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Sugar Consumption and Changes in Dental Caries from Childhood to Adolescence

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Abstract

There are no prospective studies investigating the effects of sugar-related feeding practices on changes in dental caries from early childhood to young adulthood. The aim of this study was to assess whether sugar-related feeding practices affect dental caries between the ages of 6 and 18 y. This birth cohort study was initiated in 1993 in Pelotas, Brazil. There were 3 dental clinical assessments; at ages 6 y (n = 359), 12 y (n = 339), and 18 y (n = 307). Sugar-related feeding practices were assessed at ages 4, 15, and 18 y. Covariates included sex and life course variables, such as family income, breast-feeding, mother's education, regularity of dental visit, and child's toothbrushing habits. Group-based trajectory analysis was performed to characterize trajectories of time-varying independent variables that had at least 3 time points. We fitted a generalized linear mixed model assuming negative binomial distribution with log link function on 3-time repeated dental caries assessments. One in 5 participants was classified as "high" sugar consumers, and nearly 40% were "upward consumers." "Low consumers" accounted for >40% of the sample. High and upward sugar consumers had higher dental caries prevalence and mean DMFT in all cohort waves when compared with low sugar consumers. Caries occurred at a relatively constant rate over the period of study, but in all sugar consumption groups, the increment of dental caries was slightly higher between ages 6 and 12 y than between 12 and 18 y. Adjusted analysis showed that dental caries increment ratio between ages 6 and 18 y was 20% and 66% higher in upward and high sugar consumer groups as compared with low consumers. The higher the sugar consumption along the life course, the higher the dental caries increment. Even the low level of sugar consumption was related to dental caries, despite the use of fluoride.

Keywords: epidemiology, cohort study, children, adolescents, incidence, risk factor

Introduction

There is a consensus that sugars are implicated in several noncommunicable diseases, including dental caries (World Health Organization [WHO] 2003; Sheiham and James 2014; WHO 2015). Moreover, sugars are a "sufficient" cause of dental caries (Rothman and Greenland 1999); sugars determine whether or not caries develops. Despite the wide-scale decrease in dental caries in children, caries remains a major international public health problem. Untreated caries in permanent affected 36% of the world's population (Marcenes et al. 2013).

The most reliable design to demonstrate the association between sugar intake and caries increment is prospective cohort studies. Surprisingly, although sugars are a well-known causal factor to dental caries, there are very few cohort studies that investigate prospectively the effect of sugar-related feeding practices on dental caries increment (Moynihan and Kelly 2014). Furthermore, there is no prospective cohort study from early childhood to young adulthood looking at this important public health problem. The lack of well-designed studies investigating the relationship between sugar intake and dental caries was the reason why the WHO (2015) graded the evidence of such an association as being of moderate quality (Moynihan and Kelly 2014; WHO 2015).

Patterns of sugar consumption change along the life course. There is a change in behavior from early childhood to adolescence, with adolescents being more independent in selecting their foods and drinks. That could increase the risk for caries development (Sheehy et al. 2008; Ogden et al. 2011).

As there is a dearth of well-conducted longitudinal studies of the relation between feeding practices and caries experience, a study was carried out with the aim of assessing whether

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Table 1. FFQ Data Transformation into Annual Consumption.

Responses to FFQ	Never or <1/mo	1 to 3/mo	1/wk	2 to 4/wk	5 to 6/wk	1/d	2 to 4/d	≥5/d
Estimated yearly frequency	0	1 × 12	1 × 52	2 × 52	5 × 52	1 × 365.25	2 × 365.25	5 × 365.25
Calculation	0	12	52	104	260	365.25	730.5	1,826.25

The definition of low-, intermediate-, and high-level sugar-related feeding practices was based on approximate tertile distribution.
FFQ, Food Frequency Questionnaire.

sugar-related feeding practices affect dental caries between the ages of 6 and 18 y.

