Factors Affecting Early Childhood Caries Among WIC-enrolled Children in Linn County, Iowa

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ABSTRACT

Purpose: The purpose of this study was to examine the factors associated with early childhood caries (ECC) among children enrolled in 3 centers offering Iowa Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) services in Linn County, Iowa.

Methods: Data pertaining to dental caries and its determinants were collected for 115 children. Bivariate and multivariable analyses were conducted concerning outcome variables of ECC and having greater than 50 colony-forming units (CFUs) of salivary mutans streptococcus (>50 CFUs).

Results: The final logistic regression model for factors associated with ECC found that children with presence of visible plaque were 2.78 times more likely to have ECC (odds ratio [OR]=3.78, 95% confidence interval [CI]=1.41-10.16) and children were 0.13 times more likely to have ECC (OR=1.13, 95% CI=1.04-1.26) for each increase of one month in age. A final logistic model concerning greater than 50 CFUs showed that the children with presence of plaque on any maxillary incisor were 2.39 times more likely to have greater than 50 CFUs (OR=3.39, 95% CI=1.28-8.96) and the children were 0.61 times more likely to have greater than 50 CFUs with an increase in cariogenicity of sippy cup contents by 1 level (OR=1.61, 95% CI=1.03-2.50).

Conclusions: Presence of visible plaque on maxillary incisors was associated with increased risk for presence of early childhood caries. The presence of visible plaque on any maxillary incisor and more cariogenicity of sippy cup contents were associated with having more than 50 CFUs.

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Early childhood caries (**ECC**) was previously known by several names, including nursing caries, baby bottle booth decay, rampant caries, and labial caries. These terms were defined in many different ways.[1-5] A more precise terminology that does not assume the etiology and uses age-defined criteria was recommended at the National Institute of Dental and Craniofacial Research workshop in 1999.[6] According to the new criteria, ECC is dental caries affecting primary teeth among children younger than 6-years-old,[7] and children age 3 years and younger with the presence of 1 or more cavitated or noncavitated lesions are categorized as having severe early childhood caries (**SECC**).[7]

There are many important factors that can influence the caries burden among young children, including their: race and ethnicity; annual household income; caregivers' education level; and parents' marital status.[3,8,9]

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Even though the US caries rates decreased over the past half century, there are still segments of the population that have significant disease levels.

Among microbiological factors, several studies have shown mutans streptococci (**MS**) levels to be associated with dental caries[2,10,11]; children with having greater than 50 colony-forming-units (**CFUs**) of MS (>50 CFUs) have more cavitated lesions.[11] Dental plaque also has been found to be related to dental caries.[12,13] In particular, visible plaque on maxillary incisors has been associated with the presence of cavitated lesions.[14] Tooth-brushing habits also have been shown to predict caries among children.[15]

Many diet-related behaviors have been found to be associated with increased risk of caries.[16-18] In the case of beverages, sweetened beverages such as regular soda pop, powdered sugared beverages, infant formulas, and 100% juices, have been associated with higher risk of caries among young children.[16, 17] Theese associations have become more relevant because of the changes in portion sizes and frequency of intake of many beverages, especially the increased intake of sweetened beverages and decreased intake of milk.[19] Dental caries also have been associated with greater number of sugary meals, including sweetened beverages. [18] Previous studies have suggested that it would be relevant to look at the dietary factors by dividing the products based on cariogenic sugar and starch contents, along with the oral clearance, and then leading at relationships with caries among children, rather than using just non-milk extrinsic sugar as a criteria.[20,21]

Concerning caries and the natural and artificial methods of feeding infants and young children, it has been suggested that greater importance should be given to the contents and not the container/method of feeding, since it is primarily the content that can increase or decrease the risk for caries among young children.[4] Some behaviors, such as bottle-feeding past 12-months-old and at night, earlier age when weaned from breast-feeding, and never being breast-fed have been associated with increased caries prevalence.[22,23]

The knowledge- and behavior-related information was based on the theory of reasoned action and a later theory of planned behavior.[24,25] It was noted that knowledge and attitude are mediated through behavioral intent to result in an action. Though knowledge is essential for any action, the theory of planned behavior establishes that intention is a good predictor of the action.

