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Factors Associated with Early Childhood Caries Incidence among African-American Children in Alabama

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Abstract

Objectives—To assess the relationships between different behavioral factors and Early Childhood Caries (ECC) in African-American pre-school children.

Methods—Ninety-six African-American children aged 3 to 22 months old at baseline were recruited by word of mouth from Uniontown, Alabama, a non-fluoridated community. The children had dental examinations annually following World Health Organization (WHO) criteria at baseline, 1st, 2nd and 3rd follow-up. Parents provided detailed oral hygiene and dietary information every six months by completing questionnaires. Cumulative calculations using area-under-the-curve (AUC) were made for all the independent variables that were assessed at the follow-up questionnaires. Bivariate and multivariable relationships between ECC incidence and different behavioral risk factors were assessed using logistic regression for dichotomous dependent variables and negative binomial modeling for count dependent variables. Independent variables were defined at baseline, as the AUC and at 2nd follow-up.

Results—Ninety-nine percent of the children consumed sugar-added beverages by the time of the 2nd follow-up visit. Increased frequency of toothbrushing and increased AUC composite of daily

frequency of consumption of 100% juices were associated with decreased incidence of dental caries (p-values=0.01 and 0.049, ORs=0.34 and 0.37, respectively). Greater AUC of daily frequency of consumption of sweetened foods and a history of a previous visit to a dentist by the 2nd follow-up visit were associated with increased incidence of ECC (p-values=0.002 and 0.03, ORs=9.22 and 4.57, respectively).

Conclusion—For those living in a non-fluoridated community, more frequent consumption of sweetened food, less frequent consumption of 100% juice, less frequent toothbrushing, and reporting a previous visit to a dentist were significantly associated with increased ECC incidence.

Introduction

Early Childhood Caries (ECC) is the terminology that was recommended by the National Institute of Dental and Craniofacial Research workshop in 1999 to replace the old names that described its etiology, such as rampant caries, nursing caries, and baby bottle tooth decay¹. The American Academy of Pediatric Dentistry (AAPD) defines ECC as the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 months of age or younger². Because of the adverse effects of dental caries on the children's overall health and oral health quality of life (OHQoL)³, ECC is considered one of the most costly diseases in both developed and developing countries. It is reported that the overall annual cost of dental services exceeded \$108 billion in the U.S. in 2010⁴.

There are relatively few studies which have been conducted to identify the effects of different risk factors associated with ECC incidence, in part because of difficulties related to recruitment and retention in longitudinal studies. The most commonly known risk factors are high-sugared snack intake, improper bottle use, higher levels of salivary *Streptococcus mutans* bacteria, poor oral hygiene and low socioeconomic status (SES). However, the findings of the studies that addressed ECC risk factors differ, in part because of different study designs, statistical analysis techniques, definitions of different dependent and independent variables, children's ages, and the presence of confounders, such as lack of dental insurance coverage.

Studies have been conducted to assess the relationships between the frequency and the amount of sugar consumption and dental caries in children. Some of these studies showed a statistically significant relationship between the frequency and/or the quantity of sugar consumption and ECC. For example, Kolker et al.⁵ assessed the relationships between different diets and dental caries in a cohort of 436 low-income African-American children aged 3 to 5 years in Detroit. The study showed that greater consumption of sugared soda pop and lower consumption of 100% natural juice were significantly associated with higher levels of dmfs, with p-values of 0.049 and 0.0001, respectively. In addition, Warren et al.⁶ found that infants consuming sugar-sweetened beverages were more likely to develop ECC (OR=3.04, 95% CI 1.07–8.64, p-value=0.04). However, other studies showed that there was a weak or no relationship between the frequency and/or the amount of sugar consumption and ECC. For example, Gibson et al.⁷ examined the relationships between intake of sugar-added dietary components and caries experience in 1,450 British children aged 1.5 to 4.5

years. The study⁷ showed that there were no statistically significant associations between caries experience and percentage of energy consumption from each of the following sugar-containing dietary categories: biscuits and cakes combined, sugar confectionery, chocolate confectionery, total biscuits, or cakes and confectionery combined, which were categorized as low, medium, and high daily percent energy consumption. Also, the study⁷ showed that there were no statistically significant relationships between some sugared beverages, such as soft drinks and non-milk extrinsic sugar, and caries experience.

