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Early childhood caries among premature children enrolled in WIC: A retrospective case - Controlled study

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Abstract

Purpose: To investigate the association between premature birth and Early Childhood Caries (ECC) experience, while secondarily evaluating factors that may influence development of caries.

Methods: Data collected from patients enrolled at the University of Iowa's Infant Oral Health Program consisted of prenatal history, child's demographics, neonatal history, oral hygiene, dietary habits, and clinical findings (visible plaque, enamel defects, and caries). Bivariate and logistic regression analyses were utilized (alpha=0.05).

Results: Four hundred and ninety eight randomly matched premature and full-term subjects were included (mean age=21 months [range: 6-71 months]; 51.4% males and 38.9% African Americans). Bivariate analysis revealed no significant differences existed regarding cavitated and non-cavitated caries experience between full-term and premature subjects. Additionally, compared to their counterparts, premature subjects were more likely to eat cariogenic snacks between meals (P=0.028), drink cariogenic beverages >2 times per day (P=0.027), not have their teeth brushed daily (P<0.001), and less likely to have seen a dentist (P=0.04). Logistic regression analysis showed that showed number of teeth present (OR=1.24, 95% CI: 1.10-1.39 ; P<0.001) and visible plaque on maxillary incisors (OR=5.69, 95% CI: 2.22-14.55; p<0.001) to be significantly associated with ECC in premature subjects.

Conclusions: While there was no evidence that prematurity was associated with ECC, premature subjects had cariogenic dietary behaviors and high-risk oral hygiene behaviors.

Keywords: Premature birth; Early childhood caries; Risk factors; Diet.

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Introduction

Premature birth, defined as a birth occurring before the 37th week of pregnancy is completed, is a global problem that causes emotional, physical and financial strains on families [1,2]. A number of etiological factors for premature birth are known, such as pre-eclampsia and fetal growth restriction; however, in many cases the cause of premature birth remains unclear [1]. Premature birth can lead to developmental immaturity of a wide range of organ systems, causing respiratory distress syndrome, feeding intolerance, immature immune systems, incomplete formation of the central nervous system, and oral complications [2,3]. Significant delays in physical and psychological growth and development have been found for premature children, although some studies have reported a 'catch-up' later in childhood [2,4].

Oral complications of premature birth have reportedly been the etiological factors for disturbed enamel development and mineralization in primary teeth [5]. Altered calcium homeostasis due to systemic illness is the primary mechanism hypothesized to cause developmental defects in enamel matrix formation [5]. In premature children, much of the enamel is mineralized after birth and may be subject to factors such as intubation and mechanical ventilation, which may disturb mineralization and contribute to enamel hypoplasia [5]. A systematic review on the relationship between premature birth and developmental enamel defects found an association between premature birth and an increased risk of developing enamel hypoplasia in primary teeth in nearly all studies included (ranging prevalence from 22% to 67%) [6]. The presence of enamel hypoplasia creates a greater risk of caries due to rough surfaces, which can result in greater adhesion of plaque and colony formation of caries-associated bacteria [7,8]. Enamel defects are strongly associated with Early Childhood Caries (ECC), which continues to be one of the most prevalent and costly oral conditions in young children [9].

Early childhood caries is defined as the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces (DMFTS) in any primary tooth in a child 71 months of age or younger [9]. The etiology of ECC is multifactorial and significantly associated with health behaviors. ECC risk factors include: Premature birth, low socioeconomic status, early mutans streptococci colonization, high frequency of sugar consumption, especially from added-sugar beverages and juice, poor oral hygiene, along with many other risk factors [9-15]. Premature birth was found to be associated with a diet higher in sugar and maternal stress beyond the first year of life [16,17]. Parents of children born premature are significantly more likely to use food rewards or coaxing to encourage food intake, compared to children born at term, leading to inappropriate dietary and feeding practices associated with ECC [18]. While there are many studies looking at the multifactorial risk factors of ECC, there is minimal research on premature birth and ECC directly.

The objective of this study is to determine if there is an association between premature birth and ECC experience in primary dentition, and to further evaluate caries risk factors (diet, oral hygiene practices, etc) that may influence development of ECC in our sample population.

Methods

This retrospective chart review case-control study was approved by the Institutional Review Board of the University of Iowa, Iowa City, Iowa, USA. Study subjects, aged 6-71 months, were selected from patients see at the University of Iowa's Infant Oral Health Program (IOHP), affiliated with the local Women, Infants, and Children (WIC) clinic, whose first dental visit was from 1998 until 2018. Children without any erupted teeth, as well as missing data regarding gestational characteristics or caries data, were excluded from the study. A total of 498 children, including 249 full-term and 249 premature subjects matched by age (±1 month) and sex, were included in the study.

