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Mediating effect of eating pattern on the relationship between television exposure and caries in children

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Abstract: Behavioral characteristics may also take part in the etiology of dental caries. Sedentary behavior, especially watching television, is associated with increased intake of foods high in fat or free sugar, which could influence the occurrence of dental caries. The aim of this study was to assess the mediating effect of eating pattern on the relationship between television exposure time and the presence of dental caries in children. A cross-sectional study was conducted with a representative sample of 580 parent-child dyads with children aged 7 to 8 years in 20 public schools in Pelotas, Brazil. Parents or legal guardians were interviewed and provided information on demographic/socioeconomic data, children's daily television exposure time, and answered the Biological Rhythms Interview for Assessment in Neuropsychiatry for Kids (BRIAN-K-eating pattern domain). Caries was evaluated through clinical examination. The mediating effect of eating pattern on the relationship between television exposure and presence of dental caries was estimated using the parametric *g*-formula. Prevalence of dental caries was 63%, and 22% of children watched TV 4 or more hours per day. Television exposure had no direct effect on the dental caries experience [odds ratio (OR): 1.05 (95% confidence interval (95%CI): 0.92–1.19)]. Nevertheless, difficulty maintaining regular eating pattern mediated the natural indirect effect of television exposure time (≥ 4 hours/day) on dental caries experience [OR: 1.07 (95%CI): 1.01–1.14)]. The results of this study confirm the indirect pathway between television viewing and dental caries and the role of disordered eating patterns in this association.

Keywords: Cross-Sectional Studies; Child; Television; Diet; Dental Caries.

Introduction

Dental caries is the most common non-communicable disease and is considered an international public health challenge, especially in children.[1] The prevalence of caries in deciduous and permanent teeth in children was estimated to be 46.2% and 53.8%, respectively.[2] Consequences of the disease can include poor food intake, deficient school performance, and presence of mental health disorders, which can affect the quality of life of children and their families.[3] Caries

originates from the complex interaction of socio-economic risk factors (*e.g.*, low parental educational level and low household income) with low access to and low use of preventive health services, which increase the likelihood of risky behaviors such as high consumption of cariogenic foods and irregular oral hygiene.[4]

The increasing consumption of cariogenic foods (*i.e.*, those rich in fermentable carbohydrates, such as ultra-processed foods – UPF), in particular, is a well-established contributing factor on caries development in children.[5] This consumption pattern frequently exposes teeth to an acidic plaque environment for extended periods of time , which promotes enamel demineralization and causes dental caries.[6] Indeed, a recent meta-analysis study concluded that children and adolescents who consume UPF foods (*e.g.*, snacks, fast foods, junk foods, sugar-sweetened beverages, sugary cereals, chocolate, and others) have a higher probability of having their teeth affected by caries.[7] In childhood, UPF consumption during television viewing is common, which can alter energy intake by delaying satiation and reducing satiety signals from previously consumed foods. This relationship can be explained by children's exposure to television advertisements for unhealthy foods high saturated fats, trans fat, and free sugars, which may increase their cravings for these products.[8,9]

Therefore, it is suggested that dietary changes related to sedentary habits, such as watching television, may act as modifying factors in the development of dental caries.[10] This could be due to the influence of this sedentary activity on the dietary habits of children during this period, which may favor the absence of a regular eating pattern regarding frequency, quality, and quantity of meals.[9,11] Eating patten is a broad term that encompasses food choices and motives, feeding practices, dieting behaviors, and eating-related problems.[12] Within the context of behavioral medicine, research on diet practices focuses on the impact of promoting healthy eating patterns on the management and prevention of dental (*e.g.*, dental caries) and medical (*e.g.*, obesity and diabetes) conditions,[13,14] as well as seeks the relationship with biological rhythm.[15] Recently, an instrument to measure the degree of difficulty and maintenance of the biological rhythm of circadian system, including eating patterns, was validated for Brazilian children. The eating domain of the Biological Rhythm Interview of Assessment in Neuropsychiatry for Kids (BRIAN-K) identifies the disruption of children's eating patterns considering their difficulty in maintaining mealtimes, maintaining the same amount of food eaten regularly, and their difficulty to consume moderately stimulating foods or sweets.[16]

So far, few studies have verified the association between television viewing and dental caries,[11] and they have mainly examined the effect of food intake aspects in this relationship.[17,18] Silva et al.[17] have investigated the role of cariogenic food intake while watching television on caries experience in Brazilian children aged 10 to 12 years. The authors observed that children who consume cariogenic foods while watching television and those who are exposed to television for prolonged periods of the day were more likely to have dental caries lesions than those who do not ingest these foods and watch television daily for a shorter period (< 90 minutes/day).[17]