Colonization of the oral cavity with *Streptococcus mutans* was studied by Wan et al. among a convenience sample of 312 children from birth to 24-months-old.[26] This was one of the few studies that examined cariogenic bacteria as an outcome measure. They found an increased predisposition to colonization in those with frequent sugar consumption and enamel hypoplasia. Feeding at night, drinking only from bottles, on-demand feeding, sleeping beside mother, and total exposure to sugar more than 3 times per day were the other variables associated with *S mutans* colonization.

The various aforementioned studies have examined many variables related to dental caries and MS. There are very few studies, however, that have combined most of these different variables for a comprehensive examination of these factors in specific populations. This is especially true when we consider the number of studies that have looked at the dental behaviors and the intentions behind them. Studies that exclude important moderating variables may not be able to predict associations correctly. There is also a paucity of studies that are pertinent to low income populations in Iowa, especially those dealing with ECC.

The purpose of this study was to understand the determinants of early childhood caries among children enrolled in the Special Supplemental Nutrition Program for Women, Infants and Children (**WIC**) in Linn County, Iowa.

METHODS

This study reports baseline data from an interventional study assessing the efficacy of 3 psychoeducational intervention methods using the self-determination theory to prevent ECC among toddlers.[27] Study approval was obtained from the University of Iowa Institutional Review Board.

A convenience sample of subjects was selected from the 3 WIC clinics located in Linn County, Iowa.[27] Written consent for the release of their telephone numbers was obtained from 401 participants, and they were subsequently contacted, with 174 mother-child dyads agreeing to participate in the study. Of these, 115 mother-child dyads participated in the baseline data collection and 86 participated in the 3-month follow-up. The inclusion criteria for this study were:

1. Children were 18- to 36-months-old.
2. Mothers were able to comprehend, complete, and respond to the questionnaires in English.
3. Mothers were at least 18-years-old and biological parents and/or legal guardians who had lived with the child for at least 1 year prior to study recruitment.

The overall study involved baseline assessments, random assignment to 1 of 3 psychoeducational interventions, and follow-up assessments 3 months later. For the present analyses, only baseline exam and questionnaire data were used.

During the baseline data collection, all mothers (N=115) completed a baseline questionnaire and a pre-intervention questionnaire. The baseline questionnaire included questions regarding: demographics of the mother and child; breast-feeding; bottle feeding; snacking; beverage consumption; snacking and beverage contents; tooth-brushing; sources of fluoride; and microbial transmission from mother to child. The pre-intervention questionnaire included 9 questions about the mothers'

knowledge concerning prevention of ECC and 11 questions about the intent of the mothers for behaviors preventing ECC.

Unstimulated saliva was collected from the children using a sterile wooden tongue blade and transferred to a Replicate Organism Detection and Counting (RODAC) plate filled with a mitis salivarius agar base containing sorbitol and bacitracin (MSB agar).[28] The RODAC plate was then incubated at 37°C for 48 hours and CFU numbers were counted. CFU counts ended at 250, and all those with more than 250 CFUs were designated as 250.

A flashlight, dental mirror, explorer, and gauze were used for the dental examination. A single trained examiner carried out all the dental examinations. Presence or absence of visible dental plaque was noted for the maxillary incisors' facial aspects. For the dental caries scoring, cavitated and non-cavitated lesions were recorded using a previously defined methodology.[29] The definition of ECC used for this study was the presence of 1 or more cavitated or white-spot lesions among the participating children. The examiner was trained for a previous study which used the same caries classification, and interexaminer reliability was reported for that study, [29] but intraexaminer reliability was not examined here.

The United States Department of Agriculture's (USDA) National Nutrient Database for Standard Reference[30] was used to understand the components of the various foods and drinks consumed by the children. The cariogenicity of each food and drink was determined according to its composition. A 3-point scoring system was used (0=non-cariogenic, 1=moderately cariogenic, and 2=highly cariogenic). When more than 1 food or drink were reported by the participants, the various cariogenicity scores for each food or drink were summed to make a composite cariogenicity score for each category (eg, bottle contents).