Other studies assessed the effect of toothbrushing and the use of fluoridated toothpaste on the prevalence and incidence of ECC. Toothbrushing was an important confounding factor, affecting the significance of other risk factors associated with ECC. Tsai et al.⁸ stated that there was a statistically significant difference in the prevalence of ECC between children (younger than age 6 years) whose teeth had been brushed every night before bedtime and those whose had not ($p\text{-value}<0.05$). Seow et al.⁹ stated that that ECC-free children aged 1–4 years had fewer troubles with brushing than children with dental caries experience ($p\text{-value}=0.01$).

Kumarihamy et al.¹⁰ stated that there was no statistically significant difference in the mean dmft (non-cavitated lesions included), between 1- to 2-year-old Sri Lankan children who had their teeth brushed once or less per day compared to more than twice per day ($p\text{-value}=0.18$) or between those who used fluoridated dentifrice and those who did not ($p\text{-value}=0.22$). Warren et al.¹¹ showed that there was no statistically significant difference in the prevalence of ECC (non-cavitated lesion included) between one year old WIC-enrolled children who had their teeth brushed daily and those who had not ($p\text{-value}=0.26$). Kolker et al.⁵ showed that there was no significant association between toothbrushing and different levels of dmfs among 3- to 5-year-old low SES African-American children in Detroit, Michigan ($p\text{-value}=0.55$).

These previous studies used various designs to assess risk factors for ECC and had different findings, leaving important gaps in our knowledge. Thus, more structured, longitudinal studies are warranted. To address these gaps, this study assessed the relationships between ECC incidence and several behavioral risk factors (dietary and oral hygiene practices), demographic risk indicators and birth-related factors in a high caries risk population.

Material and Methods

Data from an ongoing longitudinal study in Alabama was used and analyzed. The original “parent” study was designed to investigate the relationships between the acquisition of cariogenic bacteria associated with the eruption of first primary and permanent molars in high-risk African-American children and the pathogenesis of dental caries. The purpose of this sub-study was to assess the relationships between different behavioral factors and ECC incidence in children aged 3 to 22 months at baseline in Alabama. The African-American children recruited for this study were considered high caries-risk because of fluoridated water and low socioeconomic status within their community.

Two cohorts of high caries risk, low SES, African-American children were invited, most of whom had a single parent. In the first cohort (not the focus of this study), 91 children aged approximately five years at baseline were recruited, while in the second cohort (the focus of this study), 97 children aged 3–22 months were recruited over an 18-month period beginning in July, 2008, which was one year after the recruitment of children in the first cohort.

The inclusion criteria for the study were that infants could not have had their first primary molars erupted. Furthermore, all the children had to live with their biological mothers and have at least one biological sibling, and the parents had to plan to remain in the area for at least three years. Institutional Review Board approval was obtained from UAB and informed consent was obtained from the caregivers. The children were examined by three trained and calibrated dentists, first at baseline when the children were approximately one year old and then 1st, 2nd and 3rd follow-up when the children were approximately two, three and four years old. Children received fluoride varnish application (semi-annually) at each study visit they attended. Dental caries was reported at the cavitated level following World Health Organization (WHO) criteria¹². A total of 23 children were examined to assess inter- and intra-examiner reliability when they were approximately three and four years old. Intra-examiner weighted kappa for 17 children aged three to four years was 0.91, and inter-examiner weighted kappa for 23 children aged three to four years was 0.93 when comparing the results of the total dmfs count at the person level.

Caregivers were asked to complete follow-up questionnaires every six months after the baseline questionnaire during the first two years of the study and annually after that. The questionnaires were pilot tested with the help of “Community Health Advisors” and 10 parents of children seeking dental care at UAB. At baseline, the parents were asked to provide detailed information about their children’s demographic, medical, dietary and oral hygiene practices. Demographic information included date of birth, and sex (male or female). Medical information included information about the delivery type (standard, C-section, forceps, or others), whether the child was full term (37 to 42 weeks), birth weight (pounds and ounces), presence of allergies and chronic systemic medical conditions (yes/no), and acute illnesses in the previous 6 months (i.e., ear, sinus, skin, urinary tract infections, sore throat, and chest cold).