Although these epidemiological findings contribute to the understanding of the multifactorial etiology of caries, the interpretation and analytical approach do not usually imply the investigation of a causal effect. The *G*-computation is one approach to causal-effect estimation. The parameters in a *G*-formulation approach are estimated similarly to a perfectly randomized controlled trial, under certain assumptions that allow for causal interpretation. The *G*-computation procedure has some advantages over traditional regression analysis, including the decoupling of confounding adjustment and effect estimation, which can provide an explanation for the mechanisms underlying the association between an exposure of interest (*e.g.*, television exposure) and a specified outcome (*e.g.*, dental caries in children), considering a mediator (*e.g.*, eating pattern).[19] Therefore, this study investigated the mediating effect of eating pattern on the relationship between television exposure and dental caries in children using the parametric g-formula mediation analysis.

Methodology

Study design

This cross-sectional study was performed with school children aged 7 to 8 years in Pelotas, Rio Grande do Sul, Brazil. The report of this study was performed according to the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology checklist.

Ethical aspects

Ethical approval for this study was obtained from the Human Research Ethics Committee of the Catholic University of Pelotas (UCPel) (#843526). All parents/caregivers also received an information letter and signed written informed consent, authorizing their children's participation in the study. Children were asked for their consent to participate in the study.

Sample

This study is part of a multidisciplinary epidemiological survey entitled "Healthy Childhood in Context", which evaluated children enrolled in public schools in Pelotas, Brazil. More information can be found elsewhere. The municipality is in the extreme south of Brazil and has approximately 344,385 inhabitants. According to the latest government data, the Municipal Human Development Index of Pelotas was 0.739 (2022), the Gross Domestic Product per capita was R$25,884.35 Brazilian Reais (2022) (U$D 4,961.54 - converted on 26 December 2022), and the Gini Index was 0.5596 (2010).

The probability sampling method was used to select the schools. The Municipal Secretariat of Education of Pelotas provided a list with the location and contact information of all primary schools of the public education network and authorized the participation of the units in the research. All 40 institutions described in the list were contacted and invited to participate in the study (acceptance rate: 100%). The public schools were coded (1-40), and a total of 20 institutions were randomly selected through an online tool (www.randomizer.org). The institutions provided a list identifying all 7- and 8-year-old children enrolled in grade 3 and the contact details of their respective parents/guardians. Firstly, all parents/guardians were contacted via telephone and home visits were scheduled. In the meetings, the researchers presented the objective and methodology of the study and requested authorization to include the children and the family in the sample. Subsequently, the children were invited to participate and, upon acceptance, child-parent dyads were considered for inclusion in the study.

Since the final sample comprised 580 children and considering a prevalence of caries of 62% in the unexposed group (< 4 hours per day/TV), the study achieved a power of 80% to detect a risk ratio of 1.20 or greater as significant, with a 95% level of confidence.

Study logistics and data collection

Initially, the researchers contacted school officials and, with the authorization of the institutions, requested that an informative booklet be sent to the children to give to their parents/guardians. The booklet contained information about the general objective and execution of the project, as well as a detachable section with blanks for parents/guardians to indicate their interest in participating in the research and to provide their telephone number and current home address; the detachable section was to be given to the teacher in charge after completion. Subsequently, all parents/guardians were contacted by telephone and an in-person meeting at the family home was scheduled. In case of non-response during the day of data collection, another attempt was made before excluding the household/family. At the home meeting, all the children's parents/guardians were again briefed on the objectives of the study and those who agreed to participate completed the consent form. Data collection started in August (2015) and was completed in November (2016), respecting the annual school calendar, which is divided into two semesters (March-June; August-November). The protocol of this study was not published in part or in full prior to data collection.

The interviews with parents/guardians were carried out in the children's home by a team of

interviewers composed of psychology students, while the clinical examination of the children was carried out in the schools by a previously trained and calibrated graduate student in Paediatric Dentistry (UFPel). The psychology undergraduate students were trained in two stages: a) theoretical: presentation and interpretation of all items of the research questionnaire; b) practical: application of the questionnaire in the pilot study. The training included classes on psychopathology, how to conduct clinical interview, and application of the other instruments. In addition to applying the instruments during training, the students applied the instruments in the pilot study, doubts were discussed, and then we started data collection. The pilot study was carried out in two schools that were not selected for the study. Furthermore, a calibration was performed comparing the results of the examination of 15 children with those of a gold standard examiner (PhD in Paediatric Dentistry). Inter-examiner agreement with the gold standard examiner was high for dental caries (kappa test = 0.80; 95%CI: 0.69–0.86).