Methods

This study is reported according to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

Participants and Study Design

This is a prospective population-based birth cohort initiated in 1993 in Pelotas, Brazil (n = 5,249). The first cohort's assessment was undertaken at birth, and a random subsample of the cohort infants was subsequently selected and visited at their homes at ages 1 mo (n = 649), 3 mo (n = 644), 6 mo (n = 1,414), and 12 (n = 1,383) mo. In 1997, all low birth weight children were sampled, plus 20% of the remaining—including those visited at 1 and 3 mo. Among the 1,460 eligible children, 87% (1,270 children) were located. For the oral health studies nested in the cohort, a random subsample of 400 children was drawn at age 6 y from the 1997 cohort assessment, and 359 children were dentally assessed (Peres et al. 2005). Further assessments of all participants were at ages 6, 11, 15, and 18 y. Detailed methodological aspects of the cohort have been published elsewhere (Victora et al. 2008; Gonçalves et al. 2014). All children who participated in oral health studies were assessed at 1, 3, 6, and 12 mo and at ages 4, 6, 11, 15, and 18 y. Among the 359 children who participated in the study at 6 y of age, 339 (94.4%) were investigated at 12 y, and 307 (90.6%) of those dentally examined and interviewed at age 12 y were investigated at age 18 y.

Dental Caries Assessments at Ages 6, 12, and 18 y

All dental assessments followed WHO (1997) dental caries diagnostic criteria. Assessments included a dental examination for dental caries in the primary and permanent dentitions at aged 6 y, while at ages 12 and 18 y, only permanent dentition was assessed.

Eight, 6, and 1 examiners were involved in the fieldwork at ages 6, 12, and 18 y, respectively. Examiner calibration was performed on a tooth-by-tooth basis in all dental assessments (Peres et al. 2001). Interexaminer reliability was measured with the weighted kappa statistic. The lowest kappa value for dental caries was 0.6, which is considered good or substantial (Szklo and Javier Nieto 2007). As the oral health study at age 18 y was performed by only 1 trained dentist, the calibration was performed as compared with another dentist who did not participate in the fieldwork. For this reason, it was possible to assess inter- and intraexaminer agreement. All examinations were conducted at participants' homes in the 6- and 12-y-old assessments and at a clinic for those aged 18 y. All dental examinations were carried out under artificial light (a headlamp), with dental mirrors, and using Community Periodontal Index probes, observing proper safety and biohazard measures.

Assessments of Sugar-related Feeding Practices

The sugar-related feeding practices variable was constructed with data from the cohort waves at ages 4, 15, and 18 y. At age 4 y, mothers were questioned in relation to the foods and drinks that their children consumed and the frequency of consumption. The questions related to 6 foods: chips, soda, chocolate, candies, bubble gum, and lollypop. If the mother's response was affirmative, then the interviewer asked how many times the child consumed that food daily, weekly, or less than once a week. From all of these foods and drinks, the daily intake was determined. Scores ranged from 0 to 6 foods/drinks ingested (Chafee et al. 2015).

For the ages 15 and 18 y, the adolescents answered a Food Frequency Questionnaire. They were questioned in relation to the consumption of 81 foods and 88 drinks in the last year. At age 15 y, teenagers reported whether the food was ingested and the number of times per day, week, month, or year. At age 18 y, the options of response were closed: never or <1 per month; 1 to 3 per month; 1 per week; 2 to 4 per week; 5 to 6 per week; 1 per day; 2 to 4 per day; ≥5 per day. To create a variable of daily consumption, 11 foods with cariogenic potential were selected at ages 15 and 18 y: cake, chips/snacks, cookies, ice cream or popsicle, sugar, candies, chocolate in powder or chocolate bars, pudding, nondiet soda, natural fruit juice, and processed fruit juice. A daily consumption diary was created at ages 15 and 18 y, with scores varying from 0 to 11 foods consumed. The methodology proposed by Chafee et al. (2015), by using scores, was used to construct the sugar-related variable that we used. The Food Frequency Questionnaire used at 18 y old was transformed into annual consumption as shown in Table 1. At 15-y-old assessment of food collection allowed us to estimate the daily consumption (regardless of daily frequency). After all annual frequencies were computed, these were divided by 365.25 to obtain the daily consumption, and a score was subsequently created (0 to 11 consumed foods). The formulas used to calculate the annual consumption are displayed in Table 1.