Detailed data were gathered about antibiotic use, including total duration of antibiotics taken in the previous six months (none, 1–2 weeks, 3–6 weeks, 7–12 weeks, or more than 12 weeks), time since last antibiotics intake (days, weeks, or months), types of antibiotics (open question), and ways of taking antibiotics (liquid, pill, or other). Furthermore, height (inches) and weight (pounds and ounces) were obtained starting with the 2nd follow-up (about 24 months after baseline examination).

Dietary and nutritional information involved questions about whether the child was breastfed (yes/no), history of bed-time bottle (night and nap) and bottle use (yes/no). Also, information was collected about beverages consumed (breast milk, infant formula, milk, juice, water, and sugar-added beverages), including brand names, frequency (times per day), timing (throughout the day/at meal and snack times), method of drinking liquids other than water (drinks quickly/sips over time), and amounts (cups per day) of beverages. Juices

included 100% natural juice with no sugar added, such as orange juice, tomato juice, and apple juice, while “sugar-added beverages” included all the sugared soda pop (e.g., Coke™, Sunny Delight™, lemonade, Hi-C™, Hawaiian Punch™, Caprisun™, and Koolaid™, but not 100% natural juice. Other drinks like sugared tea, sugared coffee, sugared milk, Gatorade™, also were defined as sugar-added beverages. Sugar-free beverages (i.e., sugar free soda pop, Crystal Light™) and tea, coffee, or milk without sugar were not included in this category.

Furthermore, the questionnaire asked about oral hygiene information concerning toothbrushing (yes/no), frequency of toothbrushing (times per day), the use of toothpaste (yes/no), and type of toothpaste (brand name/open-ended). Dental history included questions about the sources of drinking water (bottled water, well water, city water, and others), the use of vitamin drops or tablets with fluoride (yes/no), history of a dental problem (yes/no), reason for last visit to the dentist (regular check/other), and the presence of a regular dentist (yes/no) at the time the questionnaires were completed. Approximately 50% of the questionnaires were filled out independently, while the remaining were completed with the coordinator’s assistance.

Follow-up questionnaires had several additional relevant dietary questions beyond the baseline questionnaire. These included questions about consumption (yes/no) and frequency of consumption (times/day) of candy and/or gum, consumption and frequency of consumption of sweetened foods such as Pop Tarts™ and sugared cereals, whether plain sugar was added to any food or drinks (yes/no) and the amount of plain sugar added to any food or drinks (teaspoons/day).

SAS 9.3 (SAS Institute Inc., Cary, NC, USA) was used to analyze all data. A SAS 9.3 macro was used to compute the area-under-the-curve (AUC) estimates for independent variables that were assessed in the follow-up questionnaires at ages 1.5, 2.0, 2.5 and 3.1 years. The trapezoidal method was used, dividing the total by the length of the time in order to get time-adjusted AUC estimates in the original assessment units. Including children who had questionnaires both at ages 1.5 and 3 years (for one child, we used age 1.8 instead of 1.5 years), and also any interim questionnaires available. Bivariate relationships were assessed between ECC incidence and the variables that were assessed at baseline, as an AUC composite and at 2nd follow-up examination. Multivariable analyses using PROC COUNTREG commands were employed when the dependent variables were counts and PROC LOGISTIC commands used when the independent variables were dichotomous. Collinearity between different independent variables was assessed and interaction terms were included in the multivariable regression models.

Each independent variable was modeled separately, using bivariate logistic regression with dichotomous dependent variables, or negative binomial models with count dependent variables. We used the significance level of 0.15 as a screening cut-off for inclusion of the independent variables in the development of the multivariable models related to risk for ECC incidence. For the logistic regression, odds ratios were used to assess the magnitudes and the directions of the associations among the dichotomous dependent variables and different independent variables. For the negative binomial models, incidence rate ratios (IRR) were

assessed. IRR is obtained from the exponentiation of the estimates of the negative binomial model regression equation, since the coefficient estimates are assessed on the log scale.

