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Dietary and oral hygiene patterns as risk factors for oral health in a Brazilian city without water fluoridation system

Padrões de dieta e higiene bucal como fatores de risco para saúde bucal em uma cidade brasileira sem sistema de fluoretação de águas

Patrones dietéticos y de higiene bucal como factores de riesgo para la salud bucal en una ciudad brasileña sin sistema de fluoración de agua

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Abstract
The objective was to investigate dietary and oral hygiene patterns as risk factors for dental caries, fluorosis and tooth erosion in a subsample of individuals of a population-based study in the city of João Pessoa (without water fluoridation program), Brazil. In this cross-sectional study data were collected through clinical examinations and questionnaires addressing dietary and oral hygiene habits. The clinical examination was performed by two calibrated examiners (Kappa > 0.80). The sample (n = 244) was distributed among four age groups: G1 (0-13 years), G2 (14-30 years), G3 (31-54 years) and G4 (≥ 55 years). The prevalence of dental caries was high (87.4%) whereas fluorosis and erosion was low (4.1% and 6.1%, respectively). The mean DMFT index was 1.49 ± 2.19 in G1, 8.19 ± 6.10 in G2, 18.19 ± 7.00 in G3 and 25.81 ± 6.80 in G4. Significant associations were found between the DMFT index and both diet (p = 0.05) and income (p = 0.022), suggesting an associated effect of these variables. Oral hygiene was not related to dental caries experience. Cariogenic diet was related to the high DMFT index in all age groups supporting that dietary pattern was a stronger risk factor for caries experience in contrast to oral hygiene habits that no association was found.
Keywords: Diet; Dental caries; Tooth erosion; Fluorosis, Dental.

Resumo
O objetivo foi identificar padrões alimentares e hábitos de higiene bucal como variáveis de risco à cárie, fluorose e erosão dentária em uma subamostra de indivíduos incluídos em um estudo de base populacional na cidade de João Pessoa (sem fluoretação de águas), PB, Brasil. Neste estudo seccional foram realizados exames clínicos e aplicados questionários sobre dieta e hábitos de higiene bucal. O exame clínico foi realizado por dois examinadores previamente calibrados (kappa > 0,80). A amostra (n = 244) foi distribuída em 4 grupos etários: G1 (0-13 anos), G2 (14-30 anos), G3 (31-54 anos) e G4 (mais de 55 anos). A prevalência de cárie dentária foi alta (87,4%), CPOD médio para os grupos etários foi 1,49 ± 2,19 no G1, 8,19 ± 6,10 no G2, 18,19 ± 7,00 no G3 e 25,81 ± 6,80 no G4. Foi encontrada

baixa prevalência de fluorose dentária (4,1%) e erosão dentária (6,1%). Houve relação significativa entre CPOD com dieta (p = 0,05) e renda (p = 0,022) sugerindo associação entre essas variáveis. O padrão alimentar cariogênico dessa população foi relacionado ao elevado índice CPOD para todos os grupos etários indicando o padrão de dieta como fator de risco mais importante para experiencia de cárie que higiene bucal.
Palavras-chave: Dieta; Cárie dentária; Erosão dentária; Fluorose dentária.

Resumen
El objetivo fue investigar patrones dietéticos y de higiene oral como factores de riesgo para caries dental, fluorosis y erosión dental en una submuestra de individuos de un estudio de base poblacional en la ciudad de João Pessoa (sin programa de fluoración de agua), Brasil. En este estudio transversal, los datos se recopilaron a través de exámenes clínicos y cuestionarios sobre hábitos alimentarios y de higiene bucal. El examen clínico fue realizado por dos examinadores calibrados (Kappa > 0,80). La muestra (n = 244) se distribuyó en cuatro grupos de edad: G1 (0-13 años), G2 (14-30 años), G3 (31-54 años) y G4 (≥ 55 años). La prevalencia de caries dental fue alta (87,4%) mientras que la fluorosis y la erosión fueron bajas (4,1% y 6,1%, respectivamente). El índice CPOD medio fue de 1,49 ± 2,19 en G1, 8,19 ± 6,10 en G2, 18,19 ± 7,00 en G3 y 25,81 ± 6,80 en G4. Se encontraron asociaciones significativas entre el índice CPOD y la dieta (p = 0,05) y los ingresos (p = 0,022), lo que sugiere un efecto asociado de estas variables. La higiene bucal no se relacionó con la experiencia de caries dental. La dieta cariogénica se relacionó con el alto índice de CPOD en todos los grupos de edad, lo que respalda que el patrón dietético fue un factor de riesgo más fuerte para la experiencia de caries en contraste con los hábitos de higiene bucal que no encontraron asociación.
Palabras clave: Dieta; Caries dental; Erosión de los dientes; Fluorosis dental.

