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Dental fluorosis: prevalence and associated factors in 12-year-old schoolchildren in Goiânia, Goiás

Fluorose dentária: prevalência e fatores associados em escolares de 12 anos de Goiânia, Goiás

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ABSTRACT: *Objective:* To describe the prevalence of dental fluorosis, to investigate its association with individual and contextual variables among 12-year-old schoolchildren, and to determine whether there were changes in the prevalence of this condition from 2003 to 2010. *Methods:* This cross-sectional study used data from an oral health survey carried out in Goiânia, Goiás, in 2010 (n = 2,075), and secondary data from the files of the local health authority. Clinical data were collected through oral examinations in public and private schools. The dependent variable was the presence of dental fluorosis, assessed using the Dean Index. The independent individual variables were sociodemographic characteristics (the child's gender and race, and the mother's level of schooling) and those related to clinical conditions (caries experience, evaluated using Decayed, Missing, and Filled teeth index; and presence of periodontal calculus and/or bleeding, evaluated using Community Periodontal Index). The contextual variables were linked to the school (type and existence of toothbrushing program) and its geographic location in the city's health districts. The Rao-Scott test was performed, and the percentage difference between the prevalences in the period from 2003 to 2010 was calculated. *Results:* The prevalence of dental fluorosis in 2010 was 18.7%, being distributed as very mild (11.2%), mild (4.4%), moderate (2.6%), and severe (0.5%). No significant association was found between prevalence of dental fluorosis and the investigated variables. The prevalence of fluorosis increased 230% from 2003 to 2010, and such difference was significant. *Conclusions:* The prevalence of dental fluorosis was low, predominantly of the very mild degree, has increased over a 7-year period, and was not associated with the individual or contextual factors studied.

Keywords: Epidemiology. Fluorosis, dental. Child. Oral health. Fluoridation. Dental health surveys.

RESUMO: *Objetivo:* Descrever a prevalência de fluorose dentária e investigar sua associação com fatores individuais e contextuais entre escolares de 12 anos, além de verificar se houve mudanças na prevalência dessa condição no período de 2003 a 2010. *Métodos:* Estudo observacional com análise transversal utilizando dados do levantamento de saúde bucal realizado em Goiânia, Goiás, em 2010 (n = 2.075) e dados secundários obtidos da Secretaria Municipal de Saúde. Os dados foram coletados através de exames bucais em escolas públicas e privadas. A variável dependente foi a presença de fluorose dentária, avaliada pelo índice de Dean. As variáveis independentes individuais foram sociodemográficas (sexo e raça do escolar e grau de escolaridade da mãe) e clínicas (experiência de cárie: índice de dentes cariados, perdidos e obturados; e presença de cálculo e/ou sangramento gengival: índice periodontal comunitário). As variáveis contextuais foram relacionadas à escola (tipo e existência de programa de escovação dentária) e sua localização geográfica nos distritos sanitários do município. Foram realizados o teste de Rao-Scott e o cálculo da diferença percentual das prevalências no período de 2003 a 2010. *Resultados:* A prevalência de fluorose dentária em 2010 foi de 18,7%, distribuída nos graus: muito leve (11,2%), leve (4,4%), moderada (2,6%) e grave (0,5%). Não houve associação estatisticamente significativa entre prevalência de fluorose dentária e as variáveis investigadas. No período de 2003 a 2010, a prevalência de fluorose dentária aumentou 230% e essa diferença foi significativa. *Conclusões:* A prevalência de fluorose dentária foi baixa, com predomínio do grau muito leve, aumentou num período de sete anos e não esteve associada aos fatores individuais e contextuais investigados.

Palavras-chave: Epidemiologia. Fluorose dentária. Criança. Saúde bucal. Fluoretação. Inquéritos de saúde bucal.

INTRODUCTION

The epidemiological surveys about oral health constitute important tools to monitor the levels and patterns of the health-disease process in the population[1]. According to recent surveys, the significant reduction of dental cavity occurs parallel to the increased prevalence of fluorosis in several parts of the world, including Brazil[2-4].

