years old, kappa=0.49).

Descriptive statistics were generated for caries experience, demographics, breast-feeding, and other risk factors. Bivariate analyses were completed at both the person and tooth levels. At the person level, children were classified into two mutually exclusive groups based on breast-feeding duration: less than six months and at least six months. Caries experience of children on primary second molars (both prevalence and dfs) at five and nine years old was compared between the two breast-feeding groups using Fisher's exact tests for prevalence and Wilcoxon rank sum tests for dfs at the person level. Generalized (repeated measures) logistic regression was used to analyze group differences in prevalence at the tooth level. Caries increase from five to nine years old (incidence and dfs increment) was also compared, as was caries experience on all primary teeth at five years old.

Logistic regression was used to analyze person-level caries incidence, and logistic generalized estimating equations[25] were used for tooth-level caries experience. Multivariable regression models for caries experience on second molars were developed using important potential risk factors, including breast-feeding duration (less than six months versus greater than six months). Other potential risk factors included: gender; hypoplasia; parental education level; family income level; gestational weeks; birth weight; age at time of dental exam; average daily fluoride intake (mg); home tap water fluoride level (ppm); average daily soda pop intake (oz/day); and daily tooth-brushing frequency.

Parental educational level included seven categories: (1) eighth grade or less; (2) some high school; (3) high school diploma or GED; (4) some college; (5) two-year college degree; (6) four-year college degree; and (7) graduate or professional school. Family income level had seven categories, including: (1) less than $10,000; (2) $10,000–19,999; (3) $20,000–29,999; (4) $30,000–39,999; (5) $40,000–49,999; (6) $50,000–59,999; and (7) $60,000 or more. The bivariate associations with caries experience at five years old were assessed using simple logistic regression, and those variables that had $P \leq .15$ were considered for the multivariable regression analysis. We arrived at a more parsimonious model by finding the best subset of variables in which all were jointly significant at $P < .10$. Two-way interactions were also tested. We refer to results as being statistically significant if the P-value is less than .05. Analyses were conducted using SAS 9.3 software (SAS Institute, Inc, Cary, N.C., USA).

Results

Among the 509 subjects, 71 percent were breast-fed for less than six months, and 29 percent were breast-fed for at least six months –18 percent for six to 12 months, and 11 percent for over 12 months). At five years old, 16 percent had caries experience on primary second molars, and the mean dfs was 0.48 (±1.67 SD). At nine years old, 36 percent had caries

experience on primary second molars, and the mean dfs was 1.42 (±2.72). Approximately 20 percent of subjects who had no caries experience on primary second molars at five years old had new caries experience by nine years old, and overall the mean dfs increment was 0.97 (±1.99). When caries experience was assessed at the tooth level, among 2,036 primary second molars, nine percent (mean dfs/tooth=0.12) had caries experience at five years old and 19 percent (mean dfs/tooth=0.36) did at nine years old. Approximately 11 percent of primary second molars developed new caries experience from five to nine years old and had a mean dfs increment of 1.74 (±0.98). The distribution of person-level demographic and other variables by breast-feeding duration is summarized in Table 1. Only parental education level and daily soda pop intake were significantly different between the two breast-feeding groups.

The bivariate relationships between breast-feeding and caries experience are presented in Table 2. At five years old, children with less than six months breast-feeding had a significantly higher second molar caries rate (18%, mean dfs=0.55) than children with at least six months breast-feeding (9%, mean dfs=0.33). At the tooth level, nine percent of primary second molars among children who were breast-fed for less than six months had caries experience at five years old versus five percent of those teeth among children who were breast-fed for at least six months (P=.08). From five to nine years old, there were no significant differences in caries increments at the person or tooth level between breast-feeding groups. However, children who were breast-fed for less than six months generally had slightly higher caries incidence and dfs increments (Table 2). At nine years old, there was no significant difference in caries experience between the two groups of children (data not shown).

