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Early-Life Patterns of Sugar Consumption and Dental Caries in the Permanent Teeth: A Birth Cohort Study

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Keywords

Child · Dental caries · Diet · Life-course · Sugar · Cohort studies

Abstract

Early-life family conditions may presage caries development in childhood. The aim of this study was to evaluate associations between patterns of sugar consumption in early childhood and permanent dentition caries at age 6 years. A cohort enrolled women accessing prenatal care at public health clinics in Porto Alegre, Brazil. Sociodemographic, anthropometric, and dietary data were collected during pregnancy and 6-month, 12-month, and 3-year follow-ups. Calibrated dental examinations occurred at ages 3 and 6 years. Multivariable logistic regression analysis was performed in series to quantify associations between early-life variables and permanent dentition caries. At age 6 years, 7.9% of children (21/266) had ≥1 caries lesion on permanent teeth (first molars). In unadjusted models, gestational weight gain, sweet food introduction (age 6 months), household sugar purchases (age 3 years), and caries (age 3 years) were positively associated with permanent dentition caries (age 6 years). In multivariable models, each 1-kg increase in gestational weight gain (odds ratio [OR]: 1.08; 95% confidence interval [CI]: 1.01, 1.16) and each 1-item increase in sweet food consumption at age 6 months (OR: 1.27; 95% CI: 1.02, 1.59) remained statistically significantly associated with permanent molar caries. Findings from this cohort study suggest family and child factors that long predate the permanent dentition, including sugar-related behaviors, predict future dental status, and may inform prevention strategies.

Introduction

Dental caries is the most common chronic disease of humankind [Kassebaum et al., 2015]. Untreated caries has a major deleterious impact on health-related quality of life among children, adolescents, and adults worldwide [Wong et al., 2011; Feldens et al., 2016; Haag et al., 2017]. Dental caries is determined by biological, psychosocial, and environmental factors [Machiulskiene et al., 2020], with critical behavioral contributions that accumulate over the life-course [Shearer and Thomson, 2010]. Dietary factors, particularly the consumption of free sugars, are prominent among risk factors [WHO, 2015].

While upstream policy is an essential strategic component in caries prevention and has the most far-reaching potential [Watt et al., 2019], complementary behavioral

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approaches also play a role and may operate best if positioned very early in life, when dietary preferences, expectations, and reward mechanisms are first being influenced and developed [Chaffee et al., 2015; Meyer and Lee, 2015]. Despite national and international guidelines for healthy eating practices, excessive sugar consumption from the first year of life has been described not only in Brazil but in diverse populations worldwide [Ha et al., 2017; Wang et al., 2018; Irving et al., 2020]. In particular, foods and drinks high in sugar are often consumed in the first 6 months of life [Feldens et al., 2021], which has long-term implications for general and oral health [Feldens et al., 2010b, 2021; Chaffee et al., 2015]. Few studies investigate variables related to diet and sugar consumption from pregnancy and through the first years of life in relation to caries of the permanent dentition. Identifying such associations may inform effective interventions, given the potentially consequential influence of early-life behaviors and considering age 6 years marks as an inflection point of accelerated caries incidence [Kassebaum et al., 2017]. The objective of the present study was to examine 3 variables related to the diet and sugar consumption at 3 early-life time periods: maternal gestational weight gain, number of sugary food items introduced by age 6 months, and household sugar purchases at age 3 years and their associations with dental caries in the permanent teeth (first molars) soon after their eruption at age 6 years.