Non-clinical data collection

The following sociodemographic and economic variables were collected: sex (female; male), family socioeconomic status, and parents/guardians' education (in complete years). Socioeconomic status was assessed using the National Economic Indicator, which is based on the accumulation of material goods and the schooling of the head of the household.[20] Family socioeconomic status was based on cut-off points in the sample tertiles, classifying families as lower, middle, and upper socioeconomic status; in this study, families were identified as lower/middle or upper socioeconomic status. Initially, caregiver education was obtained through a question about the number of years studied during elementary and high school and during college and/or graduate school. The number of years of study completed was calculated from the sum of the values reported by the participants at each educational level. For statistical analysis purposes, educational level was dichotomized based on the cut-off point in the mean number of completed years of study of the participants (up to 11 years; 12 years or more).

Parents/guardians were asked to indicate the child's total number of hours per day of television viewing on weekdays (5/7) and weekends (2/7). According to the methodology adopted in previous studies, the weighted mean number of hours of television watching per week was calculated as follows: [(hours of television on weekdays × 5) + (hours of television on weekend days × 2)] / 7].[21] Self-report methods of quantifying screen time have been shown to have acceptable reliability and validity in children.[22] For descriptive statistics, television viewing time was dichotomized based on the cutoff point in the average number of hours of television exposure,[21] classifying the sample into children with low and with high exposure time ("low": < 4 hours per day; "high": ≥ 4 hours per day).

The BRIAN-K was used to measure the degree of difficulty maintaining the biological rhythm.[16] BRIAN-K consists of 20 items, of which 17 were added to generate a quantitative measure, with higher scores indicating greater biological rhythm disruption. The final score can also be divided into four domains: sleep, social rhythm, eating pattern, and overall activities. In the present study, only the eating pattern domain (items 14 to 17) was used. Items on the subscale assess how difficult is for the child to maintain mealtimes (breakfast, lunch, snack, and dinner), difficulty in making all meals (breakfast, lunch, snack, and dinner); difficulty to maintain the same amount of food eaten regularly, and difficulty to consume moderately stimulants (such as chocolate and cola flavored soda) or sweets. The score ranges from 0 to 3 on a Likert scale (0 = not at all; 1 = just a little; 2 = quite a bit; and 3 = very much); scores for the global BRIAN-K scale and eating pattern domain range from 0 to 51 and 0 to 12, respectively - higher scores indicating greater difficulty in maintaining a regular pattern.[16]

Clinical data collection

The children's Body Mass Index (BMI) was obtained using the World Health Organization (WHO) formula [weight (kg)/height^2 (m)]. Children were weighed barefoot, standing erect, facing the

mechanical scale, with arms stretched and feet apart. The mechanical platform scale has a precision of 0.1 grams and was placed on a flat, firm and smooth surface. Height was measured using a stadiometer attached to the scale. To do so, the children stood barefoot, with their backs to the scale, arms stretched, and feet together. Both scales were calibrated and evaluated by INMETRO (National Institute of Metrology, Standardization and Industrial Quality). All anthropometric evaluations were performed by a properly trained graduate student in a reserved room and only in the presence of the child. Body weight was classified using the intercepts of the WHO z-score percentile table, in which the columns contain BMI (kg/m^2) values and the lines contain age (years) and according to sex (boys and girls, respectively): underweight (≥ -3 and < -2), normal weight (≥ -2 and ≤ +1), overweight (≥+1 and ≤ 2), and obesity (≥ +2 and ≤ +3).[23]

Dental caries experience (outcome) was assessed using the Decayed, Missing and Filled teeth (dmft/DMFT) for the deciduous and permanent dentition, according to the WHO criteria.[24] This index measures the individual number of decayed teeth requiring filling or extraction, lost teeth that have been removed as a result of caries, and filled/restored teeth. In the oral examination, children were seated on an ordinary chair in the school and with their heads facing a source of natural light. The examiner was seated in front of them and performed the exam using gauze, mirror, and examination probe. For analyses, the variable was dichotomized as dmft/DMFT ≥ 1, if children had at least one primary or permanent decayed, missing or filled tooth, or dmft/DMFT = 0. Parents of children with the need of treatment were advised to seek dental care in the public health system and at the clinic of the School of Dentistry (UFPel).

Data analysis

Data were double-entered in EpiData® software (Version 3.1) (The EpiData Association, Odense, Denmark). Statistical analyses were performed using Stata Statistical Package (Version 14.0) (Stata Corp, College Station, USA). The database of this study is not available in any open repository, but can be accessed by request via email to the corresponding author (marilia.goettems@ufpel.edu.br), according to FAIR Data Principles (www.force11.org/group/fairgroup/fairprinciples).

Dental caries experience was the main outcome of this study. The following exposure variables were included: 'sex', 'socioeconomic status', 'parents/guardians' education', 'body weight classification', 'television exposure time' and 'BRIAN-K' (eating pattern domain). Descriptive analysis of variables was performed using absolute numbers and relative frequencies, central tendency (mean), and variability (standard deviation - SD). Chi-square test was used for the bivariate analysis of categorical variables, while the analysis of continuous variables was performed with the unequal *T*-test.