1. Introduction

Diet is known to be one of the most important etiological factors for the establishment of dental caries. The high quantity and/or daily frequency of sugar intake is related to more risk of caries and severity of caries lesions (Sheiham & James, 2015; Feldens et al., 2019; Loveren, 2019). However, few studies have been developed in Brazil to assess the cariogenicity of the Brazilian diet.

Individual factors are also important to the incidence and establishment of dental caries, such as the physicochemical properties of saliva, microbiota, oral hygiene and the availability of fluoride in the oral cavity (Featherstone, 2008; Pyati et al., 2018). The latter factor is an important modulator of dental caries, but the control of dental biofilm and exposure to sugar remains the priority with regard to controlling the disease (Delbem & Pessan, 2019).

Unlike caries, diet can promote the loss of minerals in teeth without the interference of bacteria. Tooth erosion is the result of a chemical process in which the teeth are exposed to acids of either an intrinsic (gastric) or extrinsic (dietary) nature, leading to the progressive, irreversible loss of the hard surface tissue (Schlueter & Luka, 2018; Buzalaf et al., 2018). Lifestyle, occupation and salivary properties as well as the frequency and form of the consumption of potentially erosive foods and beverages are important aspects to the development of tooth erosion (Mangueira et al., 2009; Carvalho & Lussi, 2020).

A study involving 983 schoolchildren aged six to 12 years in the city of João Pessoa (northeastern Brazil) found a 19.9% prevalence rate of dental erosion in the sample (Mangueira et al., 2009). However, no in-depth study has been conducted on this condition in the general population of the city.

Dental fluorosis is the main side effect of the use of fluoride and is the result of exposure of the tooth germ (tooth in the process of formation) to high concentrations of the fluoride ion, leading to defects of the enamel resulting from hypoplasia or hypomineralization (O'Mullane et al., 2016). Despite advances in the rational use of fluoride, discussions on the effectiveness and safety of fluoride are raised at presentations and conferences (Sampaio & Levy, 2011). A high concentration of fluoride in the water supply is an important factor related to the development of dental fluorosis. A study conducted in communities in the countryside of the state of Paraíba, Brazil, found fluoride content above the acceptable limit (Sampaio et al., 2000). Moreover, in the state capital of João Pessoa, which has no fluoridated water supply, a moderate prevalence rate of fluorosis (30%) was found (Carvalho et al., 2007).

A large number of studies have been conducted in Brazil to determine the prevalence of oral problems (Saintrain et

al., 2015). However, methodological differences limit the follow up of oral problems over time (Freitas et al., 2013). Moreover, few studies have addressed dietary habits associated with oral health in Brazil and fewer still have been conducted in the northeastern region of the country. When considering dental caries and its multifactor etiology, population-based studies should seek to unite social, individual and biological elements (Frazão, 2012; Bueno et al., 2014).

The aim of the present study was to investigate dietary and oral hygiene patterns as risk factors for dental caries, fluorosis and tooth erosion in a subsample of individuals of a population-based study in the city of João Pessoa (without water fluoridation program), Brazil (Lima et al., 2015).

2. Methodology

Ethical considerations

This study received approval from the Human Research Ethics Committee of the Federal University of Paraíba (certificate number: 0493). All volunteers received clarifications regarding the objectives and procedures of the study and agreed to participate by signing a statement of informed consent.

Study design

A cross-sectional, observational epidemiological survey was conducted in the city of João Pessoa (state of Paraíba, Brazil), a city without water fluoridation system (Pereira, 2018). Sampling was performed in the five administration districts established by the Municipal Secretary of Health. The residences that participated in the study were randomly selected from within each neighborhood. Therefore, this was a population-based study representative of the population of the city.