Materials and Methods

Study Design and Participants

The present prospective cohort study is nested within a randomized controlled clinical trial that recruited pregnant women from 20 basic health units (UBS public health clinics). The UBS system is the primary access point to the Unified Health System (SUS), which nationally serves more than 70% of the Brazilian population. Services are available to all residents. While SUS patients represent a wide range of socioeconomic classes, the patient population overall is characterized by greater socioeconomic disadvantage and represents the target public health policies. Recruitment occurred in Porto Alegre, a Brazilian city with 1.4 million inhabitants and an optimally fluoridated municipal water system. The purpose of the intervention trial was to investigate the effect of training for clinic health professionals on recommended infant and toddler healthy eating practices on various child health outcomes (clinicaltrials.gov: NCT00635453). The intervention was associated with feeding and eating behaviors better aligned with national guidelines, but there was no statistically significant reduction in dental caries at age 3 years [Chaffee et al., 2013].

Between 2008 and 2009, 736 pregnant women were invited to participate in the study (exclusion criterion: HIV positive due to possible breastfeeding complications), and 715 women agreed and enrolled. A team of researchers, trained and calibrated to reduce bias, administered a structured, close-ended questionnaire and conducted anthropometric examinations during pregnancy and at 6 months and 3 years of age. A clinical dental examination was performed at age 3 years (n = 458) and age 6 years (n = 313). The present analysis is based on a subsample of the cohort that had at least one permanent first molar erupted at age 6 years (n = 266). Of these children, 233 had complete covariable data necessary for multivariate analysis. Figure 1 shows the cohort flow diagram.

Data Collection

The following variables were collected during pregnancy and/or shortly after birth: weight gain at 6 months of gestation (maternal weight measured during pregnancy less self-reported pregestational weight), maternal age at the time of delivery, maternal education (in years of study), family income (in Brazilan reais, later categorized into tertiles), child sex, birth weight, and birth length.

At age 6 months, child anthropometric variables (length and height) were measured, and body mass index was calculated and converted to WHO z-scores. In addition, mothers were asked at what age (in months) their child was first introduced to 31 specific food and beverage items. Fifteen of those items were considered high in refined sugars or other simple carbohydrates (added sugar, candy, chips, chocolate, chocolate milk, coffee with sugar added, cookies, fruit-flavored drink, gelatin, honey, ice cream, petit suisse cheese, soft drinks, sweet biscuits, and tea with sugar added). A sugar consumption index was defined as the total number of sugar items introduced to the infant before age 6 months [Chaffee et al., 2015].

At age 3 years, a maternal interview was conducted to collect the amount of sugar (in kilograms) purchased by the household per month. Monthly salt and oil purchases were also recorded to isolate any sugar purchase associations, independent of expenditures on other products. Purchase amounts were divided by the number of household members. Mothers were also asked if the child had ever visited a dentist and whether currently using fluoridated toothpaste, if any. Child height and weight were measured and converted to WHO *z*-scores. In-home dental screening examinations were performed by 2 trained and calibrated examiners to measure developmental defects of enamel [FDI World Dental Federation, 1992], the presence of visible plaque, and dental caries [WHO, 1997], with noncavitated lesions also recorded. Teeth were brushed, dried with gauze, and evaluated visually using artificial light.

At age 6 years, the in-home dental screening examination was repeated by a single trained and calibrated examiner. The main outcome variable for the present study was the presence of a carious lesion in at least 1 permanent tooth (including noncavitated lesions). Children with at least one of the 4 first permanent molars erupted and with data collected during each of the previous time points (i.e., pregnancy/birth, age 6 months, and age 3 years) were included in the analysis. Next, mothers were asked to report their child's daily frequency of toothbrushing, whether parents assisted with brushing, and whether the child was currently using fluoridated toothpaste.

The number of participants originally recruited in the trial and subsequently followed up and retained at 6 years of age determined the sample size for the present cohort study. A post hoc calculation determined that the available sample size of n = 233 had >80% power to detect an absolute difference of 12% (alpha = 0.05, two-tailed) in the prevalence of dental caries between children introduced to fewer than 6 sweet food items by age 6 months and those introduced to ≥7 items.

