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A Longitudinal Study of Dental Caries Risk among Very Young Low SES Children

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Abstract

Objectives—Early childhood caries is a challenging public health problem in the United States and elsewhere; however, there is limited information concerning risk factors in very young children. The purpose of this study was to assess baseline risk factors for 18-month caries prevalence as part of a longitudinal study of high-risk children.

Methods—212 children 6–24 months of age were recruited from a rural community in Iowa. Subjects were enrolled in the WIC program, which provides nutritional support for low-income families with children. Dental examinations using d1d2-3 criteria were conducted at baseline and after 18 months. Caries prevalence was determined at the frank decay level (d2-3 or filled surfaces), as well as at the non-cavitated level (d1), and combined (d1, d2-3 or f surfaces). Risk factor data were collected at baseline and after 9- and 18- months. These data included beverage consumption data, presence of visible plaque, and use of fluoride toothpaste for children as well as mutans streptococci (MS) levels of mothers and children and family socio-demographic factors.

Results—128 children (60%) remained in the study after 18 months. Among these children, prevalence of d-1d2-3/f level caries increased from 9% to 77%, while d2-3/f level caries increased from 2% to 20%. Logistic regression models for baseline predictors of d2-3f caries at the 18-month follow-up found presence of MS in children (OR=4.4; 95% CI: 1.4, 13.9) and sugar-sweetened beverages (OR=3.0; 95% CI: 1.1, 8.6) to be the only significant risk factors. Socio-demographic factors and use of fluoride toothpaste were not significant in these models.

Conclusions—Results suggest that early colonization by MS and consumption of sugar-sweetened beverages are significant predictors of early childhood caries in high-risk populations.

Keywords

Dental caries; primary dentition; children; risk factors; mutans streptococci

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Introduction

Early childhood caries continues to be a serious public health problem in the United States and in many other areas of the world. In fact, as reported by Beltran-Aguilar et al, the two most recent U.S. national surveys have demonstrated an increase in caries prevalence among 2–5 year-olds (1). One likely reason why the prevalence has increased is that dental caries, along with numerous other diseases, is often concentrated in low socioeconomic status (SES) families, where preventive and treatment services are often lacking (2–4). Unfortunately, research in these populations is often difficult, so that studies, particularly longitudinal studies, of more specific factors associated with early childhood caries are uncommon.

Among cross-sectional studies, factors identified to be associated with caries in early childhood have included older age (5–10), low socioeconomic status (1,3–6,8,9,11,12,13), minority status (8,9,11), high sugared snack or beverage consumption (10,13–15), improper bottle use (11,12,16,17), living in rural areas (7,8,10,15), higher levels of mutans streptococci (5,6,18–20), poor oral hygiene (5,10,17), general (21) and specific (22) genetic factors, and poor diet (23).

The few longitudinal studies have identified a similar set of risk factors. For example, Grindefjord et al (24) assessed risk factors for dental caries development in 692 Swedish children who were followed from age 2.5 to 3.5 years. They found that high sugar consumption, poor oral hygiene and mutans streptococci and lactobacilli colonization at baseline to be associated with caries development and progression, although their most striking finding was that over 90% of those with caries at baseline developed new lesions during the one-year time period. Another study from Sweden followed 575 children from age 3 to age 6 and found that presence of caries at age 3 and immigrant status were associated with caries at age 6 (25).

Litt et al (26) examined Connecticut children for caries who were 3–4 years of age at baseline, and then examined 184 of them again one year later. The study also collected interview data from parents regarding sociodemographics, dental knowledge, child's sugar intake and other factors in addition to collecting saliva samples from children to assess *S. mutans* levels. The study found that caries at baseline was strongly predictive of caries one year later, and that baseline caries were associated with *S. mutans* and poor oral health behaviors. A study conducted in Japan followed 60 children age 3–5 years at baseline for a period of one year, and focused on bacterial risk factors for caries increment (27). This study found that children who harbored both *S. mutans* and *S. sobrinus* had significantly higher caries increments than children harboring only one of these organisms (27).

Lastly, a longitudinal study of nearly 700 Iowa children collected caries risk factor data periodically beginning shortly after birth and examined children in the primary dentition at approximately age 5 (28,29). The study found that older age at examination, lower family income, less frequent toothbrushing, lower water and milk consumption and higher sugared beverage consumption to be associated with caries (28). In particular, the study found that higher longitudinal consumption of regular soda pop and powdered beverage concentrates made with sugar increased caries risk (29).