To assess the mediating effect of eating pattern on the relationship between television exposure time and presence of dental caries, the parametric *g*-formula (mediation option) was applied to estimate the total effect, the natural direct/indirect effects, and the controlled direct effect. The total effect is the difference between the potential outcome if all individuals were counterfactually exposed and unexposed. The natural direct effect is the difference between two potential outcomes: the first is the potential outcome if in the counterfactual scenario all individuals were exposed, keeping the mediators to their potential values under no exposure; the second is the potential outcome if all individuals were unexposed in the counterfactual scenario. The natural indirect effect is the difference between the total effect and the direct effect. Finally, the controlled direct effect is a comparison of the expected outcome while keeping the value of the mediators fixed (M = 0). Body weight classification (overweight) was used as a post-confounder. The Monte Carlo approach was used to estimate the effects. For a simulated hypothetical cohort, we used a sample size of 10.000, where these samples were drawn from a known probability distribution (*e.g.*, normal). The Bootstrap method was used to estimate the standard errors as well as the confidence interval of the estimated effects. For the later estimation, we used 1.000 resamples with the size of 10.000. The results of *G*-computation analysis are presented in OR, 95%CI, and standard error (SE).

Results

A total of 723 children were eligible to participate in this study. Of these, 34 (5%) did not attend school on the evaluation days and 80 (11%) parents did not consent to their children's participation. A total 596 caregivers completed the assessment and 13 (2%) were not located. Of the 596 children, 18 did not complete the oral clinical examination. Thus, 580 dyads were included in the analysis.

More than half of the sample had low/middle socioeconomic status (67%), and the majority of caregivers (85%) had up to 11 years of education. Twenty-two percent of children watched more than four hours of television per day; the mean daily screen time for the sample was 4.06 (SD 1.02) hours. The global mean score on the BRIAN-K eating pattern subscale was 2.44 (SD 2.66). The prevalence of dental caries was 63% and was associated with family socioeconomic status (p = 0.034), parents/guardians education (p = 0.005), and mean score on the BRIAN-K eating pattern domain (p = 0.050) in the bivariate analysis (Table 1).

The parametric *g*-formula analysis showed that television viewing had no direct effect on the presence of dental caries [OR_{ICE}: 1.05 (95%CI: 0.92–1.19); p = 0.484]. Nevertheless, the difficulty in maintaining a regular eating pattern mediated the natural indirect effect of television exposure time (≥ 4 hours/day) on dental caries experience [OR_{NIE}: 1.07 (95CI%: 1.01–1.14); p = 0.022] (Table 2) (Figure).

Discussion

The relationship between television viewing and dental caries has not been sufficiently investigated in the literature. In particular, the effect of a non-regular eating pattern on this relationship is still unclear.

Table 1. Sample distribution according to presence of dental caries in schoolchildren (n = 580).

Variables	Total sample	dmft/DMFT = 0	dmft/DMFT ≥1	*p*-value
Sex – n (%)				
Female	284 (48.97)	105 (36.97)	179 (63.03)	0.962*
Male	296 (51.03)	110 (37.16)	186 (62.84)	
Socioeconomic status – n (%)				
Lower/intermediate	379 (66.73)	128 (33.77)	251 (66.23)	**0.034***
Upper	189 (33.27)	81 (42.86)	108 (57.14)	
Parents/guardians education - n (%)				
Up to 11 years	478 (84.75)	164 (34.31)	314 (65.69)	**0.005***
12 years or more	86 (15.25)	43 (50.00)	43 (50.00)	
Body weight classification – n (%)				
Normal weight	315 (54.78)	111 (35.24)	204 (64.76)	
Overweight	121 (21.04)	46 (38.02)	75 (61.98)	0.572*
Obese	139 (24.17)	56 (40.29)	83 (59.71)	
Television exposure time – n (%)				
<4 hours per day	437 (77.76)	164 (37.53)	273 (62.47)	0.422*
≥4 hours per day	125 (22.24)	42 (33.60)	83 (66.40)	
BRIAN-K – mean (SD)				
Eating pattern	2.44 (2.66)	2.16 (2.44)	2.61 (2.79)	**0.050****
Total	580 (100)	215 (37.07)	365 (62.93)	

Note: *Chi-square test; **unequal T-test; SD: standard deviation.

Table 2. G-computation analysis of the eating pattern domain (BRIAN-K) as mediator in the association between television exposure and dental caries (n = 580).

