Factors Associated with Dental Caries Experience in 1-Year-Old Children

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Abstract

Objectives: *Dental caries in early childhood is an important public health problem. Previous studies have examined risk factors, but they have focused on children during the later stages of the disease process. The purpose of this study was to assess the factors associated with caries in children aged 6 to 24 months as part of a cross-sectional analysis.* ***Methods:*** *Two hundred twelve mothers with children 6 to 24 months of age were recruited from Special Supplemental Nutrition Program for Women, Infants, and Children clinic sites in southeastern Iowa for participation in a longitudinal study of dental caries. Baseline assessments included detailed questions regarding the children's beverage consumption, oral hygiene, and family socioeconomic status. Dental caries examinations using the* $d_1d_{2\text{-}3}f$ *criteria and semiquantitative assessments of salivary mutans streptococci (MS) levels of mother and child were also conducted. Counts of the number of teeth with visible plaque were recorded for maxillary and mandibular molars and incisors.* ***Results:*** *Of the 212 child/mother pairs, 187 children had teeth. Among these children, the mean age was 14 months, and 23 of the children exhibited either* d_1*,* $d_{2\text{-}3}$*, or filled lesions. Presence of caries was significantly associated with older age, presence of MS in children, family income <$25,000 per year, and proportion of teeth with visible plaque.* ***Conclusions:*** *Results suggest that not only microbial measures, including MS and plaque levels, are closely associated with caries in very young children, but that other age-related factors may also be associated with caries. Continued study is necessary to more fully assess the risk factors for caries prevalence and incidence in preschool children.*

Key Words: dental caries, early childhood caries, sugar consumption, mutans streptococci, plaque

Introduction

While the prevalence of dental caries has declined for the general population over the past decades, dental decay still remains one of the most common chronic diseases of childhood (1). For certain high-risk populations, tooth decay is rampant and occurs in epidemic proportions. It has been estimated that 80 percent of decay is found in just 25 percent of children (2), and that 80 percent of decay experienced by low-income children aged 2 to 5 years remains untreated. As reported by Kaste et al. (3), using data from the Third National Health and Nutrition Examination Survey (NHANES III), children of low socioeconomic status (SES) 2 to 9 years of age had almost twice the level of decay than did higher-SES children. In particular, mean decay experience (dfs) in young Hispanic children (2 to 4 years of age) was nearly twice that of African-American children and over three times that of White children (3). More recently, Beltrán-Aguilar et al. (2) analyzed newer NHANES data and reported that the prevalence of dental caries experience in the primary dentition had increased from 1988-94 to 1999-2002, and that caries prevalence exceeded 55 percent among children whose families were below the federal poverty level, compared with 31 percent among children whose families were at 200 percent of the federal poverty level or higher. Numerous other studies have demonstrated higher caries prevalence among children from minority and/or lower-SES backgrounds (4,5), although these studies generally did not include very young preschool children.

There are a number of factors thought to contribute to dental caries, including concentrations of mutans streptococci (MS) bacteria (6-9), and there has been a great deal of research documenting the transmission of these organisms from mother to child (6,10-14). In addition, dietary factors (5,15-18) and plaque levels (19-21) have also frequently been associated with caries in young children. Despite this knowledge, it is unclear as to why minority or lower-SES children suffer a disproportionate share of dental caries experience among young children, although it was recently reported that lower-SES children consumed more sugar-sweetened

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DOI: 10.1111/j.1752-7325.2007.00068.x

beverages than their higher-SES counterparts (22). However, it is often difficult to access such high-risk populations, so that it remains unclear what factors contribute to high caries prevalence in lower-SES groups.

As recommended in the *Surgeon General's Report on Oral Health* (1), more research is needed to explain the disparities in oral health, particularly investigations of the oral health status of minority and lower-income individuals. Thus, the purpose of this study was to report caries prevalence and assess caries risk factors in a high-risk population of very young children participating in a longitudinal study.

Methods

The sample included children ranging in age from 6 to 24 months who were enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC program) in two rural Iowa counties with significant Hispanic populations. These children and their mothers (or in a few cases another primary caregiver) were recruited into the study between June 2003 and December 2004 as part of a longitudinal study of early childhood caries. This paper reports baseline findings from the study sample.

Participants were recruited by the study coordinator at the WIC facility in Muscatine, Iowa, and WIC clinics in nearby smaller communities. At the time of recruitment, informed consent was obtained following protocols approved by the University of Iowa Human Subjects Committee. There were no exclusion criteria for the study, and one child enrolled had special needs, with all other participating children being healthy and normally developed. Children were then scheduled for examinations either at the time of recruitment or shortly afterward. At the examination appointment, parents or caregivers (usually mothers) were asked to complete questionnaires about family demographics, mother's beverage consumption, child's beverage consumption, and child's exposures to fluoride. These questionnaires were adapted from those developed for and validated by the Iowa Fluoride Study (23).