Covariates

Based on the literature, some potential confounders of the association between sugar-related feeding practices and dental caries were selected: sex, family income, breast-feeding, mother's level of education, regularity of dental visit, toothbrushing habits. Family income was collected at birth and at ages 4, 11, 15, and 18 y. Family income was a sum of all forms of income (salary, wages, pensions, cash transfer program, rental income, and investments). It was collected in reais (Brazilian currency) and transformed in tertiles for each assessment. Information on breast-feeding was collected immediately after birth and at 3, 6, 12, and 24 mo at 4 y of age according to the following questions: "Is your child being breastfed? If 'No,' when did she/he stop being breastfed?" Breast-feeding was categorized as follows: 9+ mo, 4.0 to 8.9 mo, 1.0 to 3.9 mo, and <1 mo (Peres et al. 2007). Mother's level of education was collected 3 times (at child's birth and at child's 15- and 18-y assessments) according to year of study and then categorized as <4, 5 to 8, 9 to 11, and 12+ y. Dental visits (yes/no) in the last 12 mo were assessed at ages 6, 12, and 15 y. Daily toothbrushing frequency (<2 times a day / ≥2 times a day) was measured at aged 6, 12, 15, and 18 y. All behavior-related covariates were reported by the participants' parents (usually the mother) in the first wave (6 y old) and by the participants in the subsequent assessments. Family income was reported by the participants' parents.

Statistical Analyses

Caries experience was the main dependent variable. Its descriptive statistics were presented with caries prevalence (proportion of people with DMFT >0) and caries experience (means and standard errors, DMFT). As in the follow-up study, the proportion of low birth weight children was 29.7%, while in the original cohort, it was 9.7%; therefore, it was necessary to calculate a weighted factor to perform statistical analysis. For the oral health study, a weight factor of 0.33 was used for children born with low birth weight, and 1.28 was applied for those born with adequate birth weight. Household incomes and other covariates were all descripted in cross-tables with their regrouped categories.

Group-based trajectory analysis was performed with PROC TRAJ in SAS 9.3 (Jones et al. 2001) to characterize trajectories of time-varying independent variables that have at least 3 time points. The parameters for the trajectory model were determined on a maximum-likelihood basis by a general quasi-Newton method (Dennis et al. 1981; Jones and Nagin 2007). The model selection procedure involved estimating the number of latent classes and the order of the polynomial for each latent trajectory. The final number of trajectories was established when sequential comparisons of the Bayesian information criterion (BIC) and adjusted BIC between the model with k and $k + 1$ trajectories yielded no further substantial difference in the BIC score than the $k + 1$ model. We fitted each group with trajectory of quadratics and started with the null model with 1 group. BIC analysis supports a 3-group model. The likelihood of each case belonging to each trajectory (posterior probabilities) was used to classify individual group membership. To validate the group model, we listed all the group members and tried to interpret their latent pattern. Low, intermediate, and high levels of sugar-related feeding practices were used to establish the latent 3 classes.

Ultimately, a 3-group sugar consumption trajectory was selected:

Low: ≥2 of ages 4, 15, and 18 y have been measured low (40.4%).

Upward: early life was measured low, and at least 1 of ages 15 and 18 y has been measured not low (38.7%).

High: early life was measured high or not low, and ≥2 of ages 4, 15, and 18 y have been measured not low (20.9%; see Appendix Table).

In the interests of parsimony, a 4-group trajectory analysis model was defined for family incomes and 3 groups for mother's education. Selection of that number balanced the interests of parsimony with the objective of reporting the distinctive developmental pattern in the data (Broadbent et al. 2008).