Logistic regression was used to screen the bivariate associations of important potential predictors with primary second molar caries experience (yes/no at the person level). At five years old, the P-values for associations with caries experience were: gender (P=.43); gestational weeks (P=.70); birth weight (P=.07); parental education level (P=.006); family income (P=.08); fluoride level of home drinking water (P=.15); average daily fluoride intake (P=.27); daily tooth-brushing frequency (P=.15); soda pop intake (P=.005); and enamel hypoplasia (P=.02). Based on the screening results, seven covariates with P<.15 were selected for multivariable regression analysis: (1) birth weight; (2) parental education level; (3) family income; (4) home tap water fluoride level; (5) tooth-brushing frequency; (6) soda pop intake; and (7) enamel hypoplasia.

The multivariable regression model for caries experience at five years old assessed the independent association of breast-feeding duration while controlling for potential confounders found in the bivariate (unadjusted) analyses (Table 3). The two-way interaction of breast-feeding group by home tap water fluoride level was also found to be statistically significant after adjusting for main effects and, therefore, included in the final model. After controlling for the other important predictor variables, shorter breast-feeding duration was still a significant risk factor for caries experience at five years old (odds ratio=15.58; P=.005). Moreover, enamel hypoplasia, low birth weight, less parental education, and higher intake of soda pop were also significant risk factors for caries experience at five years old. Lower fluoride level in home water was a significant risk factor for caries experience at five

years old among children who were breast-fed for less than six months but not for children who were breast-fed for at least six months. A generalized logistic regression model for caries experience at the tooth level (at five years old) showed very similar results (data not shown).

Discussion

The current study examined the risk of dental caries on primary second molars associated with breast-feeding in a cohort of children studied prospectively from birth to nine years old. The primary second molars were most consistently present at both examinations and were the focus of the analysis to reduce the effects of differential exfoliation of teeth. The results indicated that infant breast-feeding might be an important factor for ECC among a group of young children with overall low caries experience. Shorter duration of breast-feeding was found to be a significant risk factor for caries development on primary second molars among children when examined at five years old after controlling for other important factors such as parental education level, the use of soda pop, enamel hypoplasia, and fluoride level in home water. However, its impact decreased with age, since caries incidence from five to nine years old and caries prevalence at nine years old were not significantly associated with shorter duration of breast-feeding.

Several previous studies reported no association between breast-feeding and dental caries,[8,10,11,13] and one study reported that children who were breast-fed for at least 12 months had a lower caries level than those who were bottle-fed or bottle- and breast-fed for more than 12 months,[9] although these were cross-sectional and focused only on ECC before five years old. The current study did not assess caries prior to five years old and, thus, was unable to assess the influence of breast-feeding on caries development in earlier life. Therefore, this study cannot verify whether the beneficial impact of breast-feeding occurs mostly prior to three years old or from three to five years old. If the protective effect of human breast milk diminishes with age, one can speculate that breast-feeding might not have much direct systemic/intrinsic effect on teeth. Instead, it’s possible that breast milk affects the local oral cavity environment, such as with dental plaque or localized immunity from secretory antibody from human milk.

A study by Cabrera-Rubio et al. showed an association between microbial communities of breast milk and the oral cavity.[26] Breast milk contains several other factors, such as lysozyme, lactoferrin, and oligosaccharides, which are important in preventing infections and supporting the growth of beneficial bacteria during a critical development and growth period early in life.[27] Also, shorter duration of breast-feeding could be associated with poor bottle habits, such as bedtime bottle-feeding, which have been shown to increase the risk of ECC.[6,9,28]

Results from this longitudinal study support the value of breast-feeding beyond six months old. Although policies of the American Academy of Pediatrics and American Academy of Pediatric Dentistry (**AAPD**)[1,2] recommend breast-feeding for a full year, we did not have sufficient breast-feeding participation over a full year to evaluate associations with caries experience. The AAPD currently recommends weaning from the bottle or breast-feeding by