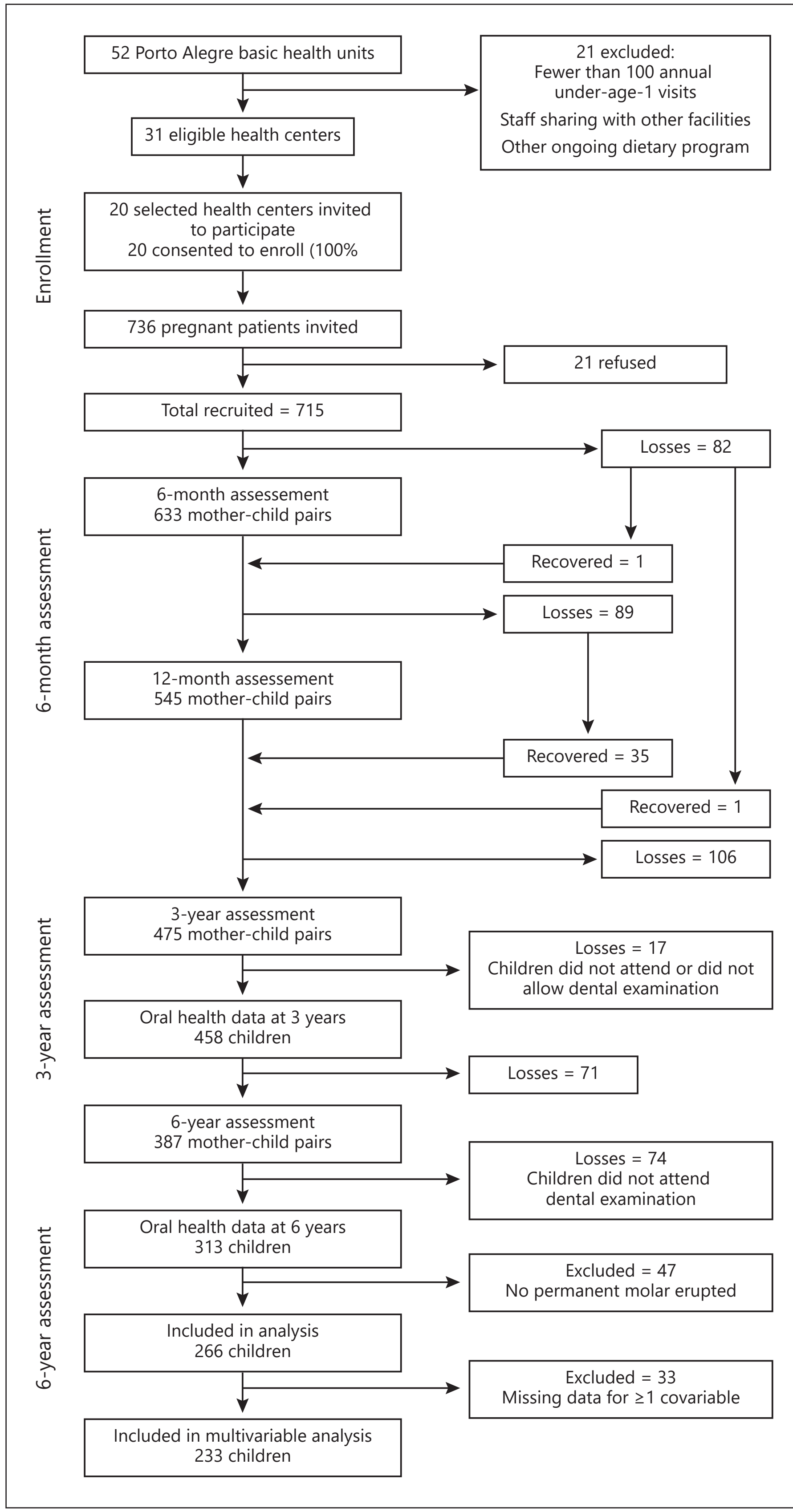

Fig. 1. Flow diagram: study participation from enrollment to 6-year assessment.