To identify the association with the main exploratory variable—sugar-related feeding practice groups—we fitted a generalized linear mixed model with SAS PROC GLIMMIX by assuming negative binomial distribution with log link function (negative binomial [NB] model) on 3-time repeated dental caries assessments. The primary assumption underlying the analyses performed by PROC GLIMMIX on the data is that it contains random effects in dealing with repeated measures on each individual. As our main focus is on the group differences, we only applied random effect to the intercept. The choice of NB model is due to the positive skewness and overdispersion of the DMFT index. Type 3 likelihood statistics were used for testing the overall effect of the variables, and Wald chi-square statistics tested the effect of category of variable as compared with the reference group in the model. All variables with type 3 likelihood statistics with $P < 0.20$ were kept in the models. Sex was kept in the models regardless of its P value. All models were adjusted for birth weight. The model allowed estimation of dental caries incidence rate ratio and respective 95% confidence intervals. Least square means were estimated through the models. The estimated expected counts of dental caries were obtained by applying the inverse link function to the least squares means. The outcome variable of the generalized linear mixed model is DMFT that was repeated measured at ages 6, 12, and 18 y. This model was used to assess the change in DMFT over time and the difference among different groups in sugar-related feeding practices. As this is an individual growth model, it must have a time variable—in our case, age.

Ethical Issues

Consent for interviews and examinations was obtained and approved by the Pelotas Federal University Ethics Committee.

Table 2. Sample Characteristics Studied in Each Wave.

	Age, y						
Variables/Categories	0	4	6	11	12	15	18
Sex							
Male	158 (53.3)	—	—	—	—	—	—
Female	144 (46.7)	—	—	—	—	—	—
Caries prevalence, *n* (%)							
dmft > 0			199 (64.4)				
DMFT > 0	—	—	9 (3.2)	—	157 (50.3)	—	217 (70.8)
Caries experience, mean (SD)							
dmft	—	—	3.39 (3.8)	—	—	—	—
DMFT	—	—	0.07 (0.4)	—	1.20 (1.6)	—	2.10 (2.4)
Sugar-related feeding practices, *n* (%)							
Low	—	210 (69.4)	—	—	—	180 (58.9)	199 (65.7)
Intermediate	—	74 (24.5)	—	—	—	99 (33.9)	87 (29.7)
High	—	18 (6.1)	—	—	—	23 (7.1)	16 (4.6)
Family income, *n* (%)							
Lower tertile[a]	134 (44.3)	98 (29.4)	—	91 (28.3)	—	87 (28.3)	88 (29.1)
Intermediate tertile	63 (20.2)	87 (29.1)	—	101 (33.4)	—	106 (32.8)	102 (33.8)
Higher tertile	103 (35.5)	117 (41.5)	—	110 (36.4)	—	109 (38.9)	112 (37.1)
Breast-feeding, mo; *n* (%)							
≥9.0	64 (22.9)	—	—	—	—	—	—
4.0 to 8.9	68 (24.6)	—	—	—	—	—	—
1.0 to 3.9	108 (36.0)	—	—	—	—	—	—
<1.0	60 (16.5)	—	—	—	—	—	—
Mother's schooling, y; *n* (%)							
0 to 4	83 (25.0)	—	—	—	—	81 (25.7)	63 (20.3)
5 to 8	145 (48.9)	—	—	—	—	131 (42.9)	131 (45.8)
9 to 11	55 (20.3)	—	—	—	—	80 (28.5)	80 (30.4)
12+	15 (5.9)	—	—	—	—	9 (2.9)	10 (3.5)
Dental visits							
Yes	—	—	110 (36.6)	—	140(64.5)	156 (53.5)	—
No	—	—	189 (63.4)	—	77(35.5)	145 (46.6)	—
Toothbrushing, *n* (%)							
<2/d	—	—	40 (11.0)	—	67 (22.2)	11 (2.5)	64 (19.3)
≥2/d	—	—	262 (89.0)	—	235 (77.8)	291 (97.5)	238 (80.7)
Birth weight, g; mean (SD)	3,194.37 (549.5)	—	—	—	—	—	—

The mean and percentage were adjusted by the oversampling on low birth weight children.
[a]Tertile was derived from the original cohort.

Participants who had dental treatment needs were referred to the Dental Clinic of the Postgraduate Program in Dentistry of Pelotas Federal University. All assessments for those in the cohorts were also approved by the Human Research Ethics Committee of the Federal University of Pelotas (Brazil).