While the above described studies have identified a number of risk factors for early childhood caries, all of the longitudinal studies and nearly all of the cross-sectional studies assessed children's caries risk late in the preschool years (3.5 years or older), and few collected risk factor data in children one year of age or younger. Given that caries development is a process that develops over months or years, and that several studies have noted severe caries in pre-school children, it is important to understand the caries process at

a very young age. Thus, the purpose of this study was to identify baseline risk factors collected at 6–24 months that were associated with 18-month caries prevalence in children from low-income and minority families.

Methods

The study sample included 212 children from 6 to 24 months of age who were enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC program). The sample was recruited on-site at a large WIC clinic in a southeast Iowa community with a large Hispanic population and followed for a period of 18 months (5). Demographic data, including child racial/ethnic information, family income, mother's education level, as well as mothers' beverage consumption were collected at baseline using questionnaires completed by the mother (or other caregiver), with clarification provided by the study coordinator as needed. Other risk factor data, including child beverage consumption, nighttime bottle feeding practices and fluoride exposure were collected using questionnaires by the study coordinator at baseline, after 4–5 months, after 9 months, after 13–14 months, and after 18 months. All questionnaires were adapted from those developed for and validated by the Iowa Fluoride Study (30). Specifically for these analyses, fluoride exposure was defined as the use of fluoride toothpaste, while beverage consumption and nighttime bottle feeding were derived directly questionnaire responses (described below). At the time of recruitment, informed consent was obtained by the study coordinator following protocols approved by the University of Iowa Human Subjects' Committee.

For the estimates of beverage consumption, mothers were asked to indicate whether they and their child consumed a specific beverage from a list contained in the questionnaires, and were also asked to report how many servings they and their child consumed per week, and the average amount per serving. Because relatively few children consumed any amount of many of the beverage categories, only the yes/no variables were used. From these data, a summary variable of sugar-sweetened beverages was created such that children consuming regular soda pop, sports drinks, powder concentrate beverages made with sugar, and juice-based drinks with added sugar were considered to be consumers of sugar-sweetened beverages. It should be noted that 100% juices with no added sugar were not included as part of this summary variable, based on previous studies (29,31,32).

Caries examinations and assessments for visible plaque were conducted by a single trained examiner at baseline, after 9 months and after 18 months. The examinations were done in the knee-to-knee position using a halogen headlight, mirror and explorer, with the examinations being primarily visual. Criteria for the exams included cavitated (d2-3) lesions, which required either demonstrable loss of enamel structure upon visual examination or softness at the base of lesion using explorer probing with controlled modest pressure, and non-cavitated (d1) lesions, characterized as having an area of distinct chalky white enamel on a smooth surface or adjacent to a pit or fissure site, with no loss of enamel (33). The examinations were conducted by a single examiner who was calibrated against a gold standard examiner with older pre-school children. Inter-examiner reliability was 96.0% and kappa = 0.84 for d_2 or filled lesions and 96.3% agreement and kappa = 0.48 for d_1 lesions. No assessment of intra-examiner agreement was made for this study, due in part to the very young age of participating children and the need for repeat examinations.

Mutans streptococci (MS) levels were assessed using a semi-quantitative method from saliva samples collected using a sterile tongue blade (34) whereby both sides of a sterile tongue blade were alternately pressed against the dorsum of the subject's tongue. Each side of the tongue blade was then pressed into a raised agar plate (RODAC plate) containing Mitis-Salivarius-Kanamycin-Bacitracin (MSKB), a selective medium for the isolation of MS. The

plates were then transported back to University of Iowa laboratory facilities and incubated for 48 hours at 37°C in 5% CO_2. The number of MS colonies were counted and categorized as none, less than 10, 10 to 100, 100 to 200 or as "too many to count"(34). These samples were collected from children and their mothers at baseline, after 9 months and after 18 months.

Data were collected on paper forms, and entered using data entry software (35), and converted into SAS (36) format for analyses. For these analyses, baseline data were assessed as predictors of d2-3f caries experience in children 18 months after baseline. Potential risk factors associated with development of caries was assessed by incidence density ratio (IDR) and odds ratios, estimated in the context of logistic regression (37–39). The variables used were demographic factors, SM, presence of plaque, fluoride exposure, sugary beverage consumption, and night time bottle feeding. Prevalence rates of caries and MS at the baseline and at the 18-month follow-up were calculated and their corresponding incidence rates evaluated. McNemar's test for matched pairs was used to compare the change in caries incidence at baseline and 18-month follow-up. Bivariate relationships between d-2, or filled surfaces and each of the potential predictive variables was assessed using conventional chi-square tests for categorical predictors and either student's t-tests or nonparametric Wilcoxon-Mann-Whitney tests, as appropriate, for the quantitative measures at 18 months.