Table 1. Characteristics of the study participants, Porto Alegre, Brazil

	Initial cohort[†]		6-year assessment[‡]	
	%	mean (SD)	%	mean (SD)
Maternal and household variables				
Maternal age at birth, years		25.4 (6.7)		25.6 (6.5)
Maternal education, years		8.5 (2.7)		8.8 (2.4)
Previous child	55.4		55.8	
Social class ≤C[§]	79.8		79.8	
Child variables				
Intervention group in original trial	50.3		54.5	
Male	52.4		50.6	
Birth weight <2,500 g	6.3		6.1	
Birth height, cm		49.0 (2.5)		49.0 (2.5)
Sugar consumption index at 6 months		5.0 (2.4)		5.0 (2.4)
Monthly sugar purchased per capita at 3 years, kg		1.13 (1.04)		1.14 (1.20)
DMFT ≥1 at 3 years	39.5		39.3	
DMFT at 3 years		1.54 (2.76)		1.51 (2.70)

SD, standard deviation; DMFT, decayed (cavitated or noncavitated), missing due to caries, restored primary tooth index. [†] *n* = 715 at birth. [‡] *n* = 266; sample size may be smaller for some variables due to missing data. [§] Brazilian Association of Economic Research Institutes classification system; C or below indicates greater socioeconomic disadvantage.

Data Analysis

Baseline characteristics of the analytic sample were compared to those of the original cohort to assess possible selection bias due to losses to follow-up. In the first unadjusted analysis, the means of 3 dietary-related variables (i.e., maternal gestational weight gain, age 6-month sugar consumption index, and age 3-year household per capita sugar purchases) were compared between children with and without permanent teeth caries lesions at age 6 years (*t*-test). In a second unadjusted analysis, child/family sociodemographic, dietary-related, and clinical dental variables were all specified categorically to compare the prevalence of permanent teeth caries lesions between each category level (χ^2 test).

Multivariable analysis was performed using logistic regression. The multivariable model was specified sequentially, following a hierarchical perspective in 3 blocks: (1) pregnancy and birth variables; (2) age 6-month variables; and (3) age 3-year variables. The models estimated the odds ratio for covariables mutually adjusted for those at the same or higher level (i.e., temporally earlier). The assignment group in the original trial (intervention or control) was retained as an adjustment variable in all models.

Results

The study sample consisted of children mostly of low socioeconomic position, with a mean maternal education of 8.8 years (Table 1). The analytic sample was similar in its baseline characteristics to the full cohort, with no statistically significant differences in socioeconomic, demographic, and anthropometric characteristics from those lost to follow-up. Dental variables at age 3 years also did not differ between children in the analytic sample and those lost to follow-up since the 3-year visit (Table 1). Among participants lost to follow-up, the most commonly recorded reasons for attrition included relocated to another city (51.8%), address could not be located (26.5%), declined participation (20.1%), and maternal death or incapacity (1.6%). Additionally, 17 children at the 3-year visit and 74 children at the 6-year visit did not allow or did not attend dental examinations.

Among children included in the analysis, the mean gestational weight gain was 11.7 kg (standard deviation [SD]: 6.5 kg). At age 6 months, children had been introduced to a range of 0 to 10 sweet items, with mean 5.0 items (SD: 2.5). At age 3 years, 83.4% of children used fluoridated toothpaste, and 39.3% of children had experienced dental caries, with a mean decayed missing filled tooth index score of 1.51 (SD: 2.70). Of the 266 children in the final sample, 55.3% had experienced dental caries at age 6 years, and 7.9% had caries lesions in permanent teeth, with all of the lesions found on the occlusal surfaces of the first permanent molars. At age 6 years, 82.6% of children brushed their teeth twice or more daily, 43.9% received brushing assistance from parents, and nearly all (99.6%) used fluoridated toothpaste.