Results

Data from 302 participants who had completed data on dental caries, sugar-related feedings practices, and covariates from birth to 18 y were analyzed. Prevalence of dental caries in primary dentition at age 6 y was 64.4%; mean dmft was 3.46 (SD, 3.9). Prevalence of dental caries in permanent dentition ranged from 2.8% at age 6 y to 48.0% when participants were 18 y old. Mean DMFT varied from almost zero at age 6 y to 1.2 at age 12 y. It almost doubled at age 18 (2.1; Table 2). Core characteristics of the participants of oral health assessments are similar to those from the original cohort. For example, the proportion of participants' mothers with >8 y of schooling was 74.2% for the general cohort and 76.0%, 77.8%, and 70.2% for participants at ages of 6, 12, and 18 y, respectively.

Trajectories of sugar consumption along the life course and dental caries prevalence and experience are presented in Table 3. One in 5 participants was classified as a "high" sugar consumer, and nearly 40% were "upward consumers." "Low consumers" accounted for >40% of the sample. High and upward sugar consumers had statistically significant higher dental caries prevalence and higher mean DMFT at the age 12- and 18-y waves when compared with low sugar consumers (Appendix Table, Table 3). Caries occurred at a relatively constant rate over the period of study, but in all sugar consumption groups, the increment of dental caries was slightly higher between ages 6 and 12 y than between 12 and 18 y. Table 4 displays negative binomial models of the association of dental caries increment from age 6 to 18 y according to sugar-feeding practice trajectories. After adjustment for potential confounders, the dental caries increment ratios between ages 6 and 18 y were 20% and

Table 3. Caries Prevalence and Experience from Age 6 to 18 y and Group Trajectories of Sugar-related Feeding Practices.

		Caries Prevalence, *n* (%)			Caries Experience–DMFT, Mean (SD)		
Sugar Group	*n* (%)	Age 6	Age 12	Age 18	Age 6	Age 12	Age 18
High	63 (20.86)	3 (6.14)	41 (65.63)	48 (78.43)	0.12 (0.52)	1.92 (2.12)	3.28 (3.34)
Upward	117 (38.74)	3 (1.64)	61 (49.05)	91 (75.10)	0.03 (0.24)	1.09 (1.46)	1.97 (2.25)
Low	122 (40.40)	3 (3.20)	55 (43.60)	78 (62.59)	0.09 (0.52)	0.92 (1.33)	1.50 (1.62)
Total	302 (100.00)	9 (3.20)	157 (50.34)	217 (71.80)	0.07 (0.43)	1.20 (1.61)	2.10 (2.40)

The mean and percentage were adjusted by the oversampling on low birth weight children.

Table 4. Negative Binomial Models on the Association between Increases in Dental Caries from Ages 6 to 18 y and Sugar-related Feeding Practice Groups.

	Model 1		Model 2		Model 3	
	IRR	95% CI[a]	IRR	95% CI	IRR	95% CI
Age/6	1,378.15	362.97 to 5,232.64	1,378.15	362.97 to 5,232.64	1,378.15	362.97 to 5,232.64
$(Age/6)^2$	0.26	0.20 to 0.34	0.26	0.20 to 0.34	0.26	0.20 to 0.34
Sugar group[b]						
High	1.88	1.37 to 2.57	1.68	1.23 to 2.28	1.67	1.23 to 2.25
Upward	1.33	1.01 to 1.75	1.20	0.92 to 1.57	1.22	0.94 to 1.59
Low	1		1		1	
Birth weight	0.09	0.71 to 1.03	0.11	0.72 to 1.04	0.84	0.70 to 1.00
Sex						
Male			0.97	0.78 to 1.26	0.996	0.79 to 1.26
Female			1		1	
dmft at age 6 y			1.10	1.07 to 1.13	1.10	1.07 to 1.14
Breast-feeding, mo						
≥9.0			1.08	0.75 to 1.57		
4.0 to 8.9			1.17	0.81 to 1.68		
1.0 to 3.9			1.14	0.82 to 1.58		
<1.0			1			
Dental visit at age 6 y						
Yes			0.83	0.64 to 1.06	0.89	0.71 to 1.13
No			1		1	
Family income						
Stable low			1.22	0.88 to 1.70		
Downward			1.16	0.72 to 1.85		
Upward			1.05	0.71 to 1.56		
Stable high			1			
Mother's education						
Low			1.22	0.87 to 1.71		
Intermediate			1.24	0.93 to 1.65		
High			1			
Toothbrushing						
Inconsistent			0.97	0.72 to 1.31		
Consistent			1			