The examinations included the collection of saliva from mother and child for enumeration of MS bacteria (including the species *Streptococcus mutans* and *Streptococcus sobrinus*) using the method originally described by Edelstein and Tinanoff (24). With this method, both sides of a sterile tongue blade were gently pressed against the dorsum of the subject's tongue in an alternating fashion. Each side of the tongue blade was then pressed into a raised selective agar plate plate. The plates were then transported back to laboratory facilities at the University of Iowa, and incubated at 37 °C in 5 percent CO_2 for 48 hours. The number of MS colonies were counted and categorized as: a) none; b) less than 10; c) 10 to 100; d) 100 to 200; or as e) "too many to count."

Dental examinations were conducted for each child in a dedicated room at the WIC clinic site using a knee-to-knee position. As part of the examination, the number of teeth with visible plaque was recorded separately for the maxillary and mandibular incisors and molars. Dental caries was evaluated using the $d_1d_{2\text{-}3}f$ criteria (25), which are primarily visual and recorded both frank ($d_{2\text{-}3}$) and noncavitated (d_1) lesions, as well as filled lesions. A single examiner (KW) conducted the examinations, using a halogen headlight and mouth mirror, with cotton gauze and shepherd's hook explorer used to remove debris and confirm frank cavitation, respectively. The examiner was calibrated against a gold standard examiner with older preschool children, and interexaminer reliability was 96.3 percent agreement and kappa = 0.48 for d_1 lesions, and 96.0 percent and kappa = 0.84 for d_2 or filled lesions. Partly because of the very young age of the participating children and the need for repeat examinations, no assessment of intraexaminer agreement was made for this study.

Data analyses focused on descriptive statistics and associations between any caries experience (d_1, $d_{2\text{-}3}$, or f) and the independent variables concerning demographics, mother/child beverage consumption, and MS. Specifically, Fisher's exact tests and Wilcoxon rank sum (Mann–Whitney two-sample) tests were used in bivariate analyses to assess the differences between those with and without caries experience. Multiple logistic regression, adjusted for the child's age, was used to evaluate multiple independent variables related to the presence of caries. All data were entered and verified using SPSS Data Entry 3.0 (26), converted to SAS format, and analyzed with SAS 10.0 (27).

Results

A total of 268 children were recruited for the study, and 212 completed the baseline examination. The 56 children recruited for the study but not examined were those who failed to appear (often repeatedly) for the dental examination for undetermined reasons. The 212 children examined ranged in age from 6 to 24 months, with a mean age of 13 months. Of the children examined, 25 had no teeth present and were excluded from the current analyses. Of the 187 children with one or more teeth present, the mean age was 14 months, with 40 percent under 12 months, 32 percent 12 to 17 months, and 27 percent 18 to 24 months of age. Gender distribution was 49 percent female and 51 percent male. Sixty-six percent of these children were Caucasian, 24 percent were Hispanic, and 10 percent were either of mixed race, African-American, Asian, or Native American. Over 80 percent of children were from families with annual incomes of less than $25,000, and 87 percent of mothers had no more than a high school education.

Among the 187 children with teeth present, 5 percent had $d_{2\text{-}3}$ decay and/or filled surfaces present (eight children with decayed surfaces, one child with decayed and filled surfaces) and 12 percent had either d_1 or $d_{2\text{-}3}$ decay or filled surfaces. MS carriage, as determined by

Table 1
Bivariate Analyses of Factors Associated with Caries Experience (d_1, d_{2-3}, or filled)

Factor	Caries prevalence (%)	*P*-value*
Child's sex		
Male ($n = 92$)	14	0.55
Female ($n = 95$)	11	
Race		
Caucasian ($n = 122$)	11	0.32
Hispanic ($n = 44$)	21	
African-American or other ($n = 18$)	6	
Age group		
17 months or younger ($n = 137$)	4	<0.01
18 months or older ($n = 50$)	34	
Family income level		
<$25,000 per year ($n = 148$)	15	0.04
$25,000 per year or more ($n = 36$)	0	
Parent/caregiver education level		
Less than high school ($n = 45$)	20	0.21
High school (HS) graduate ($n = 113$)	10	
Attended college or post-HS program ($n = 24$)	8	
Parent marital status		
Single, never married ($n = 84$)	13	0.94
Married ($n = 82$)	11	
Separated, divorced, or widowed ($n = 19$)	11	
Mutans streptococci present – child		
Yes ($n = 152$)	38	<0.01
No ($n = 32$)	7	
Mutans streptococci present – mother		
Yes ($n = 150$)	12	0.37
No ($n = 28$)	18	
Visible plaque present		
Yes ($n = 78$)	30	<0.01
No ($n = 109$)	0	
Toothbrushing		
Yes, daily ($n = 96$)	15	0.26
No ($n = 89$)	9	
Fluoride toothpaste		
Yes, daily ($n = 43$)	26	0.02
No ($n = 121$)	9	
Sippy cup use		
Yes ($n = 156$)	15	0.02
No ($n = 31$)	0	
Child's consumption of sugared beverages		
Yes ($n = 83$)	21	0.02
No ($n = 104$)	5	