This study was part of a project entitled "First diagnosis and intervention of food and nutritional situation and non-communicable diseases most prevalent in the population of João Pessoa, northeastern Brazil", in which data were collected using a food frequency questionnaire (FFQ), adapted to the target population in a pilot study conducted for its validation (Lima et al., 2015). For such, interviews were held with participants in a subsample representing approximately 25% of the total sample. The FFQ was used to evaluate the occurrence of cariogenic and potentially erosive foods. Another questionnaire was administered addressing oral hygiene habits and the water pattern used by the general population, after which the clinical examinations were performed.

Participants

Using the Core R software, 1 165 individuals were selected for the administration of the dietary questionnaires19 and 1 015 questionnaires on oral health habits were obtained (Lima et al., 2015). Among the individuals interviewed, a subsample of homes representative of each administration district was randomly selected for the clinical dental examinations; 364 examination charts were obtained. The data were then cross-checked to form a single databank with all information collected on each patient, resulting in a final sample of 244 participants.

Questionnaires

The FFQ was used to collect data on food consumption. The number of times a food item was consumed in a unit of time (day, week, month or year) and portion size of each item were recorded. Another questionnaire was administered addressing water consumption and oral hygiene habits. The origin of the water consumed, frequency and quantity of water consumed, tooth brushing frequency, amount and brand of toothpaste used, the frequency and amount of mouthwash used and the use of dental floss were recorded.

Clinical exams

The clinical examinations were performed at the participants' homes by two examiners who had undergone training and calibration exercises for the diagnosis of dental caries, fluorosis and tooth erosion (Kappa > 0.80). All participants brushed their teeth prior to the examination to facilitate the diagnosis. The examinations were performed under natural light with the aid of a mouth mirror. The examiner wore individual protective equipment and followed biosafety procedures.

In the clinical examination, the number of decayed, missing and filled teeth was observed to determine the DMFT index. For dental erosion and fluorosis, only the presence or absence of these conditions in each tooth was observed.

The data were recorded on the individual charts by an annotator. In cases of treatment need, the participant was sent to the Dentistry Sector of the hospital of the Federal University of Paraíba.

Statistical analysis

The data were entered into the SPSS 17.0 program. Three different databanks were created – one for each questionnaire. The first databank was for eating patterns. The second was for water consumption and oral hygiene habits. The third was for the results of the clinical examinations. Numeric variables were expressed as mean and standard deviation (SD). Ordinal variables were coded and expressed as frequencies. For the statistical inferences, the variables were dichotomized for the chi-square test or Fisher's exact test, as appropriate. Inferential statistics for the means of the numeric variables were performed using either parametric (Student's t-test and ANOVA) or nonparametric (Mann-Whitney U and Wilcoxon) tests, as appropriate. The Kolmogorov-Smirnov was used to determine the normality of the data distribution. The Excel, SPSS and GraphPad statistical programs were used, with the level of significance set at 5% ($p < 0.05$).

3. Results

Table 1 displays data for the characterization of the sample (n = 244) in terms of age, income and DMFT index in the five administration districts of the city. Only 12.6% of the sample had DMFT = 0. The mean DMFT was 14.69 (SD: 10.7) (Table 2).

Table 1. Demographic data of the sample (n = 244): mean (SD) age, income and DMFT index distributed among the five administration districts of the city.

District	n (%)	Age (years) Mean (SD)	Income (R$) Mean (SD)	DMFT Mean (SD)
1	73 (29.9)	32.34 (23.8) [a]	1 251.48 (1533.0) [a]	14.56 (10.8) [a]
2	67 (27.5)	37.66 (25.5) [a]	1 946.46 (2406.4) [a]	15.22 (10.6) [a]
3	35 (14.3)	26.83 (20.8) [a]	1 201.91 (1199.7) [a]	12.59 (9.4) [a]
4	27 (11.1)	38.74 (29.2) [a]	1 243.56 (1218.0) [a]	15.84 (11.70) [a]
5	42 (17.2)	23.550 (34.4) [a]	2 358.51 (1796.5) [b]	11.57 (14.5) [a]
T	-	0.19	0.0001	0.81

*ANOVA with Tukey's post hoc test. Different letters denote statistically significant differences in values in the same column ($p < 0.05$). Source: Authors.