As a group, children with caries lesions on the permanent teeth had mothers who gained more weight during

Table 2. Gestational weight gain, sugar consumption index, and sugar purchases according to permanent dentition caries prevalence at age 6 years

Variable	Children with caries in permanent teeth at 6 years Mean (SD)	Children without caries in permanent teeth at 6 years Mean (SD)	Mean difference (95% CI)	*p* value
Gestational weight gain, kg	15.3 (6.9)	11.2 (6.5)	−4.1 (−7.0, −1.1)	0.007
Sugar consumption index at 6 months, number of items	6.5 (2.2)	4.9 (2.4)	−1.6 (−2.7, −0.6)	0.003
Household monthly sugar purchases at 3 years, kg/person	2.2 (2.9)	1.0 (0.8)	−1.2 (−1.7, −0.6)	<0.001

SD, standard deviation; CI, confidence interval.

gestation, had been introduced to more sweet foods at age 6 months, and their families purchased more sugar per capita at age 3 years (Table 2). All unadjusted differences were statistically significant.

Table 3 demonstrates the unadjusted associations between caries experience in the permanent teeth at age 6 years and selected child and family characteristics. Gestational weight gain, age 6-month sugar consumption, and age 3-year household sugar purchases were all associated with caries experience in the permanent teeth (Table 3). Permanent dentition caries was also associated with lower levels of maternal education and having experienced dental caries in the primary teeth at age 3 years (Table 3).

In multivariable regression models, gestational weight gain and age 6-month sugar consumption index maintained their associations with age 6-year permanent dentition caries (Table 4). Caries experience in the primary teeth was positively associated with permanent teeth caries but no longer statistically significantly. Adjusted for maternal education, each 1-kg increase in gestational weight gain was associated with an 8% increase in the odds of permanent teeth caries (Table 4). Adjusted for maternal education and gestational weight gain, each additional indexed sweet food consumed at age 6 months was associated with a 27% increase in the odds of permanent teeth caries (Table 4).

Discussion/Conclusion

The present study identified 3 variables related to diet and sugar consumption (gestation weight gain, sweet food introduction, and sugar purchases) from 3 different periods of the life-course (gestation, infancy, and early childhood) and involving 3 different components of the family (mother, child, and household) that were each associated with dental caries in the permanent teeth (first molars) soon after their eruption at age 6 years. The presence of caries soon after tooth eruption indicates a very high cariogenic challenge with elevated probability of progression to severe loss of tooth structure [Stona et al., 2021]. Any direct, proximal effect of the particular variables on permanent teeth caries is implausible, given that these teeth had not yet erupted at the time the dietary-related variables were measured. However, we hypothesize that these variables serve as markers of the family dietary environment and behaviors that persist over time and drive up caries risk for young children.

The first years of life may represent a key intervention opportunity, helping to establish a low-sugar, low-caries trajectory over the life-course, countering an intertwined trajectory between caries and sugar intake throughout life [Heilmann et al., 2015; Peres et al., 2016]. Sugar consumption is the primary and necessary cause in the development of tooth decay [Sheiham and James, 2015]. However, translating this knowledge into effective population prevention and control strategies and clinical practices has been challenging for researchers, dental practitioners, and policy-makers, alike [Meyer and Lee, 2015]. These challenges, in part, relate to enduring patterns of a socioeconomic disadvantage that manifest in poor nutrition over time and across generations [Wightman and Danziger, 2014].

Excessive weight gain during pregnancy has been increasingly tied to multiple negative maternal and childhood health outcomes, such as postpartum weight retention, macrosomia, cesarean delivery, and childhood obesity [Wrotniak et al., 2008; Goldstein et al., 2017]. High consumption of free sugars and ultra-processed foods has been indicated as one cause of excess gestational weight gain [Maslova et al., 2015; Rohatgi et al., 2017]. Speculatively, the association between gestational weight gain and caries in the present study may result, at least in part, from shared diets between the mother and child that may feature high-sugar, cariogenic foods beginning from an early age.