Questions related to knowledge were worded to determine whether the mother knew about an aspect of oral care. Behavioral intent was determined by asking the mother the likelihood for a behavior related to her child's oral health. Composite scores for knowledge and behavioral intent were assigned by assessing the level of agreement with the pertinent questions. A 5-point Likert-type scale, from 1 to 5, was used for each knowledge and behavioral intent question. Thus, the knowledge scores (9 questions) ranged from 9 to 45 and the behavioral intent scores (11 questions) ranged from 11 to 55.

Presence of ECC was used as the primary dependent variable, and the presence of greater than 50 CFUs of SMS (>50 CFUs) was used as the secondary dependent variable. SAS 9.1 (SAS Institute, Cary, NC) was used for statistical analyses. Descriptive statistics were carried out for all the variables, followed by bivariate analyses using chi-square, Fisher's exact, Wilcoxon rank-sum, Kruskal-Wallis, and Spearman correlation tests. Based on the bivariate results, all variables with a *P*-value <.05 were considered for inclusion in multivariable modeling using logistic regression. As a general rule, the number of variables in the final model was restricted to a tenth of the number of participants with the presence of cavitated or noncavitated lesions.

Several best possible models were selected initially through the use of "best option" in SAS 9.1. Next, the variables suggested by the "best option" were tested through stepwise models to determine the final models based on the significance level and Akaike's information criterion (**AIC**) score.[31] Two- and 3-variable models were examined in logistic regression. Collinearity and 2-way interactions of the variables also were assessed for the predictor variables in the models tested.

RESULTS

This study involved 115 mother-child dyads from 3 WIC clinics in Linn County, Iowa. All children were 18-to 36-months-old (mean=25.6 months; Table 1). Only approximately one third (36%) of the children were from households with annual incomes of at least $25,000. Most mothers (65%) did not have any education past high school, and most children were Caucasian (77%), with some being African American (8%) and of other minorities (15%). Approximately 10% of the study's children (N=11) had teeth with cavitated lesions and 25% had noncavitated lesions (N=29). ECC was the primary dependent variable for this study, and there were 31 children with the presence of 1 or more teeth with cavitated and/or noncavitated lesions (27%). No children in the study had any restorations on their teeth. Most children (71%) had not visited a dentist in the previous year.

More than half (52%) of the participating children had visible plaque on the facial aspect of their maxillary incisors. Approximately 26% of the participating children had more than 50 CFUs, and most (67%) brushed their teeth at least once a day.

Bivariate analyses were carried out between the primary dependent variable (ECC) and the independent

Table 1. Univariate Results

Independent variable	N	Mean±(SD)	Median
Age of child (mos)	115	25.61±4.83	24
Cariogenicity score for 4 common snacks	114	4.32±1.33	5
Cariogenicity score for 3 common drinks	115	1.27±0.74	1
Cariogenicity score for bottle contents	115	1.83±1.08	2
Cariogenicity score for sippy cup contents	115	1.12±0.97	1
Combined cariogenic score for bottle and sippy cup contents	115	2.96±2.00	3
Age when weaned from breast-feeding	113	4.81±6.79	2
Knowledge score	109	35.72±5.01	36
Behavioral intent score	101	38.61±5.07	39

Table 2. Bivariate Analysis between the Presence of Early Childhood Caries and the Independent Variables