Exposure-mediator-outcome	G-computation Estimate		Bootstrap (SE)	p-value
	(OR)	95% CI		
TCE	1.05	0.92, 1.19	0.0666084	0.484
NDE	0.98	0.85, 1.12	0.0696435	0.750
NIE	1.07	1.01, 1.14	0.0301322	0.022
CDE	0.96	0.90, 1.20	0.0717883	0.599

Note: TCE: total causal effect; NDE: natural direct effect; CDE: controlled direct effect; NIE: natural indirect effect; SE: standard error; OR: odds ratio; 95% CI: 95% confidence interval.

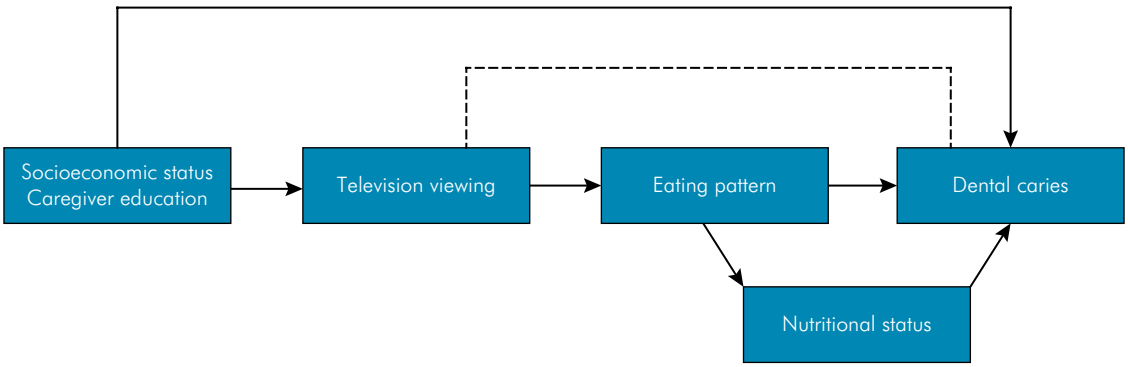

Figure. Mediation analysis model with total causal effect and natural indirect effect. Pelotas, RS, Brazil (n = 580).

Thus, the present study investigated the mediating effect of eating pattern on the relationship between television exposure time and the presence of dental caries in children using the *g*-formula. For the best of our knowledge, this is the first study investigating this relationship using the g-formula. This analytical approach is of relevance for studying the effects of exposures that cannot be allocated in randomized clinical trials for ethical reasons. The use of the parametric g-formula allowed us to test the association between television viewing and dental caries using a counterfactual approach. This statistical method uses models for the outcome and the mediator, which produces more efficient estimates (with narrower confidence intervals) than the weighting approaches that use models for the mediator and/or the exposure.[25]

In general, our results confirm that aspects of children's eating pattern, such as difficulty maintaining or taking all meals, difficulty maintaining the same amount of food eaten regularly, and difficulty consuming moderately stimulating foods or sweets, may mediate the relationship between television exposure time and caries experience. Thus, we understand that the effect of the difficulty in maintaining the eating pattern does not correspond only to the ingestion of foods potentially related to dental caries, but also to the absence of a healthy eating routine, such as eating schedules (frequency of ingestion) and quantity and quality of the foods consumed. Unfortunately, the comparison of our findings is strongly limited by the absence of similar studies; however, additional information related to food consumption during television viewing and dental caries may provide interesting insights into this relationship.

One systematic review examined the associations between television viewing during a meal or snack and the quality of children's diet and showed that eating whilst watching television reduces diet quality and increases consumption of high-fat, high-sugar foods and sugar-sweetened beverages

and decreases intake of fruits and vegetables.[9] Also, a cross-sectional study with more than 10,000 children aged 6–9 years from five European countries shows that each additional hour of screen time was associated with increased consumption of high-fat/high-sugar foods including sugar-sweetened drinks, candy bars or chocolate, and pizza, chips or hamburgers and decreased consumption of vegetables and fresh fruits.[21] In this context, the uncontrolled intake of these foods during television viewing may justify the absence of a healthy eating pattern, as snack consumption was associated with an increased odds ratio of meal skipping in children.[25] Therefore, we hypothesized that the eating pattern resulting from the difficulty in maintaining a healthy eating routine associated with the frequent consumption of potentially cariogenic foods during television viewing predisposes children to experience caries. It is recommended that interventions be directed at parents to limit screen time, particularly whilst eating, and to encourage family meals without television. Special attention must be paid to children from lower socioeconomic backgrounds,[9] considering that they are exposed to more risk factors than children from higher socioeconomic conditions.[26] Policymakers should consider the effects that sedentary habits may have on lifelong eating habits.