Table 3. Permanent dentition caries prevalence (age 6 years) according to independent variables

Variable	*N*	DMFT ≥1		*p* value
		n	(%)	
Maternal age at birth, years				
<20	48	4	(8.3)	0.901
≥20	218	17	(7.8)	
Maternal education, years				
≤8	66	11	(16.7)	0.002
>8	200	10	(5.0)	
Gestational weight gain				
≤Median (11.3 kg)	130	6	(4.6)	0.042
>Median	131	15	(11.5)	
Family income				
First tertile (lowest)	85	7	(8.2)	0.538†
Second tertile	90	8	(8.9)	
Third tertile (highest)	84	4	(4.8)	
Child sex				
Male	135	10	(7.4)	0.765
Female	131	11	(8.4)	
Child BMI *z*-scores at 6 months				
≤1 SD	188	15	(8.0)	0.901
>1 SD	71	6	(8.5)	
Sugar consumption index at 6 months				
≤3	77	1	(1.3)	<0.001†
4–6	100	7	(7.0)	
≥7	77	13	(16.9)	
Monthly sugar purchased at 3 years, kg/person				
≤Median (1.1)	109	5	(4.6)	0.047
>Median	108	13	(12.0)	
Visible plaque				
No	109	6	(5.5)	0.107
Yes	122	14	(11.5)	
Developmental defects of enamel at 3 years				
No	185	14	(7.6)	0.277
Yes	48	6	(12.5)	
Previous dental visit				
Yes	57	2	(3.5)	0.123
No	169	17	(10.1)	
Dental caries at 3 years				
Yes	92	15	(16.3)	0.001
No	141	5	(3.5)	
Toothbrushing frequency at 6 years				
≤1 × per day	43	4	(9.3)	0.663
≥2 × per day	204	15	(7.4)	

BMI, body mass index; SD, standard deviation; DMFT, decayed (cavitated or noncavitated), missing due to caries, restored permanent tooth index. † χ^2 test for linear trend.

The consumption of sweet foods in the first year of life is a risk factor for the later caries in the primary dentition [Chaffee et al., 2015]. Several possible mechanisms for this association have been proposed. Childhood is a critical period in which experiences with various foods and tastes can influence future food preferences and behaviors [Wendt et al., 1996; Ventura and Worobey, 2013]. In addition, early feeding patterns can enhance the establishment of a cariogenic biofilm, especially *Streptococcus mutans*, an important predictor of caries experience in very young children [Wan et al., 2003]. A pattern of offering high-sugar foods perpetuated from infancy and

Table 4. Multivariable models of dental caries in permanent dentition at age 6 years