Dental fluorosis is characterized by visible changes in the opacity of the enamel owing to alterations in the mineralization process during the development of the tooth germ[5]. This clinical effect is associated with the cumulative intake of fluoride in the tooth formation period[6]. The manifestations depend mainly on the amount of fluorine ingested, exposure time, age, weight, and nutritional status of the individual, being more evident in the permanent dentition[7].

Both the fluoridation of the water supply and the use of fluoride dentifrices are effective measures in reducing caries. However, fluorine is also being added to processed foods and beverages, which contributes to a concomitant ingestion of fluorides from various sources. This setting also reinforces the importance of constant monitoring of adverse effects of fluorine on the population and highlights the need for better information about the addition of fluorine on the labels of industrial products[8].

Recently, greater emphasis has been placed on the importance of socioeconomic and contextual factors in understanding the determinants of oral diseases. Although some studies

conducted in Brazil and Latin America have shown an association between higher socioeconomic status and lower prevalence of fluorosis[9,10], others have reported no association[3,11-13]. Some studies have also reported association between better socioeconomic status and higher incidence of fluorosis[14-16]. Studies analyzing an association between fluorosis and gender of the participants also had divergent findings[9,13].

Thus, it can be observed that the relationship between individual and contextual factors and dental fluorosis is not yet well established in the literature, unlike other oral health conditions, such as caries and unfavorable periodontal condition, both associated with a worse socioeconomic status. Therefore, the objective of this study was to describe the prevalence of fluorosis and investigate its association with individual and contextual factors in 12-year-old schoolchildren of a Brazilian capital, as well as to verify whether there was an increase in the prevalence of this condition in the last 7 years.

METHODS

This cross-sectional study was conducted with 12-year-old schoolchildren of Goiânia, capital of the State of Goiás, using data from the municipal oral health survey carried out in 2010. The fluoridation of Goiania's water supply began in 1985.

The research protocol of the survey was approved by the Research Ethics Committee of Universidade Federal de Goiás. Only the schools that authorized and the schoolchildren whose parents signed a term of informed consent participated in the study.

The data were collected through oral examinations. The investigated condition of interest for this study was dental fluorosis, as measured by the Dean Index[1], with the examination of the two most affected teeth and a score to be registered. This index allows the classification of fluorosis into six degrees: normal, questionable, very mild, mild, moderate, and severe. The exams were conducted in schools, with the aid of a dental mirror, under natural light, with the children seated.

Study participants were children aged 12 years old, of both genders, attending public and private schools. The sample size was calculated to be representative of the 12-year-old students of Goiânia. The cluster sampling technique was applied, and the random sample was randomly selected in two stages. Initially, we randomly picked out by lot the number of first-stage units (schools), and then the second-stage units (schoolchildren).

According to data obtained from the State and City Departments of Education, the total number of 12-year-old schoolchildren enrolled in 2009 was 17,911, in 281 public and private schools. The sample size was calculated using a formula of proportion for infinite populations, based on the prevalence of caries, using the Epi Info software, version 3.5.1. The minimum number of students to be examined was 2,171, considering a confidence interval of 95% (95%CI), sampling error of 2%, and caries prevalence of 65.3%. For effect of study sample design, a simplified and conservative correction was necessary, multiplying

the obtained sample size by 1.2 (20% more). The final sample of the 2010 survey was 2,605 schoolchildren.

To calculate the number of schools, a formula that consists of multiplying the number of schools by the number of schoolchildren in the sample, divided by the total number of schoolchildren in Goiânia of that age was adopted. We obtained a sample of 41 schools.

The sample was proportionately distributed by the seven health districts (HDs) in the city: Campinas-Central, East, Northwest, North, West, Southwest, and South. As the total sample was of 2,605 schoolchildren, and the number obtained through the listings was approximately 2,962 schoolchildren, we decided to include all students.

In the calibration procedure *in lux* (using images) of the six examiners, the interrater Kappa value for fluorosis ranged from 0.71 to 0.96, with a good to excellent reproducibility.