Data obtained from the child's first dental visit included a maternal report of several variables for both mother and child. For the mother, these variables included educational level, dental health literacy, history of caries, and health problems during pregnancy. For the child, these variables included: Demographics (sex, age, race, guardianship of the child), health history (birth maturity/weight, gestational age, medical problems), dental history and oral hygiene behaviors (has the child ever been to the dentist, are the child's teeth brushed daily, adequate fluoride exposure from water and toothpaste, main water source), and dietary behaviors (breastfeeding history, bottle-feeding history, eating between-meal cariogenic snacks more than 2 times per day, drinking cariogenic beverages more than two times per day), and bedsharing frequency.

All dental examinations were performed by examiners from the Department of Pediatric Dentistry at the University of Iowa College of Dentistry who were trained and familiar with both plaque and dental caries scoring criteria. Plaque was assessed by the naked eye, without disclosing solution, using the following dichotomized categorization: No plaque on the facial surfaces of the maxillary incisors or plaque on at least one facial surface of maxillary incisors. Dental caries was recorded as the presence of cavitated and/or non-cavitated (white spot) lesions. A Caries Risk Assessment (CRA) tool was used to determine a child's risk as either low or high. The CRA was based on several factors including medical and dental histories, clinical evaluation of child's oral health, and examiner's overall impression, as described by Weber-Gasparoni et al. (2010) in a previous publication [19].

Univariate analysis was conducted to provide a summary of characteristics of the study participants, while bivariate analysis was performed to examine the association of premature birth with demographic characteristics, characteristics of modifiable oral hygiene and dietary habits, and caries risk factors among children aged 6-71 months old who attended the University of Iowa's Infant Oral Health Program (IOHP) located at the Johnson County WIC program, using chi-square test, Fisher's exact test, Cochran-Mantel-Haenszel test, and the Wilcoxon rank-sum test. Additionally, multivariable logistic regression model was developed to identify the significant predictors for caries experiences. A p-value of less than 0.05 was used as a criterion for statistical significance. Statistical analysis was conducted using the statistical package SAS® System version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

A total of 498 children, including 249 full-term and 249 premature subjects matched by age (±1 month) and sex, were included in the study. Table 1 presents a selective summary of descriptive results of study subjects. Bivariate analysis revealed that premature subjects were more likely than full-term subjects to: Be Black or African American (47.4% vs. 33.5%; *P*=0.049), have lower mean birth weight (2.6 ± 1.0 vs. 3.4 ± 0.5kg; *P*<0.001), have maternal health problems during pregnancy (38.8% vs. 11.9%; *P*<0.001), have low maternal dental health literacy (43.3% vs. 30.8%; *P*=0.013), eat between-meal cariogenic snacks more than 2 times a day (29.4% vs. 19.6%; *P*=0.028), drink cariogenic beverages more than 2 times a day (35.9% vs. 25.3%; *P*=0.027), and not have their teeth brushed daily (34.3% vs. 16.3%; *P*<0.001).

On the other hand, premature subjects were less likely than full-term subjects to: have been to a dentist (8.8% vs. 15.1%; *P*=0.04), be breastfed (59.8% vs. 77.1%; *P*<0.001), be breastfed to sleep (34.4% vs. 49.6%; *P*<0.001), be breastfed throughout the night (42.3% vs. 56.1%; *P*=0.003), be bottle-fed to sleep (50% vs. 60.3%; *P*=0.023), and bedshare with their mother (56.8% vs. 42.7%; *P*=0.003).

Moreover, there were no significant differences between full-term and premature subjects concerning number of teeth, maternal educational level, adequate fluoride exposure from water and toothpaste**,** presence of caries, presence of enamel defects, presence of plaque on maxillary incisors, and being categorized as high risk of caries *(P*>0.05 in each instance). Significant results are summarized in Table 2.