Multivariable logistic regression and multivariable negative binomial models were used to assess risk associated with the independent risk factors and risk indicators that had screening p-values ≤ 0.15 from the bivariate analyses. A manual backward elimination procedure was performed to choose the best model. Changes in Akaike Information Criterion (AIC) were not considered when evaluating the fitted model generated from the preceding step, because AIC is sensitive to changes in sample size associated with deleting variables from the models. Thus, the variables remaining in the multivariable models were determined using only p-values. Independent variables that had the highest p-values were eliminated sequentially, so our final model had variables with statistically significant parameter estimators at $P = 0.05$.

Our main priority was to build a model with the incidence of ECC for the whole period (baseline to 3rd follow-up) as the outcome, so we had two models (dichotomous/count). However, for the incidence from baseline to the 3rd follow-up, we had the smallest sample size, because we had fewer children at the 3rd follow-up examination than all other exams, due to attrition. Thus, we chose another incidence period that gave us reasonably high incidence of ECC and a larger sample size, so we would possibly have greater power to detect differences in the incidence of ECC. After some initial descriptive analyses, we found that the incidence from the 1st follow-up to the 2nd follow-up was relatively high (38.6%), with a relatively large sample ($n=83$). Thus, we built four main multivariable models (two incidence periods (baseline to 3rd follow-up and 1st follow-up to 2nd follow-up) times two types of incidence (dichotomous and count)). Also, since there was a difference in the ages of the children at recruitment (from 3–22 months), we decided to adjust for age in each of the four multivariable models.

Results

Behavioral and clinical questionnaires for all follow-up visits were completed by the majority of parents (99%). Birth-related information collected at baseline showed that approximately 12% of the children were not full-term (37 to 42 weeks), 22% had low birth weight, and 46% were delivered by C-section. Baseline feeding practices collected at baseline showed that almost all of the children were never breast-fed (97%) and approximately 28% had a history of night or nap-time bottle-feeding. The percentages of using well water, bottled water, and city water were 2%, 75%, and 37%, respectively, with parents checking more than one source of water, if applicable.

Dietary information collected at baseline (Table 1) showed that 98%, 92% and 99% of the children consumed milk (including infant formula), 100% natural juice and water, respectively, while few children (1%) consumed sugar-added beverages. Baseline oral health behavior information (Table 1) showed that approximately 41% of the children had their teeth brushed and 14% reportedly were permitted to brush their own teeth. Approximately 33% of the children used toothpaste and 2% each reportedly had a regular dentist and a previous visit to a dentist.

At the 2nd follow-up, 37% and 100% of the children reportedly consumed candy and/or gum and sweetened foods, respectively. All the children reportedly had their teeth brushed and used toothpaste (100%), and 78%, 51% and 64% of the children reportedly brushed their own teeth, had a regular dentist and reported a history of previous dental visits, respectively.

The mean frequencies of consumption of candy and/or gum and sweetened food at the 2nd follow-up were 0.35 and 1.76, respectively (Table 2). The mean frequencies of consumption of milk, 100% juice, water and sugar-added beverages at the 2nd follow-up were 3.25, 1.99, 4.65 and 0.69 times per day, respectively. Table 2 also shows that the mean toothbrushing frequency among the study children at the 2nd follow-up was 1.94 times per day. The AUC estimate of candy and/or gum consumption was low (mean=0.15 times per day) compared to the AUC estimate of sweetened foods consumption (mean=1.65 times per day (Table 2). AUC estimates also showed that the mean toothbrushing frequency was 1.77 times per day.