Demographic and socioeconomic data of the participants were also collected: gender, self-reported color/race, and the mother's level of schooling. Self-reported color/race followed the criteria of the Brazilian Institute of Geography and Statistics: white, black, yellow, brown, or indigenous. The mother's level of schooling was based on the number of years of study, obtained from the school files. Other investigated oral health conditions were caries experience, characterized by the visual presence or absence of caries in the permanent teeth, evaluated by the Decayed, Missing, and Filled (DMF) teeth index; and adverse periodontal condition, characterized by the presence or absence of gingival bleeding and/or periodontal calculus, assessed using two components of the Community Periodontal Index.

The secondary data referred to the school environment and were obtained with the City Department of Health. Information about the prevalence of dental fluorosis in 2003, for comparison purposes, was collected in previous publications[17]. That year, the Kappa for fluorosis was 1.00, showing a high reproducibility, and the calibration was performed using the traditional method.

A limitation of this study was the difficulty to analyze information from two data sources constituted through different calibration procedures and sampling designs. The sample weights were considered in the 2010 study, but not in the one from 2003. Thus, we chose to analyze the prevalence of fluorosis in 2010 without considering the sample weights for the comparison between the 2 years.

For the data analysis, the dependent variable was the presence of dental fluorosis: yes (very mild, mild, moderate, and severe categories) and no (normal and questionable categories). The independent variables were organized in two levels: individual (schoolchildren) and contextual (schools and HDs). In the individual level, the following items were analyzed: a demographic characteristic (gender), two socioeconomic characteristics (color/race and the mother's level of schooling), and two oral conditions (gingival bleeding and/or periodontal calculus, and caries experience). Color/race was categorized as white and non-white. The level of schooling of the mother was grouped into < 8, 8 – 11, and > 11 years of study.

The contextual variables were administrative status of the school (public and private), existence of the Toothbrushing Program in the schools, and the HDs of the school's location. The Toothbrushing Program was developed in 1992 through a partnership between

the city's Health and Education departments, with the aim of improving oral health conditions of schoolchildren enrolled in primary education in public schools by implementing daily toothbrushing with fluoride toothpaste after the school snack. The probable influence of this program would only happen in schoolchildren that, at 6 years of age, attended schools that were part of the program, considering that this is the last age at which excessive intake of fluorine presents risk for the occurrence of fluorosis in permanent teeth.

The seven HDs were grouped according to their socioeconomic characteristics, as reported by the City Health Department. The centrally located HD (Campinas-Central) had better socioeconomic and health indicators than the others, located peripherally. Thus, they were classified as Group I, with better indicators (Campinas-Central); Group II, with intermediate indicators (North, South, and East); and Group III, with the worst indicators (Southwest, West, and Northwest).

Individual and contextual independent variables were described according to the prevalence of fluorosis. The Rao-Scott test[18], equivalent to the χ^2 test for complex samples, was used to compare the prevalence of fluorosis and its 95%CI between the different groups. This analysis was performed using Stata software, version 12, considering the complex sample plan, the sample weights, and the 5% significance level. Then, we performed the percentage increase calculation to compare the prevalence of fluorosis between 2010 and 2003 and the χ^2 test using the Epi Info software, version 7.1.3.

RESULTS

Of the 41 schools invited to participate, 39 accepted (24 public and 15 private). Of the 2,962 schoolchildren invited to participate, 2,075 agreed and were examined (response rate = 70.0%).

The sample consisted mostly of male students (50.9%), non-white (63.6%), and whose mothers had 8 – 11 years of schooling (51.2%). The majority was studying in public schools (71.2%) and presented caries experience (54.0%).

The prevalence was 18.7%, being distributed in the degrees: very mild (11.2%), mild (4.4%), moderate (2.6%), and severe (0.5%). Table 1 shows the prevalence of dental fluorosis according to the variables studied and the results of the bivariate associations between the dependent and the independent variables.

The rate of dental fluorosis was slightly higher in students from schools located in the HDs of Group III, from public schools, and from schools with Toothbrushing Program. Female students and children of mothers with lower schooling levels also had slightly higher prevalence of dental fluorosis. Nevertheless, no statistically significant association was found between the prevalence of dental fluorosis and the variables investigated.