Dependent variable	Independent variables	Statistic used	N	*P*-value	Mean value	
					Caries experience	No caries experience
Presence of ≥1cavitated or noncavitated lesions	Child's age (mos)	Wilcoxon rank-sum test	115	<.01	27.87	24.77
	Presence of plaque on any maxillary incisor teeth	Fisher's exact test	113	<.01	0.76	0.45
	>50 CFU of mutans streptococcus	Fisher's exact test	115	.03	0.42	0.50
	Cumulative cariogenic levels of bottle contents (0, 1, or 2)	Fisher's exact test	115	<.05	2.16	1.71
	Age when weaned from bottle-feeding	Wilcoxon rank-sum test	90	.01	14.31	12.82
	Cumulative cariogenic drink levels (0, 1, or 2)	Fisher's exact test	115	.02	1.42	1.21
	Cumulative cariogenic levels of sippy cup contents (0, 1, or 2)	Fisher's exact test	115	.18	1.23	1.08
	Combined cariogenic levels of bottle and sippy cup contents	Wilcoxon rank-sum test	115	.27	3.39	2.80
	Cumulative cariogenic snack levels (0, 1, or 2)	Fisher's exact test	114	.50	4.17	4.38
	Cumulative behavioral intent score	Wilcoxon rank-sum test	101	.04	36.57	39.40
	Cumulative knowledge score	Wilcoxon rank-sum test	109	.09	35.28	35.89

variables (Table 2). Age in months at the time of examination was significantly associated with ECC (*P*<.01), with a greater proportion of older children having ECC. The presence of visible plaque on the facial surface of any maxillary incisor was positively and significantly (*P*<.01) associated with ECC. Having greater than 50 CFUs also was significantly associated (*P*=.03) with the presence of ECC, with a higher proportion of those with greater than 50 CFUs having ECC.

The variables concerning the cumulative cariogenicity scores for bottle-contents, age when weaned from bottle-feeding, and cumulative cariogenicity scores of each child's 3 most common drinks were significantly associated with ECC (*P*=.05, *P*=.01, and *P*=.02, respectively). The behavioral intent of the mothers for actions related to prevention of ECC also was significantly (*P*=.04) associated with ECC. Those with lower intent scores for behaviors that prevent ECC, were more likely to have children with ECC. Non-significant associations were found with the cumulative knowledge score (*P*=.09), cariogenicity of snacks (*P*=.51), cariogenicity of sippy cup contents (*P*=.18), and combined cariogenicity of bottle and sippy cup contents (*P*=.27).

Bivariate analyses of the secondary dependent variable (>50 CFUs) were carried out with all the independent variables (Table 3), including the presence of plaque on any maxillary incisors (*P*<.01), cumulative cariogenicity scores of sippy cup contents (*P*=.02), and cumulative cariogenicity scores of bottle-feeding contents (*P*=.01).

The independent variables with a *P*-value less than or equal to .05 in the bivariate analyses (Tables 2 and 3) were considered for multivariable regression. The independent variables for ECC were further narrowed using the "best option" under PROC LOGISTIC in SAS 9.1 (Table 4). Two independent variables (ie, age when weaned from bottle-feeding and behavioral intent score), however, were excluded from the multivariable analyses because of a large number of missing values. For the multivariable analysis with the primary dependent variable, the presence of plaque, age in months, and greater than 50 CFUs were the 3 variables with the highest single variable test statistics (chi-square scores). Among the 2-variable models, plaque and age collectively had a higher score than other models.

Logistic regression was carried out for all the 2- and 3-variable models that were suggested by the "best option" analyses. The 2-variable model with the presence of plaque on any maxillary incisor and the age of the child in months resulted in an AIC score of 117.89, with both variables significantly associated with ECC (Table 5). The children with visible plaque were 2.78 times more likely to have ECC than those without it (odds ratio [**OR**]=3.78, 95% confidence interval [**CI**]=1.41-10.16). With an increase in age of 1 month, the children were 0.13 times more likely to have ECC (OR=1.13, 95% CI=1.04-1.26). Testing the 2-variable model with age of the child and the presence of greater than 50 CFUs produced an AIC score of 126.75, and both variables were statistically significant. Children with greater than 50 CFUs were 1.58 times more likely to have ECC than those without it (OR= 2.58, 95% CI=1.02- 6.51). Again, the children older by a month were 0.13 times more likely to have ECC (OR=1.13, 95% CI=1.04- 1.25).