* Based on Fisher's exact test.

the method described by Edelstein and Tinanoff (24), was found for 17 percent of the children and 84 percent of the mothers.

A summary of bivariate analyses of categorical factors related to the presence of d_1 or d_{2-3} decay or filled surfaces is presented in Table 1. Older age group, low family income level, presence of MS in the child's saliva, presence of visible plaque on the incisors or molars, use of fluoride toothpaste, use of sippy cup, and the child's sugared beverage consumption were significantly ($P < 0.05$) associated with presence of caries. Caries appeared to be higher among Hispanic children, but this relationship was not statistically significant.

Table 2 presents data comparing the mean weekly consumption of sugar-containing beverages between those with d_1 or d_{2-3} decay or filled surfaces and those with no caries present. There were large and statistically significant differences in the mean consumption of certain beverages between the two groups including regular soda pop, sugared powdered beverages, 100% juice, juice drinks, and other sugared beverages.

Following the initial assessment of the relationships between the presence of caries and the abovementioned factors, multiple logistic regression was used to evaluate the multiple independent factors related to the prevalence of caries. Because the number of cases was somewhat small (23 cases were excluded because of missing data), the models were limited to using not more than two covariates to prevent overfitting and possible spurious associations. In addition, only the total sugared beverage consumption variable was included in the model because of the small number of cases and the relatively small number of individuals consuming specific beverage types. In the multivariate models, age was used as a surrogate for exposure and therefore the odds ratios were all age adjusted. As demonstrated in Table 3, age was significantly associated with the prevalence of caries (odds ratio = 1.43, 95 percent confidence interval = 1.25 to 1.64), with the odds for caries increasing by 43% for each additional month of age. Annual family income of less than $25,000 was also significantly ($P = 0.03$) associated with the presence of caries, as was the presence of MS in the child's saliva ($P < 0.01$). The variable "plaque score," created by dividing the total number of incisors and molars with plaque by the total number of incisors and molars present, was strongly associated ($P < 0.01$) with the prevalence of caries, and Hispanic ethnicity approached a statistically significant relationship with caries ($P = 0.05$). Neither sugared beverage consumption nor fluoride toothpaste use was associated with increased risk of dental caries in the age-adjusted multivariate models.

Table 2
Mean Quantity of Beverages Consumed per Week according to Child Caries Status (d_1, $d_{2\text{-}3}$, or filled surfaces)

Beverage	Mean (standard deviation) amount consumed/week (oz): Caries present ($n = 23$)	Mean (standard deviation) amount consumed/week (oz): No caries present ($n = 164$)	*P*-value*
Regular soda pop	7.0 (14.6)	4.5 (20.7)	<0.01
Diet soda pop	1.0 (3.4)	0.7 (3.8)	0.23
Sugared, powdered beverages	18.9 (39.8)	3.9 (17.1)	<0.01
100% juice	87.5 (74.0)	54.0 (58.4)	<0.01
Juice drinks	24.8 (46.9)	10.0 (34.2)	0.04
Sports drinks	19.3 (70.0)	3.5 (15.4)	0.14
Other sugared beverages	10.1 (20.4)	2.3 (9.6)	<0.01
Total sugared beverages†	80.0 (127.0)	23.7 (60.4)	<0.01

* Based on Wilcoxon rank sum two-sample test.
† Includes regular soda pop, sugared powdered beverages, juice drinks, sports drinks, and other sugared beverages, but not 100% juice or milk.

Discussion

Dental caries is a complex disease with a variety of risk factors. In 1-year-olds, there is additional complexity because of the variable number of teeth present, acquisition of MS, and changes in diet during the transition from infancy. The present study found that older age (18 months and older), presence of MS in the child's saliva, presence of visible plaque, and lower family income level (<$25,000/year) were associated with the presence of caries.