Variable	Unadjusted models			Adjusted models†		
	OR	95% CI	*p* value	OR	95% CI	*p* value
Gestational and birth variables						
Maternal age at birth, years						
<20	1.07	(0.34, 3.35)	0.901	0.70	(0.18, 2.70)	0.601
≥20	1.00			1.00		
Maternal education						
≤8 years	3.80	(1.53, 9.42)	0.004	3.68	(1.22, 11.07)	0.021
>8 years	1.00			1.00		
Family income						
First tertile	1.79	(0.51, 6.37)	0.516	1.11	(0.27, 4.55)	0.886
Second tertile	1.95	(0.57, 6.74)		1.61	(0.43, 5.97)	0.475
Third tertile	1.00					
Gestational weight gain, kg	1.10	(1.02, 1.17)	0.008	1.08	(1.01, 1.16)	0.029
Child sex						
Male	1.00		0.765	1.00		
Female	1.15	(0.47, 2.80)		1.30	(0.48, 3.54)	0.601
Birth weight	1.00	(1.00, 1.00)	0.564	1.00	(1.00, 1.00)	0.197
Birth height	1.01	(0.84, 1.21)	0.920	0.87	(0.64, 1.17)	0.352
Variables at 6 months						
Child BMI *z*-scores						
≤1 SD	1.00		0.901	1.00		0.928
>1 SD	1.06	(0.40, 2.86)		1.05	(0.34, 3.23)	
Sugar consumption index	1.33	(1.09, 1.62)	0.005	1.27	(1.02, 1.59)	0.036
Variables at 3 years						
Child BMI *z*-scores						
≤1 SD	1.00		0.922	1.00		0.534
>1 SD	1.05	(0.42, 2.63)		0.63	(0.14, 2.74)	
Monthly sugar purchase, kg/person	1.66	(1.14, 2.43)	0.008	1.62	(0.78, 3.36)	0.198
Monthly oil purchase, kg/person	1.46	(0.84, 2.54)	0.175	0.61	(0.11, 3.42)	0.571
Developmental defects of enamel at 3 years						
No	1.00		0.282	1.00		0.765
Yes	1.74	(0.63, 4.81)		0.77	(0.15, 4.15)	
Visible plaque						
No	1.00		0.115	1.00		0.590
Yes	2.22	(0.82, 6.01)		1.50	(0.34, 6.63)	
Previous dental visit						
Yes	1.00		0.141	1.00		0.684
No	0.32	(0.07, 1.45)		0.68	(0.11, 4.33)	
Dental caries at 3 years						
Yes	1.00		0.001	1.00		0.271
No	5.30	(1.85, 15.14)		2.26	(0.53, 9.62)	

BMI, body mass index; SD, standard deviation; OR, odds ratio; CI, confidence interval. † Covariables added to models in series such that covariables are mutually adjusted for all covariables at the same level or higher (i.e., measured contemporaneously or earlier). All adjusted models also include the assignment group in the original trial (intervention or control) as a covariable.

throughout childhood may explain long-term associations observed in the permanent dentition [Peres et al., 2016].

The household sugar purchase at age 3 years is a reflection of family sugar consumption, not necessarily the child's intake. However, considering that young children quickly develop dietary patterns similar to their families, it is plausible that household sugar purchases are shared. Furthermore, sugar purchases are presumably aligned with family preferences and behaviors that persist throughout childhood, reflected in the association with permanent dentition caries observed in the present study.

Among the clinical and practical implications of the present study, multiple independent markers of dietary behaviors over several years suggests an ongoing pattern of potentially cariogenic feeding behaviors must be disrupted for effective caries prevention. Preventive interventions could be most impactful if implemented prior to permanent tooth eruption, rather than in adolescence or adulthood, when the majority of the population has already experienced tooth decay.

Previous research has identified a number of clinical, socio-environmental, and behavioral variables that can be measured in the first years of life and that may predict caries occurrence in the permanent dentition, including hygiene and diet behaviors and primary tooth caries. While the goal of the present investigation was specifically to assess dietary factors at different time points, caries risk assessment tools that classify children from low to high risk for future caries have potential clinical utility to inform treatment decisions and patient-tailored behavioral interventions [Doméjean et al. 2017; Martignon et al. 2019]. In this context, the present findings underscore the potential value of risk assessments that include child and family dietary variables from an early age. In particular, sugar consumption in the first years of life could prove a helpful indicator of future caries risk. The potential contribution to oral health is yet another rationale for emphasizing healthy diets for infants, mothers, and all family members both in individualized dental and medical care and under broader health-promoting policies.

Two behavioral interventions to reduce child sugar consumption have been tested in this population of low-income Brazilian families. One-on-one nutritional counseling for mothers and caregivers during the child's first year of life that stressed national guidelines for infant feeding, which included avoiding sugar during the first 2 years of life, was shown to be effective in reducing dental caries in early childhood [Feldens et al., 2010a]. However, incorporating these same guidelines into a training and educational intervention for health professionals in public primary care health centers (a lower cost approach with potentially greater reach) showed a more modest reduction in sugar consumption without a statistically significant effect on primary dentition caries [Chaffee et al., 2013]. Together, the results of these studies showed that mothers of young children are able and willing to adhere to simple, objective recommendations, such as delaying the introduction of sugar in the first year of life and increasing the interval between meals. However, some recommendations, such as reducing bottle consumption, which may be emotional charged for a child, were more challenging to follow. The present study findings suggest the importance of delaying the introduction of sugary foods and beverages, which previous studies suggest may be an effective and acceptable message to present to caregivers.