Table 2. Comparison* of mean (SD) DMFT index and components distributed among age groups.

Age groups (years)	n	DMFT Mean (SD)	Decayed Mean (SD)	Missing Mean (SD)	Filled Mean (SD)
G1 (0 – 13)	63	1.49 (2.19) [a]	0.62 (1.48) [a.c]	0.35 (0.88) [a]	0.76 (1.68) [a]
G2 (14 – 30)	59	8.19 (6.10) [b]	0.92 (2.07) [a.c]	1.34 (2.12) a	5.41 (4.88) [b]
G3 (31 – 54)	59	18.19 (7.00) [c]	1.36 (2.86) [a.b]	8.85 (8.26) b	6.90 (5.43) [b]
G4 (55+)	58	25.81 (6.80) [d]	0.45 (1.14) [c]	23.17 (9.41) [c]	1.64 (3.00) [a]
Total	239[**]	14.69 (10.7)	1.14 (2.00)	8.23 (11.04)	3.64 (4.74)

*ANOVA with Tukey's post hoc test. Different letters denote statistically significant differences in values in the same column ($p < 0.05$).
* Five files with no identification of age. Source: Authors.

The dietary pattern revealed that 50.4% of the sample (n = 123) consumed milk with sugar and 61.1% (n = 149) added sugar to coffee. Cakes, torts, ice cream, homemade jams and sugary soft drinks were consumed regularly by 86.9% (n = 217), 75.4% (n = 184), 45.1% (n = 110) and 85.7% (n = 209), respectively. Considering the regular consumption of all these items as indicative of a cariogenic diet, the data reveal that 26% of the sample were at risk of developing caries as a result of eating patterns.

The prevalence of tooth erosion and fluorosis was low, affecting only 6.1% (n = 15) and 4.1% (n = 10) of the sample, respectively. A total of 86.6% (n = 13) of the individuals with tooth erosion reported consuming carbonated soft drinks and citric juices.

Regarding oral hygiene habits, 82.8% (n = 202) of the interviewees reported brushing their teeth before going to sleep, 66% (n = 160) brushed after meals and 41.4% (n = 101) reported brushing three times a day. No association was found between oral hygiene habits and income ($p > 0.05$). Regarding the water consumption pattern, 69.3% (n = 169) consumed tap water, 25% (n = 61) consumed bottled water and 3% (n = 7) reported other sources (wells).

In the linear regression model, income ($p = 0.022$) and a cariogenic diet ($p = 0.050$) were the only variables with a significant predictive value for the DMFT index (Table 3).

Table 3. Linear regression using DMFT index as the dependent variable.

Factor	Beta	t	p-value	Confidence interval
(Constant)	-	6.977	0.000	12.966 to 23.182
District	-0.066	-0.923	0.357	-1.526 to 0.553
Income[*]	0.165	2.307	0.022	0.000 to 0.002
Brushing frequency	-0.100	-1.454	0.141	-2.277 to 0.344
Cariogenic diet[*]	-0.132	-1.907	0.050	-6.533 to 0.109

*Significant variables for the regression model. R = 0.242 and adjusted R2 = 0.09. Linear regression, Enter model. Source: Authors.

4. Discussion

The high prevalence of dental caries and high DMFT indices in the sample may be explained by the cariogenic

components of the diet, as a positive association was found these two variables. This finding underscores the need for awareness campaigns to alert the population with regard to the harm of certain dietary practices. Considering dental caries a progressive and cumulative disease, policies addressing oral health promotion and the use of fluoride as instruments for combating caries may not be enough if the underlying cause (dietary sugar) is not controlled (Moyniham, 2016). This is particular true in Latin American where a high production and consumption of sugar has been observed in many countries of the region (Sampaio et al., 2021).

Other studies in Northeast Brazil have also identified groups characterized by a cariogenic diet and a positive correlation with the prevalence of caries lesions, although these have only evaluated children and adolescents, reinforcing the importance of oral health education and policies to reduce sugar consumption in Brazil (Felix et al., 2021; Oliveira et al., 2022).