In the literature, the relationship between skipping meals or snacking out of meal time and the consumptions of refined carbohydrate or sugar has been already established. Bonotto et al.[27] showed that limiting snacks is a protection factor against untreated dental caries. It is clear that the availability of snacks leads to the establishment of inadequate eating patterns and good dietary habits promotes oral health.[28] Thus, raising the awareness of parents/caregiver about good habits such as eating breakfast daily and limiting snacks between meals could be important.

Among the various types of screens, television is the most popular form of media used by young children,[29] due to easy access, and by low-income populations.[30] The most relevant sedentary behavior, in terms of the effect on food and beverage consumption, is television watching.[31] Thus, the present study investigated only the association with television. However, further studies could investigate the association with other media, including cell phones, which are becoming more easily available. Also in this context, international associations recommend that the use of screen-based devices by children under 18 months should be avoided, except for video chatting, whereas in children aged 2-5 years, the use of screen-based devices should be limited to 1 h/day of quality programming. For children/youth aged 5-12 years, it is recommended that recreational sedentary screen time be limited to no more than 2 hours per day.[32,33] In this study, children aged 7-8 years were exposed to a mean screen time of 4.06 hours per day. This value is double the sedentary time specified in international recommendations for this age group and contrasts with other investigations that observed a lower average screen time in samples of Brazilian, Portuguese, and North American children.[34,35] These data largely argue for policies to limit abusive screen use by children, because there is evidence of health harms in a wide range of health domains that go far beyond the oral aspects, but also the impact of this behavior on physical and biopsychosocial dimensions.[36]

A recent systematic review investigated the content of television advertising during children's viewing time, focusing on the number of cariogenic food advertisements, and confirmed that the most frequently advertised foods during children's programming are foods that are potentially harmful to dental health, with a large amount of hidden sugars.[37] Following the trend of more specific regulation of food advertising in Brazil, the National Health Surveillance Agency published in June 2010 the Resolution RDC nº. 24, which requires that the advertisement for foods high in sugar, fat, and sodium, as well as for nutrient-poor beverages, include warnings about the possible health risks in the case of over-consumption. For now, this resolution is suspended. Nowadays, there is no law in Brazil that regulates the advice on cariogenic foods. It seems that policy-makers need to review and revise regulations on child-targeted food advertisements to promote health habits, especially those that support healthier eating patterns.

Socioeconomic factors were associated with dental caries, which confirmed in our hypothesis. It is known that parental educational background frequently determines income, which affect access to personal or professional preventive means such as toothpaste, dental floss, low calorie, sugar-reduced diets, and dental treatments.[38] Besides, educational background can also affect other characteristics such as health behavior, including dietary and tooth brushing habits, or health service utilization frequency.[39] Of note, differences were confirmed despite the fact that all children were attending public schools.

This study has some strengths that should be highlighted. First, the results presented fill an under-explored gap in the literature and reinforce that television viewing may play an indirect role in the progression of dental caries. This makes the harmful effects of excessive television viewing on general and oral health particularly clear. The number of sampling points of this study ensured external variability, making it representative of the public-school population of Pelotas, RS, Brazil. Furthermore, according to the local education authority, all children in urban areas are enrolled in the schools included in the process of sample randomization. The internal validity of the study was ensured, as the dentist was trained and calibrated and interviewers were previously trained.

Some limitations of this study should be considered when interpreting the results. The exclusion of private schools limits the reproducibility and comparison of the findings to only children from public schools. Despite our large population sample, some of the associations tested could have been affected by lack of statistical power. The cross-sectional design of the study does not allow the inference of causality between exposures and outcome variables. The use of data self-reported by parents/guardians can also be listed as a limitation of the study as it may lead to social causality bias in the perception and reporting of aspects related to the children's behaviors and biological rhythm. The frequency (*i.e.*, number of times per day and duration of television exposure) and type of food/beverages (*i.e.*, natural foods or ultra-processed foods) consumed by children while watching television could help understand the association between these variables and dental caries, but unfortunately this information was not collected in this investigation. Therefore, further longitudinal investigations using recognized methods to assess diet, exposure to TV or screen devices, and the overall spectrum of dental caries in representative samples of this population should be conducted.

Conclusion

The results of this study confirm the indirect pathway between television viewing and dental caries in children and the role of eating pattern disruption in this association. These findings are useful in supporting the behavioral and dietary guidelines provided by dentists to parents and children during clinical care and to guide new integrated health care policies for this population.