Three-variable models were not considered, as they were not statistically significant during modeling and reverted back to the 2-variable models. Consequently,

Table 3. Bivariate Analysis between the Presence Greater than 50 Colony-forming Units (CFUs) of Salivary Mutans Streptococcus (SMS) and the Independent Variables

Dependent variable	Independent variables	Statistic used	N	*P*-value	Mean value	
					Caries experience	No caries experience
Presence of >50 CFUs of SMS	Child's age (mos)	Wilcoxon rank sum test	115	.14	26.67	25.24
	Presence of plaque on any maxillary incisor teeth	Fisher's exact test	113	<.01	0.76	0.45
	Cumulative cariogenic levels of bottle contents (0, 1, or 2)	Fisher's exact test	115	.01	2.20	1.70
	Age when weaned from bottle-feeding	Wilcoxon rank sum test	90	.72	14.57	12.87
	Cumulative cariogenic drink levels (0, 1, or 2)	Fisher's exact test	115	.54	1.37	1.24
	Cumulative cariogenic levels of sippy cup contents (0, 1, or 2)	Fisher's exact test	115	.02	1.56	0.96
	Combined cariogenic levels of bottle and sippy cup contents	Wilcoxon rank sum test	115	.10	3.78	2.67
	Cumulative cariogenic snack levels 0, 1, or 2)	Fisher's exact test	114	.67	4.00	4.44
	Cumulative behavioral intent score	Wilcoxon rank sum test	101	.54	37.63	38.97
	Cumulative knowledge score	Wilcoxon rank sum test	109	.44	36.57	35.43

the final model with the lower AIC score contained the presenceof plaque on the facial surface of any maxillary incisor and age in months (AIC score=117.89). Two-way interactions were tested for the variables in the model, and the interaction terms were not statistically significant.

All 3 independent variables significantly associated in bivariate analyses with the secondary dependent variable —having greater than 50 CFUs—were tested using PROC LOGISTIC. Children with plaque on any maxillary incisor were 2.39 times more likely to have greater than 50 CFUs (OR=3.39, 95% CI=1.28-8.96), and those using a sippy cup with greater levels of cariogenicity were 0.61 times more likely to have greater than 50 CFUs (OR=0.61, 95% CI=1.03-2.50) (Table 6). The AIC score for the model was 121.63.

DISCUSSION

The goal of this study was to assess the various factors that affect the prevalence of ECC among 18- to 36-month-olds who enrolled in the WIC program in Linn County, Iowa. The ECC definition used was the same as the SECC definition used by the American Association of Pediatric Dentistry (AAPD). The AAPD definition states that for children younger than 3-years of age, "any sign of smooth-surface caries is indicative of severe early childhood caries".[7] The primary outcome variable was the presence of cavitated and/or non-cavitated lesions. Approximately 10% of the children who participated in the study had teeth with cavitated lesions—a rate lower than the 18% to 37% for 1- to 5-year-olds reported by other studies.[8,9,32,33] This difference in caries rates could be due in part to the inclusion of older children in many of those studies. It was surprising to note that none of the children in the study had any restorations on their teeth. Previous studies found at least some restorations in children from lower socioeconomic households, especially among Caucasian children.[3,8,9]

The presence of plaque on maxillary incisors was significantly related to ECC in the bivariate and multivariable results. A previous study of 4 predictors (visible plaque on the labial surfaces on the maxillary incisors, nursing bottle usage, mother's DMFT index value, and mothers' salivary levels of MS) for future caries incidence was conducted with 92 19- to 55-month-old children.[14] The visible plaque on the maxillary incisors; labial surfaces was associated with the presence of cavitated lesions ($P<.001$), and it also was the most predictive of the future incidence of caries (91%). The relationship between dental caries and dental plaque (not restricted to maxillary incisors) also was investigated among a convenience sample of 504 12 to-36-month-old Iranian children.[13] Children with the presence of abundant plaque were 3.3 times more likely to have dental caries.

In a study involving 87 9- to 36-month-old US children, Barsamian-Wunsch et al found a significant correlation between the presence of cavitated lesions and the presence of greater than 50 CFUs of salivary mutans streptococci (**SMS**).[10] SMS also was studied among 148 3-

to 8-year-old preschool children with semi-quantitative analysis of CFUs of SMS.[11] The presence of greater than 50 CFUs of SMS was associated with the presence of caries; regardless of the baseline caries status, they had higher increments of caries than those with less than 50 CFUs of SMS. Similar results were found among a group of 142 1- to 2.5-year-old Brazilian children from lower socioeconomic backgrounds, with bivariate analyses between the presence of greater than 50 CFUs of SMS and the presence of cavitated or non-cavitated lesions finding significant associations.[34] Our study showed similar findings, but the final model for the multivariable analysis of ECC did not include more than 50 CFUs, as it was not statistically significant.