Sugared beverage consumption was associated with caries in bivariate analyses, but not in the age-adjusted logistic regression analyses. This suggests that sugared beverage consumption is associated with older age. Given the young age of the subjects in the present study and the cross-sectional analyses of the data, sugared beverage consumption cannot be dismissed as a potential risk factor for caries in young children. That is, it is plausible that the duration of sugared beverage consumption for most children in this study (with a mean age of 14 months) may not have been long enough to produce a significant association. The planned analyses of the longitudinal data from this study may provide stronger evidence for or against this relationship.

To that end, it must be emphasized that the present study reports only on the baseline findings of a longitudinal study, and as such represents cross-sectional findings, which are not amenable to an assessment of cause-and-effect relationships. As the present study is a longitudinal study with plans to follow the subject children for a period of 18 months, it is hoped that the study will provide valuable information not only about the existence of relationships with caries occurrence, but also about temporal sequences. In particular, the study will attempt to assess how risk factors predict the development of caries, and how risk factors interrelate over time.

The study also found a positive association between brushing with fluoride toothpaste and the presence of caries in bivariate analyses, which may reflect the difficulties in effectively brushing very young children's teeth (as evidenced by the association between plaque levels and caries). However, this finding more likely is a function of age, in that children who had their teeth brushed with fluoride toothpaste were generally older, had more teeth, and had longer exposures to other risk factors. Again, planned longitudinal analyses of the study data may provide clarification of this relationship.

The findings of the present study are generally consistent with previous studies of caries risk in children (5-9,15-21). In particular, the findings are similar to those of Ramos-Gomez et al. (28), who assessed a sample of children of similar age and socioeconomic background as the present study. In their study, Ramos-Gomez et al. assessed 146 predominantly Hispanic children ranging in age from 3 to 55 months (median age = 30 months) and found that higher MS and lactobacillus levels, older age, lower family income level, and lower maternal education level were associated with caries. Similarly, their study did not find dietary factors or fluoride exposure variables to be associated with caries (28). Another study that utilized a predominantly Hispanic population to assess the risk factors for caries in young children was conducted by Smith et al. in New York City (29). This case-control study assessed the maternal risk factors for 60 mothers of 3- to 5-year-old children and found that higher maternal MS levels and higher maternal sugar consumption levels were associated with caries experience in their children. Family sociodemographic variables and child's age were not associated with caries, and child MS levels and sugar consumption were not assessed (29).

The findings of the present study not only support these earlier findings, but may also provide a better understanding of how caries in early childhood initially occurs, as the present study was unique in focusing on 1-year-old children. While the very young age range is a strength of the study, there were also limitations. These include a fairly small, nonrepresentative sample from a limited geographic area, which limited the statistical power to identify associations. The study also did not collect data on other potential risk factors such as nonbeverage sugar consumption and non-MS bacterial levels. In addition, partly because of the young age of the children, the dependent variable, dental caries experience, included many cases

Table 3
Results of Age-Adjusted Logistic Regression Analysis of Factors Associated with Caries (n = 164)

	$\hat{\beta}$ (SE $\hat{\beta}$)	*P*-value	Odds ratio	95% confidence interval
Age (in months)	0.37 (0.073)	<0.01	1.5	1.3-1.7
Hispanic	1.18 (0.604)	0.05	3.3	0.99-10.6
Age (in months)	0.38 (0.073)	<0.01	1.5	1.3-1.7
Income	3.01 (1.3)	0.03	20.2	1.5-280.0
Age (in months)	0.33 (0.07)	<0.01	1.4	1.2-1.6
Mutans streptococci – child	1.56 (0.58)	<0.01	4.8	1.5-14.7
Age (in months)	0.34 (0.075)	<0.01	1.4	1.2-1.6
Plaque level	2.5 (0.89)	0.01	12.2	2.1-69.9
Age (in months)	0.35 (0.074)	<0.01	1.4	1.2-1.6
Fluoride toothpaste	0.61 (0.558)	0.28	1.8	0.6-5.5
Age (in months)	0.35 (0.073)	<0.01	1.4	1.2-1.6
Sugared beverage consumption	0.83 (0.60)	0.17	2.3	0.7-7.4

SE, standard error.

with only noncavitated (white spot) lesions, which is not comparable with most other studies; however, given the revised definition of early childhood caries (30), including noncavitated lesions may be more appropriate in this age group. While the study has limitations, it provides some evidence of the factors contributing to dental caries occurrence very early in childhood. Further research is needed to assess how the range of factors contributes to dental caries development over time.

Acknowledgments

The authors wish to acknowledge the assistance of research assistants Elisabeth Howe and Katie Tharp in recruiting subjects and coordinating study activities, and Bonny Olson for her work with the bacterial samples.

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