Sheiham and James (2015) reported that the association between sugar intake and dental caries and the effect of lifelong use of fluorides has been investigated little in adults when one considers that this disease has a cumulative effect, as the teeth are submitted to innumerous cariogenic challenges over the years, consequently, a higher DMFT in this age group is an expected outcome.

Oral health education and sugar reduction policies in foods are important strategies for the prevention of oral diseases, which would have a long-term impact on this scenario. Such strategies may reflect, for example, a reduction in the rate of missing teeth, as it is mostly a result of the evolution of dental caries or periodontal disease (Moyniham, 2016; Manji et al., 2018; Sampaio et al., 2021).

The number of missing teeth was the largest contributor to the DMFT index among older adults, which is in agreement with previous studies. Peres et al. (2013) compared the findings of epidemiological oral health surveys conducted in Brazil and found that no decline had occurred in the number of missing teeth among older adults in the country.

An association was found between the DMFT index and income variable. Indeed, income is considered an important factor for the outcome of caries. In previous studies, Bueno et al. (2014), performed an ecological study and found an association between social determinants and oral health in adults living in Brazilian capitals, and Schwendicke et al. (2015), in their systematic review, shows a higher risk of caries associated with social inequalities, such as lower education, occupational level and lower income (Schwendicke et al., 2015).

The low prevalence of tooth erosion may be due to the number of edentulous individuals who participated in the study or may be due to under-reporting, since no index sensitive to this condition was employed. The low prevalence of fluorosis may be explained by the broad age range, as teeth become worn over time and small or surface signs of fluorosis may disappear. The number of edentulous individuals in the sample may also have exerted an influence on this result.

The data on water consumption suggest that the few cases of fluorosis may be associated with another source of fluoride, such as fluoridated toothpaste. In the literature, a significant association has been found between the risk of fluorosis and the frequency of brushing and the type of toothpaste used by children (Nascimento et al., 2013).

The finding that 70% of the study population consumes tap water underscores the importance of fluoridating the water supply. It is noteworthy that, although the Brazilian National Oral Health Policy supports access to fluoride in the drinking water, the municipality in question does not have fluoridation program. In a city with characterized by a high DMFT in many age groups and potentially cariogenic diet, a great impact on the quality of oral health of this population is expected if a water fluoridation is implemented (Ministério da Saúde do Brasil, 2004).

With regard to oral hygiene practices, standard responses (brushing three times a day) were found in all age groups, but this variable was not associated with the outcome (caries). This may be an example of responding without a direct link to actual behavior. In other words, the interviewee may, out of embarrassment or fear, respond that he/she brushes three times a

day although this may not actually be true.

Food inquiries for the determination of eating patterns have some limitations due to the use of reported data. In an attempt to minimize this limitation, images with size portions of foods were used with the FFQ.

Cross-sectional epidemiological surveys should always be analyzed with caution, since dental caries, fluorosis and tooth erosion are conditions with a chronic evolution that respectively require frequent consistent exposure to sugar, fluoride and acidic substances. Therefore, longitudinal studies are more indicated for the determination of the association between diet and oral conditions. Nonetheless, this study demonstrated the importance of diet and socioeconomic characteristics as modulating factors in the association between sugar and dental caries. The risk factors for the development of dental caries were a cariogenic eating pattern associated with an underprivileged socioeconomic status.

A clear limitation of this study can be related to the study design. For instance, in all cross-sectional investigations data are recorded only once. Hence, it is impossible to infer the temporal association between the risk factors (e.g. diet and oral hygiene) and the outcome (oral diseases). Moreover, the lack of association between oral hygiene and caries might be limited since both variables are chronic events suggesting that longitudinal approach is much more suitable.

5. Final Considerations

The present sample can be characterized as a population at high risk of developing dental caries, with a high DMFT index, large number of missing teeth (especially among older adults), healthy teeth and considerable dental treatment needs. Moreover, despite reports of adequate oral hygiene practices, this factor was not sufficient to ensure a favorable oral health outcome.

Due to the chronicity of the oral health conditions evaluated in this survey, the importance of further studies to monitor the oral health of this population is highlighted.

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