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References

1. Pitts NB, Twetman S, Fisher J, Marsh PD. Understanding dental caries as a non-communicable disease. Br Dent J. 2021 Dec;231(12):749-53. https://doi.org/10.1038/s41415-021-3775-4
2. Kazeminia M, Abdi A, Shohaimi S, Jalali R, Vaisi-Raygani A, Salari N, et al. Dental caries in primary and permanent teeth in children's worldwide, 1995 to 2019: a systematic review and meta-analysis. Head Face Med 2020; 16: 22. 20201006. https://doi.org/10.1186/s13005-020-00237-z

3. Fernandez MDS, Pauli LA, Costa VPP, Azevedo MS, Goettems ML, et al. Dental caries severity and oral health-related quality-of-life in Brazilian preschool children. Eur J Oral Sci 2022; 130: e12836. 20211205. https://doi.org/10.1111/eos.12836
4. Selwitz RH, Ismail AI, Pitts NB. Dental caries. Lancet. 2007 Jan;369(9555):51-9. https://doi.org/10.1016/S0140-6736(07)60031-2
5. Shqair AQ, Motta JVS, Silva RA, Amaral PL, Goettems ML. Children's eating behaviour traits and dental caries. J Public Health Dent. 2021 Mar;2021: https://doi.org/10.1111/jphd.12449
6. Tinanoff N. Dental caries. In: Nowak AJ, Christensen JR, Mabry TR, et al., editors. Pediatric dentistry. 6th ed. Philadelphia: Elsevier; 2019. p. 169-79.
7. Cascaes AM, Silva NRJ, Fernandez MDS, Bomfim RA, Vaz JS. Ultra-processed food consumption and dental caries in children and adolescents: a systematic review and meta-analysis. Br J Nutr 2022: 1-10. 20220727. . https://doi.org/10.1017/S0007114522002409
8. Bellissimo N, Pencharz PB, Thomas SG, Anderson GH. Effect of television viewing at mealtime on food intake after a glucose preload in boys. Pediatr Res. 2007 Jun;61(6):745-9. https://doi.org/10.1203/pdr.0b013e3180536591
9. Avery A, Anderson C. McCullough F. Associations between children's diet quality and watching television during meal or snack consumption: a systematic review. Matern Child Nutr. 2017 Oct;13(4):e12428. https://doi.org/10.1111/mcn.12428
10. Zhang G, Wu L, Zhou L, Lu W, Mao C. Television watching and risk of childhood obesity: a meta-analysis. Eur J Public Health. 2016 Feb;26(1):13-8. https://doi.org/10.1093/eurpub/ckv213
11. Ghimire N, Rao A. Comparative evaluation of the influence of television advertisements on children and caries prevalence. Glob Health Action 2013;6. https://doi.org/10.3402/gha.v6i0.20066
12. LaCaille L. Eating behavior. In: Gellman MD, Turner JR, editors. Encyclopedia of behavioral medicine. New York: Springer; 2013. p. 641-2.
13. Stein C, Cunha-Cruz J, Hugo FN. Is dietary pattern a mediator of the relationship between socioeconomic status and dental caries? Clin Oral Investig. 2021 Sep;25(9):5441-7. https://doi.org/10.1007/s00784-021-03852-5
14. Seckold R, Howley P, King BR,Bell K, Smith A, Smart CE. Dietary intake and eating patterns of young children with type 1 diabetes achieving glycemic targets. BMJ Open Diabetes Res Care 2019 June;7(1):e000663. https://doi.org/10.1136/bmjdrc-2019-000663
15. Potter GD, Cade JE, Grant PJ, Hardie LJ. Nutrition and the circadian system. Br J Nutr 2016 Aug;116(3):434-42. 20160525. https://doi.org/10.1017/S0007114516002117
16. Berny T, Jansen K, Cardoso TA, Mondin TC, Silva RA, Souza LD, et al. Construction of a biological rhythm assessment scale for children. Trends Psychiatry Psychother. 2018 Mar;40(1):53-60. https://doi.org/10.1590/2237-6089-2017-0081
17. Silva RNMT, Duarte DA, Oliveira AM, Silva RNMT. The influence of television on the food habits of schoolchildren and its association with dental caries. Clin Exp Dent Res. 2019 Sep;2020(6):24-32. https://doi.org/10.1002/cre2.244
18. Shqair AQ, Pauli LA, Costa VP, Cenci M, Goettems ML. Screen time, dietary patterns and intake of potentially cariogenic food in children: a systematic review. J Dent. 2019 Jul;86:17-26. https://doi.org/10.1016/j.jdent.2019.06.004
19. Wang A, Arah OA. G-computation demonstration in causal mediation analysis. Eur J Epidemiol 2015;30 1119-27. https://doi.org/10.1007/s10654-015-0100-z
20. Barros AJD, Victora CG. A nationwide wealth score based on. Rev Saúde P[ública. 2005 Aug;39(4). https://doi.org/10.1590/S0034-89102005000400002
21. Börnhorst C, Wijnhoven TM, Kunešová M, Yngve A, Rito AI, Lissner L, et al. Obesity surveillance initiative: associations between sleep duration, screen time and food consumption frequencies. BMC Public Health. 2015 Apr;15(1):442. https://doi.org/10.1186/s12889-015-1793-3
22. Lubans DR, Hesketh K, Cliff DP, Barnett LM, Salmon J, Dollman J, et al. A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. Obes Rev. 2011 Oct;12(10):781-99. https://doi.org/10.1111/j.1467-789X.2011.00896.x
23. World Health Organization. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. Geneva: World Health Organization; 2006.
24. World Health Organization. Oral health surveys: basic methods. 5th ed ed. Geneva: World Health Organization, 2013.
25. Tchetgen EJ, Shpitser I. Semiparametric theory for causal mediation analysis: efficiency bounds, multiple robustness, and sensitivity analysis. Ann Stat. 2012 Jun;40(3):1816-45. https://doi.org/10.1214/12-AOS990
26. Bae JH, Obounou BW. Presence of dental caries is associated with food insecurity and frequency of breakfast consumption in Korean children and adolescents. Prev Nutr Food Sci. 2018 Jun;23(2):94-101. https://doi.org/10.3746/pnf.2018.23.2.94
27. Bonotto DV, Montes GR, Ferreira FM, Assunção LR, Fraiz FC. Association of parental attitudes at mealtime and snack limits with the prevalence of untreated dental caries among preschool children. Appetite. 2017 Jan;108(108):450-5. https://doi.org/10.1016/j.appet.2016.11.007
28. Sujlana A, Pannu PK. Family related factors associated with caries prevalence in the primary dentition of five-year-old children. J Indian Soc Pedod Prev Dent. 2015;33(2):83-7. https://doi.org/10.4103/0970-4388.155108