Results

Of the 212 children who participated at baseline, 128 (60%) remained in the study at the 18-month follow-up. Among those who remained in the study, there were higher proportions who were Caucasian children, married mothers, had annual family incomes greater than $25,000, and mothers who were high school graduates than the sample at baseline. None of these differences were statistically significant. Among the 128 who remained the study, 58% were male and most (75%) were Caucasian, with a significant minority (18%) being Hispanic and the others being black (3%) or of other or mixed race (4%). Just over half (51%) of the mothers were married, with 38% being single and 82% of mothers had no more than a high school education; 74% of children were from families with annual incomes under $25,000. The mean age of the 128 children at baseline was 12.6 months (range 6–24 months), with an equal number (n=64) of the children under age 12 months and 12 to 24 months of age. The children had an average of 6.8 teeth present (range 0–20) at baseline.

Table 1 presents the prevalence of cavitated and non-cavitated carious lesions as well as mutans streptococci and plaque levels at the baseline and the 18-month follow-up examinations. As seen in Table 1 there were significant ($p<0.05$, McNemar's test) changes from baseline to 18-month follow-up for d-1d2-3/f level and d2-3/f level caries prevalence, the proportion of children with visible plaque present, and the prevalence of mutans streptococci carriage in children.

Incidence density of caries was estimated as the number of new caries developed during 18 months divided by the total person time at risk during the follow-up period. These ratios for the baseline presence of plaque, mutans streptococci, nighttime bottle feeding and sugar sweetened beverage consumption is presented in Table 2. As demonstrated in Table 2, baseline presence of mutans streptococci and sugar sweetened beverage consumption were strongly associated with d2-3f caries experience 18 months later as was baseline presence of plaque. Night-time bottle feeding at baseline was marginally associated with caries ($p=0.062$), but baseline fluoride exposure variables (water fluoridation status, dentifrice use) were not associated with caries 18 months later (data not shown). In addition, none of the baseline socio-demographic variables (sex, race, family income level, mothers' marital status or education level) were associated with d2-3f caries occurrence 18 months later.

Child's age demonstrated a significant (p=0.006, chi-square) association with caries, with frank caries occurring in 11% (7 out of 64) of those under 12 months at baseline, in 18% (6 out of 33) of those age 12 to 17 months at baseline, and 39% (12 out of 31) of those age 18 to 24 months at baseline. Age-adjusted logistic regression models found that significant baseline risk factors for d2-3f caries at the 18-month follow-up were presence of MS in children (OR=4.4; 95% CI: 1.4, 13.9) and children's consumption of sugar-sweetened beverages (OR=3.0; 95% CI: 1.1, 8.6). The results of the logistic regression analyses are presented in Table 3.

Discussion

The prevalence and severity of dental caries in pre-school children can be quite high as demonstrated by several studies (6–12,16). Thus, it is of great importance to begin preventive efforts at very young ages in vulnerable populations; however, information has been somewhat lacking concerning individual risk or specific factors to address in preventive programs for the very young. The results of this study suggest that two relatively easily-identified risk factors in 1-year-olds, presence of mutans streptococci and sugar-sweetened beverage consumption, are predictive of frank (d2-3f) caries in the middle pre-school years.

The identification of such risk factors early in life may allow tailored interventions for individual children including nutritional counselling and antimicrobial therapy or other appropriate prevention. Similarly, on a larger scale, the results of the study suggest that approaches to early childhood caries prevention may require more emphasis on behavioral change in regard to dietary practices and on antimicrobial agents as first-line preventive agents in young children. Thus, it appears that further studies of behavioral change methods (e.g., motivational interviewing, self-determination theory) are justified, and studies of antimicrobial agents including chlorhexidine, iodine and other agents are warranted.

Overall, the risk factors identified in the present study are similar to those identified in other studies (6,10,13–15,18–20,24,26), including two longitudinal studies of older children (24,26). In the study by Grindefjord et al (24), presence of SM and consumption of sugar-containing beverages at baseline were associated with caries development during the succeeding 1-year period, and the odds ratios for these two risk factors were 4.5 and 2.1, respectively – similar to the findings of the present study. However, unlike the present study, these odds ratios were based on bivariate analyses that weren't adjusted for age, and in these analyses several other risk factors were identified (e.g., immigrant status, low education level of mothers) so that it is not clear which risk factors were most germane to caries development. Moreover, the children in this study were at least 2 ½ years old and 11% of them had frank caries at baseline so that the findings may not apply to younger children.