Statistically significant differences were found only for high vs. low and not for upward vs. low or high vs. upward.
CI, confidence interval; IRR, incident rate ratio.
[a]Wald test.
[b]$P < 0.01$ in the type 3 likelihood ratio statistics, which test the overall effect of sugar specified in the MODEL statement (null hypothesis: sugar in the model does not explain a significant proportion of the variance, given the other variables are in the model), while the Wald statistic tests the effect of sugar groups as compared with the reference group (null hypothesis: there is no difference for the outcome variable between the other categories of sugar and reference).

66% higher in upward and high sugar consumer groups as compared with low consumers. However, statistically significant differences were found only for high when compared with low consumers and not for upward versus low or high versus upward. The predicted values of DMFT from model 1 (Table 4) are shown in the Figure.

The aim of this study was to assess the progression and dynamic growth of dental caries in the permanent dentition from 6 to 18 y of age. However, we included dmft as a covariate given that dental caries in deciduous teeth is a strong predictor of dental caries in permanent dentition. We sum up dmft-DMFT at age 6 y in Table 4 (Appendix Table).

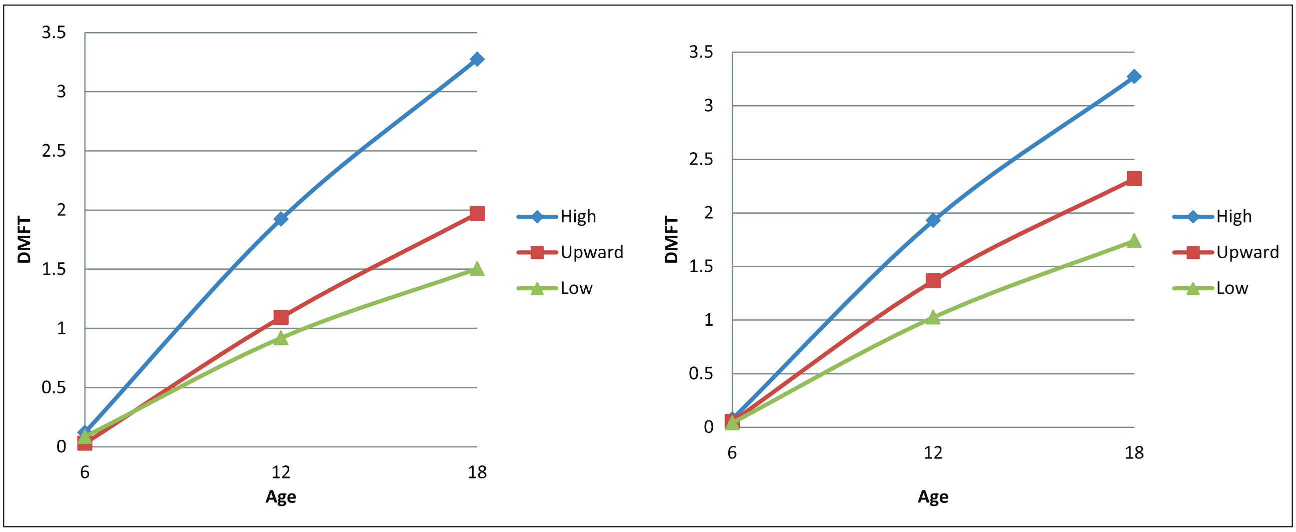

Figure. Actual mean DMFT (left) and estimated expected counts of DMFT from model 1 (right) with sugar-related feeding practices.

Discussion

Dental caries increment from 6- to 18-y-olds was consistently and positively associated with high patterns of sugar consumption along the life course even after adjustment for potential well-known confounders. As identified in the Dunedin cohort study (Broadbent et al. 2008), caries occurred at a relatively constant rate throughout the study period in the sample as a whole, but the pattern dental caries varied across sugar consumption trajectory groups. Caries prevalence and experience in the highest sugar consumer group were higher than for low and upward sugar consumers.