Since the data provided strong evidence that there were no differences in ECC experience between the premature and full-term study participants, further analyses were conducted to identify significant predictors of ECC experiences within each study group (not shown in tables). Among the premature children group, the final logistic regression model showed that there were two significant predicator variables for ECC experience: Number of teeth present and presence of visible plaque on maxillary incisors. This analysis revealed that the odds for the presence of ECC increased 24% for each additional tooth (OR=1.24, 95% CI: 1.10-1.39;*P*<0.001). Moreover, for the children who had visible plaque on maxillary incisors, the odds of having ECC were 5.69 times as likely as for those who didn't have visible plaque on maxillary incisors *(P*<0.001). As for the full-term group, the final logistic regression model showed that there were four significant predicator variables for ECC experience: Number of teeth present, irregular dental care (defined as late dental home establishment or lack of IOHP follow-up appointments), cariogenic beverages more than 2 times a day, and presence of visible plaque on maxillary incisors. The logistic regression analysis revealed that the odds for the presence of ECC increased 22% for each additional tooth (OR=1.22, 95% CI: 1.04, 1.42; *P*=0.005). Moreover, the children who had irregular dental care (OR=4.06, 95% CI:1.21-13.71; *P*<0.001), had cariogenic beverages more than two times a day (OR=10.52, 95% CI: 2.90-38.21; *P*<0.001), and had presence of visible plaque on maxillary incisors (OR=5.39, 95% CI:1.25-23.24; *P*=0.018) were more likely to experience ECC than those who didn't have.

Table 1: Non-statistically significant characteristics of participants in the study.

	Total N=498	Full-Term N=249	Premature N=249
Child demographics:			
Sex (n, %)			
Female	242 (48.6)	121 (48.6)	121 (48.6)
Male	256 (51.4)	128 (51.4)	128 (51.4)
Age (months)			
Mean (SD)	21.0 (11.3)	21.0 (11.3) 18.0	21.0 (11.3)
Median (Range)	18.0 (6-71)	(6-71)	18.0 (6-71)
Weeks born premature (weeks)			
Mean (SD)	1.8 (2.8)	0.0 (0.0)	3.8 (2.9)
Median (Range)	0 (0-17.5)	0.0 (0.0-0.0)	3.0 (0-17.5)
Child has medical problems (n, %)			
Yes	50 (12.1)	20 (9.9)	30 (14.1)
No	365 (87.9)	182 (90.1)	183 (85.9)
Child has special health care needs (n, %)			
Yes	3 (0.8)	3 (1.2)	0 (0.0)
No	389 (99.2)	244 (98.8)	145 (100.0)
Maternal information:			
Mother's highest level of education (n, %)			
High school diploma or lower	262 (69.0)	157 (67.1)	105 (71.9)
2-year college degree or higher	118 (31.0)	77 (32.9)	41 (28.1)
Past or current history of maternal caries (n, %)			
Yes	241 (67.7)	149 (68.0)	92 (67.2)
No	115 (32.3)	70 (32.0)	45 (32.5)
Child feeding and dietary practices:			

Current and past history of bottle-feeding (n, %)			
Yes	464 (94.3)	237 (95.2)	227 (93.4)
No	28 (5.7)	12 (4.8)	16 (6.6)
Current and past history of bottle-feeding throughout the night (n, %)			
Yes	251 (52.6)	129 (53.3)	122 (51.9)
No	226 (47.4)	113 (46.7)	113 (48.1)
Main water source of child (n, %)			
City water (unfiltered)	224 (46.4)	113 (45.9)	111 (46.8)
City water (filtered)	67 (13.9)	36 (14.6)	31 (13.1)
Well water	27 (5.6)	8 (3.3)	19 (8.0)
Bottle water	165 (34.2)	89 (36.2)	76 (32.1)
Child dental history and oral hygiene practices:			
Adequate fluoride exposure from water and toothpaste (n, %)			
Yes	396 (82.7)	196 (80.7)	200 (84.7)
No	83 (17.3)	47 (19.3)	36 (15.3)
Child clinical findings			
Number of teeth present			
mean (SD)	12.2 (6.1)	12.5 (6.0)	12.0 (6.3)
Median (Range)	12 (1-20)	12 (2-20)	10.0 (1-20)
Presence of caries (n, %)			
No carious lesions present	417 (88.4)	211 (88.3)	206 (88.4)
Non-cavitated lesions present	18 (3.8)	9 (3.8)	9 (3.8)
Cavitated lesions present	20 (4.2)	7 (2.9)	13 (5.6)
Combined non-cavitated and cavitated lesions present	17 (3.6)	12 (5.0)	5 (2.2)
Child has irregular dental care (n,%)			
Yes	67 (19.8)	43 (19.5)	24 (20.5)
No	271 (80.2)	178 (80.5)	93 (79.5)
Presence of enamel defects (n, %)			
Yes	20 (4.2)	11 (4.5)	9 (3.9)
No	456 (95.8)	233 (95.5)	223 (96.1)
Presence of visible plaque on maxillary incisors (n, %)			
Yes	71 (14.8)	32 (13.2)	39 (16.6)
No	407 (86.2)	211 (86.8)	196 (83.4)
Caries risk assessment			
Low risk	321 (65.1)	166 (66.7)	155 (63.5)
High risk	172 (34.9)	83 (33.3)	89 (36.5)

*The number of total subjects may be less than 498 (or n=249/per group) for each variable due to missing values and/or unsure answers

Table 2: Significant demographic and clinical risk factors associated with premature birth.