While a strength of the present study was its longitudinal assessment of very young children, there were limitations. These included somewhat self-selected samples who remained in the study over an 18-month period, and who were from a limited geographic area. In addition, while Caucasian and Hispanic populations were well-represented in the sample, other groups were not. Taken together, the study sample cannot be considered representative of any population, so that extrapolation of study results should be done with caution. In addition, the study did not fully assess some potential risk factors including organisms other than MS; fluoride exposures other than water or dentifrice; parental health, health knowledge or beliefs, or other, non-beverage sugar exposures. Given that the study was conducted in a WIC clinic, it may not have allowed for enough variation in socio-economic status to identify SES as a caries risk factor. Moreover, sample size limited logistic modeling such that it was not possible to jointly consider all important risk factors in a

single model. In addition, the sample size did not allow separate analyses based on narrower age ranges. Nonetheless, as a longitudinal study of children who were 1-year-olds at baseline, the study is unique and provides valuable insights into the initiation of caries in early childhood.

In conclusion, the results suggest that consumption of sugar-sweetened beverages in children up to 24 months of age is a strong and identifiable predictor of early childhood caries development in this population. Consistent with earlier studies, results also suggest that presence of mutans streptococci at an early age is strongly associated with ECC development. Health care providers should be alerted to substantially increased risk for ECC among infants and toddlers who consume sugar-sweetened beverages on a regular basis. Moreover, preventive strategies for very young children should include interventions to address SM as well as reduced sugar-sweetened beverage consumption.

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Table 1

Prevalence of Caries, Plaque and Mutans Streptococci (MS) Carriage at Baseline and after 18 Months (n = 128)

	Baseline n (%)	18-Month Follow-up n (%)
d-1, d-2 or filled surface	11 (8.6%)	99 (77%)
d-2 or filled	3 (2.3%)	25 (19.5%)
d-1 decayed	10 (7.8%)	97 (76%)
Plaque present	42 (67%)	122 (95%)
MS present in Mother	102 (84%)	96 (83%) n = 116
MS present in Child	19 (15%)	53 (44.5%) n = 119

Table 2

Results of Incidence Density (ID) and Logistic Regression Analysis of Baseline Caries Risk Factors Relationship to d2-3f Caries after 18 months (n = 128)

Baseline Factor		Incidence Density (ID) Analysis			Odds Ratio (95% CI) from Logistic Regression Analysis
		ID/ month	IDR*	p-value	
Presence of Plaque	Yes (n=39)	0.017	2.41	0.015	3.4 (1.4, 8.4)
	No (n=86)	0.007			
Presence of MS	Yes (n=17)	0.026	5.55	<0.001	7.4 (2.6, 21.3)
	No (n=106)	0.005			
Sugar-Sweetened Beverage‡ Consumption	Yes (n=44)	0.019	3.44	0.001	5.2 (2.0, 13.3)
	No (n =81)	0.006			
Night time bottle Feeding	Yes (n = 73)	0.008	0.55	0.062	0.4 (0.2, 1.03)
	No (n = 52)	0.014			

*IDR = Incidence Density Ratio

‡Sugar Sweetened Beverages included regular soda pop, sugared beverages made from powder, sports drinks, juice drinks and other sugared beverages

Table 3

Results of Age-Adjusted Logistic Regression Analysis of Baseline Predictors of d2-3f Caries Experience after 18 Months.

Baseline Characteristic	No. w/Frank decay	Odds Ratio (95% CI) p-value
Age	Yes (n=25) No (n=103)	1.14 (1.03,–1.26) 0.009
Presence of Plaque		1.65 (0.59–4.41) 0.35
Age	Yes (n =24) No (n=102)	1.11 (1.01–1.22) 0.03
Presence of MS		4.38 (1.39, 13.87) 0.01
Age	Yes (n=25) No (n=103)	1.11 (1.01–1.22) 0.03
Sugar-Sweetened Beverage‡ Consumption		3.04 (1.07–8.64) 0.04
Age	Yes (n=25) No (n=103)	1.18 (1.06–1.32) 0.003
Night time bottle feeding		1.34 (0.40–4.5) 0.6

‡Sugar Sweetened Beverages included regular soda pop, sugared beverages made from powder, sports drinks, juice drinks and other sugared beverages