As water fluoridation was implemented in the study area in 1962 and covers almost all of the population (Lima et al. 2004) and as toothbrushing with fluoride toothpaste is ubiquitous in Pelotas (e.g., at 18 y of age, only 3% of participants brushed teeth once a day and 99.8% used fluoride toothpaste) and was controlled for, the role of different sources of fluoride cannot explain our findings. Caries increased even among low sugar consumers, suggesting that caries occurs even in low sugar consumers using multiple sources for fluoride. Moreover, in those where sugar consumption goes upward, the disease will eventually be as high as in the high consumption group, indicating that low sugar consumption in a specific period of life is unlikely to prevent dental caries later on in life.

This study has several strengths. It is a long-term population-based birth cohort study with 3 dental assessments at ages 6, 12, and 18 y performed by the same research team. Examiner reliability and participation rates were high, contributing to the strength and internal validity of the study. In addition, the statistical approach used allowed us to analyze time-varying variables and impute missed cases. When the food frequencies were collected, the traditional practice is using factor analysis to reduce the variable to a few factors. That is variable centered. In our analysis, food consumption was first conducted to person-centered categories. Furthermore, as there were 3 categories in each of the 3 assessments, there was a total of 27 possible permutations for the sugar-related feeding practices. Based on the group trajectory method, sugar intake was modeled to categories of sugar-related feeding practice latent groups (low, upward, and high). Another strength of this study was the use of group trajectory analysis. It is common practice to use multiple imputing to deal with data missing in a longitudinal study. Group trajectory analysis provided another statistical approach that allowed us to analyze time-varying variables that permit inclusion of individuals not accessed at all time points.

Most research on dental caries has been based on cross-sectional data collection, or, even when the data were collected longitudinally, the final caries outcomes or caries increments over time were not considered in the analyses. It is not clear about caries changes over time in the general population or a given sample and what variables are associated with the overall trend and the differences within person and between person. Growth mixed model was used to examine the unique trajectories of individuals and groups in repeated measured data. A time-varying variable representing different status of outcome is needed in the model. This method overcomes some of the limitations of traditional repeated measuring techniques and offers additional benefits and information.

However, this study has some limitations. It is a relatively small sample, which may have precluded the identification of some differences. The lack of the assessment of the amount of added sugars may have underestimated the magnitude of the effect of sugar-related feeding practices on dental caries increment. In addition, the use of different instruments to collect dietary data is another limitation of the current study. However, we used the same approach adopted in a similar population (Chaffee et al. 2015).

The findings of this study should be generalized to populations with similar socioeconomic characteristics and similar patterns of sugar-related feeding practices. Our findings have clear public health policy implications. As sugar-related feeding practices in childhood and adolescence are risk factors for dental caries, diabetes, obesity, and early surrogate markers of cardiovascular diseases, the common risk factor approach (Sheiham and Watt 2000) should be adopted as the most effective way to prevent these diseases. Caries has serious impacts on individuals and populations. It causes pain, discomfort, and social and functional limitations, which ultimately can impair oral health–related quality of life. Also, the economic impact of caries is considerable. The WHO estimates that oral diseases are the fourth-most expensive disease to treat in industrialized countries (Petersen et al. 2005).

In conclusion, the higher the life course sugar consumption, the higher the dental caries increment. Low levels of sugar consumption caries occurred even in low sugar consumers using multiple sources for fluoride.

Author Contributions

M.A. Peres contributed to conception, design, data acquisition, analysis, and interpretation, drafted and critically revised the manuscript; A. Sheiham contributed to conception and data interpretation, drafted and critically revised the manuscript; P. Liu contributed to conception, data analysis, and interpretation, drafted and critically revised the manuscript; F.F. Demarco, A.E.R. Silva, M.C. Assunção, and A.M. Menezes contributed to conception, data acquisition, and interpretation, drafted and critically revised the manuscript; F.C. Barros contributed to design, data acquisition, drafted and critically revised the manuscript; K.G. Peres contributed to conception, design, data acquisition, analysis, and interpretation, drafted and critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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