Table 4. Logistic Regression Models Selected by a Score Criterion for the Presence of at Least 1 Carious Lesions (Including Both Cavitated and Noncavitated) and Greater than 50 Colony-forming Units (CFUs) of Salivary Mutans Streptococcus

Dependent variable	No. of variables	Chi-square score	Variables included in the model
Early childhood caries	1	9.16	Age
	1	8.12	Plaque
	1	5.05	Mutans streptococcus >50 CFUs
	2	16.05	Plaque, age
	2	12.66	Mutans streptococcus >50 CFUs, age
	2	11.88	Cariogenicity of bottle-contents, age
	3	17.95	Plaque, cariogenicity of bottle- contents, age
	3	17.55	Plaque, mutans streptococcus >50 CFUs, age
>50 CFUs of salivary *Streptococcus mutans*	3	16.51	Plaque, cariogenicity of drinks contents, age
	1	8.44	Plaque
	1	6.82	Cariogenicity of sippy cup contents
	1	3.47	Cariogenicity of bottle contents
	2	13.26	Plaque, cariogenicity of sippy cup contents
	2	12.47	Plaque, cariogenicity of snacks
	2	10.85	Plaque, cariogenicity of bottle contents
	3	16.63	Plaque, cariogenicity of sippy cup contents, cariogenicity of snacks
	3	14.68	Plaque, cariogenicity of bottle contents, cariogenicity of snacks
	3	14.24	Plaque cariogenicity of bottle contents, cariogenicity of sippy cup contents

Table 5. Final Logistic Model for the Presence of 1 or More Carious Lesions (Including Both Cavitated and Non-cavitated)*

Dependent variable	Variables in final model	Odds ratio	95% confidence interval	*P*-value
Presence of ≥1 carious lesions	Presence of plaque on any maxillary incisor	3.78	1.41-10.16	.01
	Age (mos)	1.13	1.04-1.26	.01

** Akaike's information criterion=117.89.*

Table 6. Final Logistic Model for the Presence of Greater than 50 Colony-forming Units (CFUs) of Salivary Mutans Streptococcus

Dependent variable	Variables in final model	Odds ratio	95% confidence interval	*P*-value
Presence of >50 CFUs of SMS	Presence of plaque on any maxillary incisor	3.39	1.28-8.96	<.01
	Cariogenicity score for sippy cup contents	1.61	1.03-2.50	.03

** Akaike's information criterion=121.63.*

The results of analyses of SMS as the dependent variable were similar to a previous study, [26] with the cariogenicity of both the bottle contents and sippy cup contents being significantly associated with more than 50 CFUs. The difference in the other results with that study might be due to differences in variables used in the studies, sampling frames, and sample size.

The present study had a limited sample size of 115, 31 of whom had either a cavitated or non-cavitated lesion. Hence, it must be remembered that the variables that were not significant in the multivariable analyses or those that were not included in the multivariable analysis should not be excluded from future research, since it is possible that they could be significant in a larger sample size study or with a different population.

The current study found significant bivariate associations between ECC and: cariogenicity scores of bottle contents; cariogenicity scores of drink contents; and age when weaned from bottle-feeding. Similar results were found in a previous study, where regular soda pop, powdered beverages, and 100% juices were associated with a higher risk for caries.[16] Similarly, the use of milk with sugar and a combined variable for formula with added sugar and breast-feeding were found to be associated with increased odds for dental caries.[17,18]

The behavioral intent concerning prevention of ECC among the mothers was significantly associated with ECC in bivariate analysis. In our study, the theory of planned behavior suggested that the intention for an action could predict the likelihood of the related action taking place.[25] The questions related to behavioral intent were aimed at actions pertaining to ECC, so it was not surprising to find an association between behavioral intent and the variables for dental caries.