12 to 14 months old.[2,29] The current study did not provide evidence that prolonged breast-feeding for more than 12 months increased the risk of childhood caries, but it indicated that breast-feeding for six months or longer may be associated with a lower risk of ECC. Other studies have also reported the association of longer duration of breast-feeding with lower caries risk.[9]

Several other factors, such as enamel hypoplasia, soda pop intake, and parental education level, were found to be independently associated with the prevalence of caries in primary second molars at five years old among this study's cohort. Enamel hypoplasia was associated with increased risk of dental caries, consistent with several previous studies.[30–34] While higher levels of fluoride in home tap water were significantly associated with lower caries experience in children who were breast-fed for less than six months, the study found no such association for children who were breast-fed for at least six months. This might indicate that exposure to fluoride during the first six months of life is protective against caries, particularly for those at higher risk.

It is well recognized that SES is an important risk factor for dental caries.[12,13,31,35] This study confirmed a significant association between parental education level and dental caries. Because the vast majority of the children were Caucasian and non-Hispanic, the influences of race and ethnicity were not assessed.

A major strength of this study is its longitudinal study design, with two examinations for dental caries conducted at five and nine years old. This allowed us to assess the long-term effects of breast-feeding on childhood caries as well as other important factors, such as fluoride intake levels, oral hygiene practices, and developmental tooth defects, thus giving valuable information that many previous studies were not able to provide.

However, several limitations of the study must be recognized. Since the current study was part of a parent study whose main purpose was to investigate the relationships between fluoride exposures and children's dental health, the information on breast-feeding patterns was somewhat limited. For example, neither the quantity of breast-feeding nor the quantity of additional supplemental feedings was assessed. Studies with better characterization of nursing patterns are needed. Also, since caries was not assessed prior to five years old, we were unable to assess the impact of breast-feeding on caries development in children younger than five years old. If the protective effect of breast-feeding comes primarily from a local mechanism, our results suggest that its effects are still detectable in five-year-olds and that breast-feeding could have an even more detectable impact on caries among younger children. Moreover, the subjects were a convenience sample, mostly Caucasian, and from families with a relatively high SES in Iowa, so caution is needed in generalizing the results. Also, the study had focused mainly on educational levels and family income for parental characteristics, and there could be other important known or unknown confounding factors. This further limits the generalization of the study results.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Breast-feeding beyond six months old seems to reduce the risk of early childhood caries in early years of life.
2. Additional studies with more detailed information on the patterns, duration, quality, and quantity of breast-feeding, together with caries examination data early in life, are needed.

Acknowledgments

This study was supported in part by NIH grants R01-DE09551, R01-DE12101, and M01-RR00059. The sponsoring organizations of this study has no role in study design and implementation, data analysis and interpretation, or manuscript writing.

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Table 1

DISTRIBUTION OF SUBJECT-LEVEL VARIABLES BY BREAST-FEEDING DURATION

Subject-level factor	Breast-feeding duration (mos)		*P*-value
	<6 (N=360)	≥6 (N=149)	
Gender (%)			
Boys	50	49	.78*
Girls	50	51	
Hypoplasia (%)			
Any teeth	7	7	1.00*
Primary second molars	3	5	.46*
	Mean	**Mean**	
Parent educational level (1–7)	4.33	4.91	<.001†
Family income level (1–7)	4.57	4.85	.11†
	Mean (±SD)	**Mean (±SD)**	
Gestational weeks	39.62±1.92	39.27±2.15	.10‡
Birth weight (kg)	3.50±0.54	3.52±0.56	.69‡
Dental exam age (ys)			
Primary dentition	5.15±0.42	5.13±0.34	.64‡
Mixed dentition	9.20±0.70	9.28±0.71	.28‡
Increment	4.05±0.74	4.15±0.68	.18‡
Home tap fluoride (ppm)§			
3–5 ys old	0.85±0.48	0.77±0.38	.06‡
5–9 ys old	0.83±0.46	0.77±0.36	.09‡
Daily fluoride intake (mg/day)			
3–5 ys old	0.78±0.40	0.75±0.36	.41‡
5–9 ys old	0.71±0.38	0.70±0.35	.79‡
Daily soda pop intake (oz/day)			
3–5 ys old	2.33±2.40	1.94±1.72	.04‡
5–9 ys old	3.13±2.48	2.71±2.21	.07‡
Tooth-brushing frequency (per day)			