Bivariate analyses relating the three-year incidence of ECC (dichotomous) to various explanatory variables found three factors significantly related at $P<0.15$. (data not shown). These were: premature delivery (OR=0.29, p-value=0.08), more frequent consumption of 100% juice (AUC, OR=0.54, p-value=0.13), and more frequent consumption of sweetened foods (AUC, OR=6.67, p-value=0.003). The multivariable model (Table 3, Model A) for the three-year incidence of ECC (dichotomous) showed that children who consumed sweetened foods (AUC) one more time per day had approximately 9.2 times the odds of developing caries for the three-year incidence period as those who consumed one unit less per day of sweetened food (p-value=0.002). Children who were delivered prematurely had approximately 80% lower odds of developing dental caries for the three-year incidence of ECC, compared to those who were delivered full-term (p-value=0.049). Also, children who consumed 100% juice (AUC) one more time per day had approximately 60% lower odds of developing dental caries for the three-year incidence of ECC, compared to those who consumed 100% juice (AUC) less frequently per day (p-value=0.049). Two-way interactions were not significant between different combinations of the variables (all p-values>0.10). After adjustment for age, only greater daily frequency of sweetened foods consumption was statistically significantly associated with the three-year incidence of ECC (p-value=0.003, results not shown).

Bivariate analyses relating incidence of ECC from 1st follow-up to 2nd follow-up (dichotomous) found five factors significantly related at $P<0.15$. These factors considered for the multivariable regression were: low birth weight (OR=0.38, p-value=0.12), toothbrushing (yes) at baseline (OR=0.42, p-value=0.08), increased daily frequency of toothbrushing at baseline (OR=0.59, p-value=0.07), presence of a regular dentist at 2nd follow-up (OR=2.14, p-value=0.12) and history of previous visit to a dentist at 2nd follow-up (OR=2.42, p-value=0.11). For the multivariable model with incidence of ECC from 1st follow-up to 2nd follow-up (dichotomous), since toothbrushing (yes/no) and the frequency of toothbrushing at baseline were collinear (p-value<0.001), toothbrushing (yes/no) was manually eliminated from this model because the variable frequency of toothbrushing provided more information (none/once per day/twice per day, etc.) than toothbrushing (yes/no). The final multivariable model (Table 3, Model B) showed that increased daily frequency of toothbrushing at baseline had statistically significant association with lower incidence of

ECC from 1st to 2nd follow-up (OR=0.34, p-value=0.01), while having a history of a previous visit to a dentist at the 2nd follow-up was associated with higher incidence of ECC from 1st follow-up to 2nd follow-up (OR=4.57, p-value 0.03), and no significant two-way interaction was detected. After adjustment for age, the models remained essentially unchanged (data not shown).

Bivariate analyses relating the three-year incidence of ECC (count) found two factors significantly related at $P < 0.15$: greater mother's DMFS at baseline (IRR=1.02, p-value=0.13) and history of previous dental visit at the 2nd follow-up (IRR=1.99, p-value=0.15). In the multivariable model for the three-year incidence of ECC (count), none of the variables met the significance level of $P = 0.05$, with or without adjustment for age (Table 3, Model C).

Bivariate analyses relating incidence of ECC from 1st follow-up to 2nd follow-up (count) found three factors significantly related at $P < 0.15$: presence of a regular dentist at 2nd follow-up (IRR=3.63, p-value=0.04), history of a visit to a dentist at 2nd follow-up (IRR=2.83, p-value=0.12) and self-brushing at 2nd follow-up (IRR=0.36, p-value=0.15). The final multivariable model (Table 3, Model D) showed that children with a history of a visit to a dentist had statistically significantly higher ECC dmfs count from 1st follow-up to 2nd follow-up than those who had no history of a visit to a dentist at the 2nd follow-up (p-value of 0.03). After adjustment for age, the models remained essentially unchanged (data not shown).

Discussion

Our study assessed dental caries experience longitudinally at the surface level at four time points (baseline, 12-month, 24-month and 36-month follow-up). Children enrolled in the study were about 12 months of age when participating in the baseline visit. Person-level net caries incidence (yes/no and dmfs count) was used as outcome variables. A strength of our study was that detailed demographic, dietary and oral hygiene information was collected longitudinally at the recruitment and follow-up visits. This detailed information at different stages during a child's development helped us to assess the relationships between incidence of ECC and different dietary and oral hygiene behaviors over time.