Variables	Full-Term N=249 N (%)	Premature N=249 N (%)	*P*-value
Child demographics:			
Birth weight (kg)			
Mean (SD)\median	3.4 (0.5)\3.4	2.6 (1.0)\2.6	<0.001[b]
Race			0.049[a]
Black or African American	81 (33.5)	74 (47.4)	
Hispanic or Latino	54 (22.3)	26 (16.7)	
White or Caucasian	76 (31.4)	39 (25.0)	
Other	31 (12.8)	17 (10.9)	
Maternal information:			
Maternal low dental health literacy			0.013[a]
Yes	76 (30.8)	61 (43.3)	
No	171 (69.2)	80 (56.7)	

Maternal health problems during pregnancy			
Yes	29 (11.9)	94 (38.8)	<0.001[a]
No	215 (88.1)	148 (61.2)	
Child feeding and dietary practices:			
Current and past history of breastfeeding			
Yes	192 (77.1)	146 (59.8)	<0.001[a]
No	57 (22.9)	98 (40.2)	
Current and past history of breastfeeding to sleep			
Yes	123 (49.6)	79 (34.4)	<0.001[a]
No	125 (50.4)	151 (65.6)	
Current and past history of breastfeeding throughout the night			
Yes	138 (56.1)	96 (42.3)	0.003[a]
No	108 (43.9)	131 (57.7)	
Current and past history of bottle-feeding to sleep			
Yes	149 (60.3)	118 (50.0)	0.023[a]
No	98 (39.7)	118 (50.0)	
During the bottle- or breastfeeding period, the child bedshared with the mother for the following number of nights per week			
0 night	103 (42.7)	125 (56.8)	
1-7 nights	138 (57.3)	95 (43.2)	0.003[a]
Eat between-meal cariogenic snacks > 2 times a day			
Yes	48 (19.6)	42 (29.4)	0.028[a]
No	197 (80.4)	101 (70.6)	
Drink cariogenic beverages > 2 times a day			
Yes	61 (25.3)	52 (35.9)	0.027[a]
No	180 (74.7)	93 (64.1)	
Child dental history and oral hygiene practices:			
Child has been to a dentist			
Yes	34 (15.1)	19 (8.8)	0.04[a]
No	191 (84.9)	198 (91.2)	
Child's teeth brushed daily			
Yes	200 (83.7)	88 (65.7)	<0.001[a]
No	39 (16.3)	46 (34.3)	

[a] Statistically significantly *(P*<0.05) using chi-square test
[b] Statistically significantly *(P*<0.05) using the Wilcoxon rank-sum test

Discussion

Bivariate analyses revealed no significant associations of gestational age (i.e. premature vs. full-term) with the presence of carious lesions (cavitated and non-cavitated), presence of enamel defects, visible plaque on maxillary incisors, and higher caries-risk classification. Other published literature has also found no statistically significant association between premature birth and presence of carious lesions [20-24]. Cruvinel et al. (2010) did not find a statistically significant difference in the occurrence of dental caries between premature and full-term children [20]. Rajshekar and Laxminarayan found there was no statistical difference between decayed, missing, and filled teeth between premature, low-birth weight children, compared to full-term, and normal birth weight children [23].

When comparing children born premature to their full-term counterparts, statistically significant differences in dietary behaviors were found. Children born premature were less likely to be breastfed (including to sleep or in the middle of the night), less likely to be bottle fed to sleep, more likely to eat cariogenic snacks between meals and more likely to drink cariogenic beverages more than 2 times a day. Documented barriers of breastfeeding premature children include establishing and maintaining the mothers supply of milk during initial hospitalization, the child's increased nutritional requirements, and the child's limited ability to suckle [25-28]. Other published literature found similar associations between diets high in sugar and children born prematurely [17].

Our study indicated that premature birth was positively associated with the child's infrequent brushing habits, when compared to full-term children. This factor could be due to the low socio-economic status of the population as a whole. Vargas et al. found that children from low socio-economic status backgrounds, or belonging to a racial/ethnic minority, were less likely to have had a dental visit in the previous year; therefore they may not have been given preventive instructions on frequency of brushing [28]. Lee et al. found that there was a need for interventions to increase oral health literacy in the WIC population [29]. Children born full-term in our study were found to be more likely to bedshare with their mothers, when compared to their premature counterparts. Bedsharing has been found to be significantly associated with children deemed at a high caries risk [30].