29. Vandewater EA, Rideout VJ, Wartella EA, Huang X, Lee JH, Shim MS. Digital childhood: electronic media and technology use among infants, toddlers, and preschoolers. Pediatrics. 2007 May;119(5):e1006-15. https://doi.org/10.1542/peds.2006-1804
30. Miguel-Berges ML, Santaliestra-Pasias AM, Mouratidou T, Androutsos O, Craemer M, Pinket AS, et al. Associations between food and beverage consumption and different types of sedentary behaviours in European preschoolers: the ToyBox-study. Eur J Nutr. 2017 Aug;56(5):1939-51. https://doi.org/10.1007/s00394-016-1236-7
31. Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act. 2011 Sep;8(1):98. https://doi.org/10.1186/1479-5868-8-98
32. American Academy of Pediatrics. Committee on Public Education. Children, adolescents, and television. Pediatrics. 2001 Feb;107(2):423-6. https://doi.org/10.1542/peds.107.2.423
33. Reid Chassiakos YL, Radesky J, Christakis D, Moreno MA, Cross C, Hill D, et al. Children and adolescents and digital media. Pediatrics. 2016 Nov;138(5):e20162593. https://doi.org/10.1542/peds.2016-2593
34. Walsh JJ, Barnes JD, Cameron JD, Goldfield GS, Chaput J-P, Gunnell KE, et al. Associations between 24 hour movement behaviours and global cognition in US children: a cross-sectional observational study. Lancet Child Adolesc Health 2018 Nov;2(11):783-91. https://doi.org/10.1016/S2352-4642(18)30278-5
35. Santos A, Silva-Santos S, Andaki A, Mendes EL. Screen time between Portuguese and Brazilian children: a cross-cultural study. Motriz: Rev Educação Física. 2017;23(2). https://doi.org/10.1590/s1980-6574201700020006
36. Janssen X, Martin A, Hughes AR, Hill CM, Kotronoulas G, Hesketh KR. Associations of screen time, sedentary time and physical activity with sleep in under 5s: a systematic review and meta-analysis. Sleep Med Rev 2020; 49: 101226. 20191101. https://doi.org/10.1016/j.smrv.2019.101226
37. Pournaghi Azar F, Mamizadeh M, Nikniaz Z, Ghojazadeh M, Hajebrahimi S, Salehnia F, et al. Content analysis of advertisements related to oral health in children: a systematic review and meta-analysis. Public Health. 2018 Mar;156(156):109-16. https://doi.org/10.1016/j.puhe.2017.12.012
38. Schwendicke F, Dörfer CE, Schlattmann P, Foster Page L, Thomson WM, Paris S. Socioeconomic inequality and caries: a systematic review and meta-analysis. J Dent Res. 2015 Jan;94(1):10-8. https://doi.org/10.1177/0022034514557546
39. Costa VP, Goettems ML, Oliveira LJ, Tarquinio SB, Torriani DD, Correa MB, et al. Nonuse of dental service by schoolchildren in Southern Brazil: impact of socioeconomics, behavioral and clinical factors. Int J Public Health. 2015 May;60(4):411-6. https://doi.org/10.1007/s00038-015-0670-2