Our study showed a negative association between increased daily frequency of consumption of 100% juice and ECC incidence. This might be due in part to the negative correlation between daily frequency of consumption of 100% juice and daily frequency of consumption of sugar-added beverages (Spearman Correlation= -0.60 with p-value<0.0001). Sugar-added beverages most commonly have sucrose or high-fructose corn syrup, while 100% juices contain fructose and glucose without sucrose¹³. Cariogenic bacteria, such as *Streptococcus mutans*, are more effective in metabolizing sucrose (present in sugar-added beverages), rather than fructose or glucose, to produce extracellular glycan^{14–16}. Extracellular glycan is an important component in the formation of dental plaque, as it facilitates dental plaque adherence to the tooth surface. Extracellular glycan enables acid's diffusion, which increases the risk for developing dental caries^{14–16}. In addition, 100% juices are more expensive than regular soda pop and other sugar-added beverages. Children who reportedly consumed more

100% juice might be from higher SES and more educated families which can afford them more easily. Thus, SES and education are important confounders, which we were unable to control for this study. Our finding regarding the negative association between greater consumption of 100% juice and ECC incidence was consistent with data reported by Chankanka et al.¹⁷ who conducted secondary analyses of the Iowa Fluoride Study to assess the effects of frequency of beverage consumption on cavitated and non-cavitated caries incidence in 156 mostly white, higher SES children, with exams conducted at five, nine and 13 years of age. The overall results of that study, similar to our findings, showed that increased frequency of 100% juice was significantly associated with fewer non-cavitated and cavitated caries surfaces ($P=0.003$ and <0.0001 , respectively).

Marshall et al.¹³ conducted analyses of the Iowa Fluoride Study data, with 417 children examined by two trained and calibrated dentists between ages four and seven. Dental caries was reported at both the tooth and surface levels (cavitated and non-cavitated lesions were included without differentiation between cavitated enamel (d2) and dentin (d3) lesions). When using caries (cavitated and non-cavitated combined) as a dichotomous outcome, children who reportedly consumed less 100% juice at age 5 had lower caries experiences at age four and seven ($OR=0.57$, $CI\ 0.34, 0.97$). Additional Iowa Fluoride Study data analyses by Marshall et al.¹⁸ assessed the relationships between caries experience (present vs. absent) at age ~five years and daily overall exposures to beverages at earlier ages (one, two, three, four, five and one to five years) separately. At age two years, children ($n=527$) who were in the highest quartile for exposure to 100% juice at snack time and both snack and meal time combined (total) had greater dental caries experience, compared to the children in the lowest quartile ($OR=2.18$ and 2.69 , $CI\ 1.10-4.33$ and $1.30-5.58$, respectively). However, the study¹⁸ showed that consumption of 100% juice at meal time was not significantly associated with ECC ($OR=0.58$, $95\% CI\ 0.29-1.19$). In contrast, Kolker et al.⁵ showed that lower consumption of 100% natural juice among 436 low SES African-American children was significantly associated with higher levels of dmfs ($p=0.0001$). Similarly, the study reported herein showed a significant negative association between greater total 100% juice consumption and ECC incidence ($OR=0.37$, $CI\ 0.15-0.75$).

Our study showed a strong positive association between daily frequency of consumption of sweetened foods and incidence of ECC ($OR=9.22$, $P=0.002$). Previous studies have found similar relationships between intakes of sweetened foods and dental caries. Seow et al.⁹ assessed the relationships between ECC and different dietary practices among 670 Australian children aged 0–4 years living in non-fluoridated areas. Use of added sweeteners to bottles, sugar added to weaning solids, sugary fluids and sugary snacks were all significantly associated with greater prevalence of ECC. In contrast, Gibson et al.⁷ showed that energy consumption from biscuits and cakes combined, sugar confectionery, chocolate confectionery, total biscuits, or cakes and confectionery combined, were not statistically significantly associated with dental caries among 1,450 British children aged 1.5 to 4.5 years. Kolker et al.⁵ reported that greater consumption of sugared soda pop was significantly associated with higher levels of dmfs among socio-economically disadvantaged African-American children. Likewise, Warren et al.⁶ showed that consumption of sugar-sweetened beverages among children aged 18 months was associated with increased prevalence of ECC ($OR=3.04$, $p\text{-value}=0.04$).