The important association between dental plaque and ECC was seen in the results of bivariate and multivariable analyses. The presence of visible plaque on the facial surface of maxillary incisors could be a risk factor easily recognized by medical professionals, lay persons, and dental professionals. Caregivers and/or

other health care workers could be easily trained to identify the presence of plaque on maxillary incisors, and measures to prevent ECC could then be better developed and prioritized. Emphasizing plaque removal also may be an important consideration for any programs that may be in place or are being planned for this population.

There were some limitations to this analysis, including limited sample size, convenience sampling, and use of cross-sectional data and its secondary analyses. Only the participants who could read and comprehend English were included in the study. Thus, individuals with limited ability to read and comprehend English and who are not English speakers could not participate. The dietary data for beverages did not include frequency data for liquid foods. Since largely non-validated questionnaires were used in the study, there could be recall bias and under- or overestimation of the reported behaviors, knowledge, and/or behavioral intent.

CONCLUSIONS

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

1. In the present study, 27% of 18- to 36-month-olds had early childhood caries.
2. The presence of visible plaque on maxillary incisors and older age in months were related to ECC in 18- to 36-month-olds enrolled in this study.
3. The presence of visible plaque on any maxillary incisor and more cariogenicity of sippy cup contents were associated with the presence of greater than 50 CFUs of salivary *Streptococcus mutans*.

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REFERENCES

1. Milnes AR. Description and epidemiology of nursing caries. J Public Health Dent 1996;56:38-50.
2. Kreulen CM, de Soet HJ, Hogeveen R, Veerkamp JS. *Streptococcus mutans* in children using nursing bottles. J Dent Child 1997;64:107-11.
3. Louie R, Brunelle JA, Maggiore ED, Beck RW. Caries prevalence in Head Start children, 1986-87. J Public Health Dent 1990;50:299-305.
4. Behrendt A, Sziegoleit F, Muler-Lessmann V, Ipek-Ozdemir G, Wetzel WE. Nursing-bottle syndrome caused by prolonged drinking from vessels with bill-shaped extensions. J Dent Child 2001;68: 12, 47-50.
5. Burt B, Eklund S. *Dentistry, Dental Practice, and the Community*. 6th ed. St. Louis, Missouri: WB Saunders Co; 2005.
6. Drury TF, Horowitz AM, Ismail AI, Maertens MP, Rozier RG, Selwitz RH. Diagnosing and reporting early childhood caries for research purposes: A report of a workshop sponsored by the National Institute of Dental and Craniofacial Research, the Health Resources and Services Administration, and the Health Care Financing Administration. J Public Health Dent 1999;59:192-7.
7. Council on Clinical Affairs, American Academy of Pediatric Dentistry. Definition of early childhood caries. Available at: "www.aapd.org/media/Policies_Guidelines/D_ECC.pdf". Accessed November 25, 2009.
8. Tang JM, Altman DS, Robertson DC, O'Sullivan DM, Douglass JM, Tinanoff N. Dental caries prevalence and treatment levels in Arizona preschool children. Public Health Rep 1997;112:30-1, 319-29.
9. Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III, 1988-1994. J Am Dent Assoc 1998; 129:1229-38.
10. Barsamian-Wunsch P, Park JH, Watson MR, Tinanoff N, Minah GE. Microbiological screening for cariogenic bacteria in children 9 to 36 months of age. Pediatr Dent 2004;26:231-9.
11. O'Sullivan DM, Thibodeau EA. Caries experience and mutans streptococci as indicators of caries incidence. Pediatr Dent 1996;18:371-4.
12. Karjalainen S, Soderling E, Sewon L, Lapinleimu H, Simell O. A prospective study on sucrose consumption, visible plaque, and caries in children from 3 to 6 years of age. Community Dent Oral Epidemiol 2001;29:136-42.
13. Mohebbi SZ, Virtanen JI, Vahid-Golpayegani M, Vehkalahti MM. Early childhood caries and dental plaque among 1- to 3-year-olds in Tehran, Iran. J Indian Soc Pedod Prev Dent 2006;24:177-81.
14. Alaluusua S, Malmivirta R. Early plaque accumulation: A sign for caries risk in young children. Community Dent Oral Epidemiol 1994;22:273-6.
15. Stecksen-Blicks C, Gustafsson L. Impact of oral hygiene and use of fluorides on caries increment in children during one year. Community Dent Oral Epidemiol 1986;14:185-9.
16. Marshall TA, Levy SM, Broffitt B, et al. Dental caries and beverage consumption in young children. Pediatrics 2003;112:e184-91.
17. Peres RC, Coppi LC, Franco EM, Volpato MC, Groppo FC, Rosalen PL. Cariogenicity of different types of milk: An experimental study using animal model. Braz Dent J 2002;13:27-32.
18. Rosenblatt A, Zarzar P. Breast-feeding and early childhood caries: An assessment among Brazilian infants. Int J Paediatr Dent 2004;14:439-45.
19. Nielsen SJ, Popkin BM. Changes in beverage intake between 1977 and 2001. Am J Prev Med 2004;27:205-10.
20. Marshall TA, Eichenberger-Gilmore JM, Larson MA, Warren JJ, Levy SM. Comparison of the intakes of