Subject-level factor	Breast-feeding duration (mos)		*P*-value
	<6 (N=360)	≥6 (N=149)	
3–5 ys old	1.29±0.52	1.37±0.52	.12 ≠
5–9 ys old	1.48±0.48	1.57±0.47	.08≠

*P-value from Fisher's exact test.

†P-value from Cochran-Armitage trend test.

≠P-value from *t* test.

§New Department of Health and Human Services' recommendation for optimally fluoridated water. is at 0.7 ppm.

Table 2

BIVARIATE RELATIONSHIPS BETWEEN BREAST-FEEDING DURATION AND DENTAL CARIES

Person level (N=509 children)		**Breast-feeding duration (mos)**		***P*-value**
		<6	**≥6**	
A	*All primary teeth (5 ys old)*			
	Caries prevalence % (N)	25 (89/359)	19 (29/150)	.21[*]
	Mean dfs[†]	1.19	0.97	.15[‡]
B	*Primary second molars (5 ys old)*			
	Caries prevalence % (N)	18 (65/359)	9 (14/150)	.02[*]
	Mean dfs[†]	0.55	0.33	.02[‡]
C	*Primary second molars increment (5–9 ys old)*			
	Caries prevalence % (N)	32 (116/359)	31 (46/150)	.76[*]
	Mean dfs[†] increment	0.96	1.00	.89[‡]
Tooth level		**<6 mos (%) (N)**	**≥6 mos (%) (N)**	***P*-value**
A	All primary tooth $d_{2-3}f$[§] prevalence (5 ys old) (N=10,180 teeth)	4 (248/7,180)	3 (80/3,000)	.34[//]
B	Primary second molar $d_{2-3}f$[§] prevalence (5 ys old) (N=2,036 teeth)	9 (123/1,436)	5 (29/600)	.08[//]
C	Primary second molar $d_{2-3}f$[§] incidence (5–9 ys old) (N=2,036 teeth)	17 (242/1,436)	14 (84/600)	.29[//]

[*] Fisher's exact test.

[†] dfs=decayed filled surfaces.

[‡] Wilcoxon rank sum test.

[§] $d_{2-3}f$=cavitated enamel/dentin and/or filled.

[//] Generalized logistic regression with exchangeable correlation structure.

Table 3

PERSON-LEVEL MULTIVARIABLE LOGISTIC REGRESSION FOR PRIMARY SECOND MOLAR CARIES IN 5-YEAR-OLDS ($d_{2-3}f$[*]), N=491

Outcome variable	Predictor variables	Odds ratio	*P*-value
Primary second molar caries experience (dfs[†]>0) at 5 ys old	Birth weight (kg)	1.70	.04
	Parent minimum education (1–7)	0.77	.008
	Hypoplasia on second molars	3.19	.04
	Soda pop, 3–5 ys old (oz/day)	1.13	.02
	Breast-feeding <6 mos	15.58	.005
	Home water fluoride level, 3–5 ys old (ppm) for subjects breast-feeding <6 mos [‡]	0.35	.006
	Home water fluoride level, 3–5 ys old (ppm) for subjects breast-feeding >6 mos [‡]	4.33	.12

[*] $d_{2-3}f$=cavitated enamel/dentin and/or filled.

[†] dfs=decayed filled surfaces.

[‡] Effect of home water fluoride level differed by breast-feeding duration.