Greater daily frequency of toothbrushing, as assessed at baseline was significantly associated with decreased ECC incidence. Many studies have shown that toothbrushing and the increased frequency of toothbrushing are associated with decreased prevalence and incidence of dental caries. However, Kolker et al.⁵ did not find a significant association between greater frequency of toothbrushing among poor African-American children and dmfs level (1=0 dmfs, 2=1–4dmfs, 3=5–11 dmfs and 4=12–52 dmfs), with $P=0.55$. In contrast, Tsai et al.⁸ showed that toothbrushing every night before bedtime had a statistically significant association with lower prevalence of ECC. When Chankanka et al.¹⁷ assessed the effect of toothbrushing on cavitated and non-cavitated caries incidence in the Iowa Fluoride Study children, increased daily frequency of toothbrushing was significantly associated with fewer non-cavitated caries surfaces ($P=0.03$). However, increased daily frequency of toothbrushing was not significantly associated with cavitated caries surfaces ($P=0.08$). Other studies did not find a statistically significant effect of toothbrushing on caries prevalence and incidence. Warren et al.¹¹ found no significant difference in the prevalence of ECC between children who had their teeth brushed daily and those who had not, after adjusting for age ($p\text{-value}=0.26$).

In our study, results showed that a history of a previous visit to a dentist was statistically significantly associated with increased incidence of ECC ($P=0.03$). This might be due to self-identified need to see a dentist and/or the referrals to local dentists that have been made by the UAB team when diagnosing children with cavitated lesions. Also, visiting a dentist might inflate the number of tooth surfaces with dental caries experience, due to the use of radiographs and involving more surfaces in the treatment according standard care for treating primary teeth, as well as the dentist's clinical judgment¹⁹.

The following limitations need to be considered when interpreting the results of this study: 1) Limited sample size decreased the study's power to detect differences in the incidence and dmfs counts of ECC among children with different dietary and oral hygiene behaviors; 2) the study reported dental caries at the cavitated level, without radiographs, so the possibility exists for an underestimation of the magnitude of the dependent variables of the regression models; 3) questionnaires were completed by parents via self-report, leaving room for misinterpretation of questions and social desirability bias, however, study coordinators assisted parents in completing questionnaires, answering any clarifying questions they had; and 4) The study is a secondary data analysis of previously collected data, which limits our analysis to variables available.

Overall, the findings of our study showed that ECC incidence in African-American children was significantly associated with increased frequency of sweetened food consumption, decreased frequency of 100% juice consumption and decreased frequency of toothbrushing.

Conclusion

Our study showed that some oral hygiene and dietary practices were associated with ECC incidence. Increased frequency of sweetened foods consumption was associated with increased incidence of dental caries. However, both greater frequency of toothbrushing and greater frequency of 100% juice consumption were associated with decreased incidence of

dental caries. Additional large-scale studies evaluating risk factors for caries development among other risk groups are necessary to better understand the disease process and determine foci for prevention of caries.

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Table 1

Dietary and oral hygiene characteristics of participants at baseline and 2nd follow-up*

Category	Variables	Baseline*		24-month follow-up*	
		N	Percentage (yes)	N	Percentage (yes)
Foods	Candy and/or gum consumption	NA**	NA**	79	37.2%
	Sweetened foods consumption***	NA**	NA**	79	100%
Beverages	Milk consumption	94	97.9%	81	94.7%
	100% juice consumption	96	91.7%	81	73.4%
	Water consumption	96	99.0%	81	97.9%
	Sugar-added beverages consumption****	96	1.0%	81	100%
Oral Hygiene	Toothbrushing	93	40.5%	81	100%
	Self-brushes	87	13.6%	81	78.2%
	Use of toothpaste	83	32.5%	81	100%
Dental Care	Regular dentist	95	2.1%	76	50.6%
	Previous visit to a dentist	95	2.1%	73	64.1%

* Mean (S.D.) ages were approximately 1.1 (0.3) and 3.1 (0.4) years at baseline and 24-month follow-up, respectively.