Beyond interventions focused directly on individual family behaviors, more upstream policy-based strategies are better suited to combat the longstanding promotion of sugar consumption from the global sugar industry [Watt et al., 2019]. Potential policy measures include taxation of sugar products, restrictions on the availability and sale of sugar products in or near schools, restrictions advertising, clearer labeling of health risks, and anti-marketing, pro-health public communication. Favorably, a systematic review has reported that policy-level strategies are more likely to reduce population inequality in contrast to individual counseling [McGill et al., 2015]. For oral health, simulation studies have estimated that implementing a tax on sugar-sweetened beverages would reduce dental caries occurrence, substantially lowering treatment costs [Schwendicke et al., 2016].

Ultimately, adopting multi-strategy, interprofessional actions (including downstream and upstream components) that feature stakeholder engagement from the planning stages has the greatest potential to enable people exercise control over factors that affect their health [Watt, 2007a, b]. Sugar deserves particular attention as a common risk factor for dental caries, obesity, and cardiovascular diseases [WHO, 2015], and the results of the present study add further evidence that such risks begin to take hold very early in life.

From a clinical perspective, the incidence of caries lesions in first molars soon after eruption confirms the need for early detection to allow implementation of non-invasive, less complex, and lower cost interventions, particularly those that can inactivate early lesions [Hilgert et al., 2015; Zenkner et al., 2019]. In addition to mechanical plaque control, a fundamental self-care behavior for maintenance of oral health [Kumar et al., 2016], fissure sealants, and fluoride application can contribute to inactivation of early lesions [Hilgert et al., 2015; Chestnut et al., 2017].

Among the potential sources of bias in the present study, losses to follow-up between pregnancy and age 6 years were substantial, albeit not atypical of longitudinal studies in low- or middle-income countries featuring disadvantaged populations. Despite study attrition, any impact of selection bias can be considered low, given that the average characteristics of the initial and analyzed cohort were virtually identical. Sugar consumption and prepregnancy weight were by self-report and could have been underestimated; although it is unlikely, measurement error was differential by child caries status. While adjusted models did include multiple covariables, unmeasured confounding cannot be ruled out. The available sample size and low outcome prevalence resulted in wide confidence intervals. Participants were enrolled from municipal public health centers; thus, findings may not generalize to upper income or rural families. Likewise, results may not generalize to other geographic and cultural contexts.

In conclusion, the present study identified associations between dental caries in the permanent teeth at age 6 years and gestational weight gain, sugar consumption at age 6 months, and household sugar purchases at age 3 years, albeit household purchases lost statistical significance in adjusted models. These results must be interpreted cautiously in light of study limitations. That said, these data suggest that dietary-related behaviors at the family and child level manifest from pregnancy and continue into childhood, with potential health consequences that continue into the permanent dentition. These findings indicate the need for multilevel interventions to interrupt this pattern and preserve good oral health over the life-course.

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Statement of Ethics

Research Ethics Committees of the Federal University of Health Sciences of Porto Alegre and the University of California Berkeley approved the study protocol. After research staff explained the study and all phases of data collection, parents provided written free and informed consent for themselves and on behalf of their children.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

C.A.F., I.F.S., and M.R.V. conceived study design; M.R.V. and B.W.C. contributed to data collection; C.A.F. analyzed the data; C.A.F. and B.W.C. drafted the initial manuscript; and all authors contributed to data interpretation and provided critical manuscript comments and revisions.

Data Availability Statement

Data analysed during the current study are available from the corresponding author on reasonable request.

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