When we explored the difference between premature birth and their matched full-term counterpart, we found that enamel defects and plaque present on maxillary incisors were not significantly associated with gestational age in this study. The lack of statistical significance in enamel defects finding is consistent with published literature [31]. However, Graviana et al. found a higher prevalence of enamel defects in premature children, along with a significant association between enamel defects and low birth weight [32]. Our findings contradict Rythen et al. (2012) who found a significantly increased prevalence of plaque among adolescents who had been born extremely premature compared to matched controls; however the difference in findings may be explained by the difference in the age groups studied (6-71 months vs. 12-16 years) [33].

Finally, when compared to full-term children using bivariate analyses, premature birth was not found to be associated with a high caries risk status, as measured by the caries risk assessment described by Weber-Gasparoni et al. (2010) in a previous publication [19]. Rythen et al. found that children aged 12-16 years who had been born prematurely had an increased number of risk factors for a poor oral outcome, including increased bleeding on probing, decreased salivary secretion, increased Streptococci mutans counts, and increased localized and generalized plaque [24]. Our study used a population of children with a mean age of 21 months; therefore, ECC may not have had enough time to express itself. Overall, only 11.6% of children had a history of caries, so there may have been insufficient power to detect a difference based upon prematurity status. Also, a great percentage of this studies population had adequate fluoride exposure. Therefore, we speculate that there is no difference in caries experience between the two groups due to adequate fluoride exposure from drinking water and use of fluoridated toothpaste when brushing, which according to the American Academy of Pediatric Dentistry are perhaps the most effective method to reduce prevalence of dental caries in children [33].

Premature children have important social, psychological, and behavioral risk factors, which may affect ECC experience. Poverty and social disadvantages predispose low socioeconomic groups to a high risk of ECC. Low socioeconomic status is associated with lower levels of maternal education, a higher prevalence of high-risk health behaviors, and less access to dental care [34]. Premature birth can increase maternal stress for mothers [35]. The Fisher-Owens conceptual framework for ECC unifies determinants of oral health through child, family and community level influences; these influences include diet, microflora, health behaviors and practices, family practices, culture, socioeconomic status, health status of parents, social environment and support, and the dental and healthcare system characteristics [15].

After discovering there was no association of ECC experience between the premature and full-term children, further analyses were conducted to identify significant predictors of ECC experiences within each study group. Within both the premature and the full term study groups analyzed separately, significant associations were found between ECC experience and the number of teeth present along with visible plaque on maxillary incisors. Increasing the number of teeth present in the mouth increases the surfaces available and the amount of time in which caries can form. Visible plaque on maxillary incisors is an indicator of poor oral hygiene and bacterial plaque colonization.

In addition, the analysis within the full-term children group showed that irregular dental care and cariogenic beverages were additional risk factors for full-term children who experience ECC. Irregular dental care may indicate inadequate preventive dental guidance and lack of previous dental care. Frequent ingestion of cariogenic beverages can enhance the cariogenic activity of Streptococci mutans biofilms leading to increase risk of caries development.

This study was subject to the inherent limitations of survey studies that rely on self-reported data collection and retrospective secondary data analysis. Although the questions used in the study were deliberately created to avoid leading answers, response bias could not be controlled. This study population is very likely not representative of the U.S. population; our population has a disproportionately large number of low-income children, and it includes families from the Midwest. A major strength of this study is that it includes ethnically diverse families.

In summary, this study did not demonstrate that children born prematurely were significantly more likely to have a higher risk of caries when compared to their counterparts. However, it did find associations between ECC experience and several risk factors. The study is important because it reports certain dietary and oral hygiene factors that are associated with ECC among premature children. Therefore, as clinicians, we should emphasize establishing a dental home, increased oral hygiene and non-cariogenic dietary practices early in the child's life.

Conclusion

Based on this study's results, the following conclusions can be made for children aged 6-71 months from WIC-enrolled children attending the University of Iowa IOHP:

1. There was no evidence of a relationship between children born premature compared to those born full-term and:
   a. Presence of carious lesions (cavitated & non-cavitated)
   b. Presence of enamel defects
   c. Visible plaque on maxillary incisors
   d. Being deemed at moderate to high risk of caries
2. Further analyses were conducted to identify significant predictors of ECC experiences within each study group. Among the separate premature children group and the full-term group, the final logistic regression model showed that there were two significant predictor variables for ECC experience for both:
   a. Number of teeth present
   b. And presence of visible plaque on maxillary incisors
3. Within the full-term group, there were two additional significant predictor variables:
   a. History of irregular dental care
   b. Drinking cariogenic beverages more than two times a day.

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