** NA=Not applicable, since questions were not asked at baseline.

*** Sweetened foods include Pop Tarts™, sugared cereals, etc.

**** Sugar-added beverages include all beverages with added sugar. This excludes milk, water, 100% juice, and other sugar-free beverages (e.g., Crystal Light™ and unsweetened tea and coffee).

Table 2

Mean frequencies of dietary consumption and toothbrushing behaviors per day *

Category	Daily frequency of	Baseline (n=96)		24-month follow-up (n=81)		AUC (n=81)	
		Mean	SD	Mean	SD	Mean	SD
Foods	Candy and /or gum consumption	NA	NA	0.35	0.58	0.15	0.26
	Sweetened foods consumption	NA	NA	1.76	0.53	1.65	0.46
Beverages	Milk consumption	3.89	1.31	3.25	1.30	3.36	1.00
	100% juice consumption	2.44	1.00	1.99	1.39	0.88	0.63
	Water consumption	2.40	1.31	4.65	1.09	4.09	0.89
	Sugar-added beverage consumption	3.00	-	0.69	1.23	1.88	0.90
Oral Hygiene	Toothbrushing	0.41	0.50	1.94	0.24	1.77	0.35

* Mean (S.D) ages were 1.1 (0.3) and 3.1 (0.4) years at baseline and 24-month follow-up, respectively, while AUC covered the period from age 1.5 to 3.0 years.

** Milk included infant formula at baseline.

*** Sugar-added beverages include all beverages with added sugar. This excludes milk, 100% juice and sugar-free drinks.

**** NA=Not applicable, since questions were not asked at baseline.

***** Sweetened foods include Pop Tarts™, sugared cereals, etc.

***** Sample size at 2nd follow-up was 81, except for daily frequency of consumption of candy and/or gum and sweetened food (both=79) and daily frequency of toothbrushing (n=80).

***** Sample size for AUC was 81, except for daily frequency of consumption of candy and/or gum and daily frequency of toothbrushing (both=78) and daily frequency of consumption of sweetened foods (n=77).

Table 3

Multivariable analyses of factors significantly associated with ECC incidence.

Dependent Variables		Results (not adjusted for age)			
Model	Dichotomous dependent variable	Multivariable logistic analysis*****			
		Variables in the final model	OR (95% CI)	P-value	
A.	Three-year incidence from baseline to 36-month follow-up (dichotomous)***	AUC* of daily frequency of sweetened foods consumption**	9.22 (2.32–36.67)	0.002	
		Premature delivery (<37 weeks)	0.21 (0.04–0.99)	0.049	
		AUC* of daily frequency of 100% juice consumption	0.37 (0.13–0.99)	0.049	
B.	Incidence from 12- to 24-month follow-up (dichotomous)***	Daily frequency of toothbrushing at baseline	0.34 (0.15–0.75)	0.01	
		History of previous visit to a dentist at 24-month follow-up***	4.57 (1.14–18.25)	0.03	
Model	Count dependent variable	Multivariable negative binomial model analysis*****			
		Variables in the final model	Estimate (SE)	IRR****	P-value
C.	Three-year incidence from baseline to 36-month follow-up (dmfs increment)***	No variables significant at P<0.05*****	NA	NA	NA
D.	Incidence from 12- to 24-month follow-up*** (dmfs increment)	Presence of a regular dentist by 24-month follow-up***	1.29 (0.61)	3.63	0.03

* AUC includes visits when mean ages of children were 1.5, 2.0, 2.5 and 3.1 years, respectively.

** Sweetened foods include Pop Tarts™, sugared cereals, etc.

*** Mean (S.D) ages were 1.1 (0.3), 2.0 (0.4), 3.1 (0.4), 4.0 (0.4) years at baseline, 12-month, 24-month, and 36-month follow-up, respectively, while AUC covered the period from age 1.5 to 3.0 years.

**** IRR obtained from the exponentiation of the regression coefficients.

***** No two-way interactions were significant between pairs of variables (all p-values>0.05)

Neither mother's DMFS at baseline nor history of previous dental visit by 24-month follow-up were significant here at P<0.05.