sugars by young children with and without dental caries experience. J Am Dent Assoc 2007;138:39-46.
21. Marshall TA, Broffitt B, Eichenberger-Gilmore J, Warren JJ, Cunningham MA, Levy SM. The roles of meal, snack, and daily total food and beverage exposures on caries experience in young children. J Public Health Dent 2005;65:166-73.
22. Kaste LM, Gift HC. Inappropriate infant bottle feeding. Status of the Healthy People 2000 objective. Arch Pediatr Adolesc Med 1995;149:786-91.
23. Milgrom P, Riedy CA, Weinstein P, Tanner AC, Manibusan L, Bruss J. Dental caries and its relationship to bacterial infection, hypoplasia, diet, and oral hygiene in 6- to 36-month-old children. Community Dent Oral Epidemiol 2000;28:295-306.
24. Ajzen I, Fishbein, M. *Understanding Attitudes and Predicting Social Behavior*: Englewood Cliffs, NJ: Prentice-Hall; 1980.
25. Ajzen I. *From Intentions to Actions: A Theory of Planned Behavior.* Heidelberg, Germany: Springer; 1985.
26. Wan AK, Seow WK, Purdie DM, Bird PS, Walsh LJ, Tudehope DI. A longitudinal study of *Streptococcus mutans* colonization in infants after tooth eruption. J Dent Res 2003;82:504-8.
27. Weber K. *A Comparison of the Effectiveness of Three Educational Interventions in the Prevention of "Early Childhood Caries."* Iowa City, Iowa: University of Iowa; 2003.
28. Kimmel L, Tinanoff N. A modified mitis salivarius medium for a caries diagnostic test. Oral Microbiol Immunol 1991;6:275-9.
29. Warren JJ, Levy SM, Kanellis MJ. Dental caries in the primary dentition: Assessing prevalence of cavitated and noncavitated lesions. J Public Health Dent 2002;62:109-14.
30. US Department of Agriculture. *USDA National Nutrient Database for Standard Reference*. Washington, DC: USDA; 2007.
31. Burnham K, Anderson DR. *Model Selection and Multimodel Inference*, 2nd edition: Heidelberg, New York: Springer; 2002.
32. Barnes GP, Parker WA, Lyon TC, Jr., Drum MA, Coleman GC. Ethnicity, location, age, and fluoridation factors in baby bottle tooth decay and caries prevalence of Head Start children. Public Health Rep 1992;107:167-73.
33. Nurko C, Skur P, Brown JP. Caries prevalence of children in an infant oral health educational program at a WIC clinic. J Dent Child 2003;70:231-4.
34. Mattos-Graner RO, Zelante F, Line RC, Mayer MP. Association between caries prevalence and clinical, microbiological, and dietary variables in 1.0 to 2.5-year-old Brazilian children. Caries Res 1998;32:319-23.