Between 2003 and 2010, the prevalence of dental fluorosis in Goiânia, Goiás, increased 230% (p < 0.001) (Table 2).

Table 1. Prevalence and confidence intervals of 95% of fluorosis (very mild, mild, moderate, severe) according to the independent variables in 12-year-old schoolchildren, Goiânia, GO, Brazil, in 2010.

Contextual Level Variables	Sample (%)*	Fluorosis (%)*	95%CI	p-value[†]
Health districts				
Group I	18.4	12.2	8.2 – 17.9	
Group II	37.9	19.2	14.3 – 25.2	0.225
Group III	43.7	21.1	13.7 – 31.1	
School (Administrative status)				
Private	28.8	16.2	11.7 – 22.0	0.378
Public	71.2	19.8	14.2 – 26.8	
Toothbrushing program				
Yes	30.5	23.3	16.5 – 31.8	0.165
No	69.5	16.8	11.9 – 23.1	
Individual Level Variables (Sociodemographic)	**Sample (%)***	**Fluorosis (%)***	**95%CI**	**p-value[†]**
Gender				
Masculine	50.9	18.1	14.1 – 22.8	0.495
Feminine	49.1	19.5	14.2 – 26.1	
Race/color				
White	36.4	18.7	15.5 – 22.4	1.000
Non-white	63.6	18.7	13.0 – 26.2	
Mother's level of schooling (years of schooling)				
> 11	21.3	18.4	14.4 – 23.3	
8 – 11	51.2	17.2	13.3 – 21.9	0.237
< 8	27.5	21.9	14.4 – 31.8	
Individual Level Variables (Clinical)	**Sample (%)***	**Fluorosis (%)***	**95%CI**	**p-value[†]**
Presence of bleeding or periodontal calculus				
No	93.0	18.8	14.4 – 24.2	0.802
Yes	7.0	17.9	11.6 – 26.7	
Caries experience				
No	46.0	18.7	15.1 – 23.0	0.991
Yes	54.0	18.8	13.2 – 26.0	
Total	100.0	18.7	14.4 – 24.0	

95%CI: confidence interval of 95%; *adjusted for the sampling design; [†]Rao-Scott test.

DISCUSSION

This study showed that the prevalence of dental fluorosis among 12-year-old schoolchildren in 2010 was low, although it has increased considerably in the last 7 years in Goiânia. It also showed no association between dental fluorosis and demographic and socioeconomic factors and no association between fluorosis and other oral conditions.

The increase in the prevalence and severity of dental fluorosis is in line with that in other Brazilian studies that had reported increased dental fluorosis in a period of 10 years in Porto Alegre, Rio Grande do Sul[19], and in a period of 13 years in Piracicaba, São Paulo[3]. This trend

Table 2. Sample distribution according to degree of fluorosis and 12-year-old schoolchildren, Goiânia, GO, Brazil, in 2010.

Fluorosis (Dean Index)	2003 (n = 1,945)		2010 (n = 2,075)		Increase % (2003 – 2010)	p-value*
	n	%	n	%		
No	1,837	94.4	1,691	81.5		< 0.001
Yes	108	5.6	384**	18.5**		
Very mild	98	5.0	233	11.2		
Mild	4	0.2	87	4.2	+230%	< 0.001***
Moderate	6	0.3	53	2.6		
Severe	0	0	11	0.5		

*χ^2 test; **values not considering the sample weights, because in 2003 they were not estimated; ***each subcategory (very mild, mild, moderate) was compared to "without fluorosis."

was also shown in the national oral health survey of 2010 (SB Brazil 2010)[20] compared to 2003 (SB Brazil 2003)[21]. However, Narvai et al.[22] reported that the prevalence of dental fluorosis in children from São Paulo was stationary in 1998 – 2010.

The prevalence of dental fluorosis observed in this study was higher than that in Brazil in the same year (16.7%)[20]. It is worth noting that the severe category, which is less susceptible to bias, rose from 0.0 to 0.5% in the time frame analyzed, and that the moderate category increased from 0.3 to 2.6%. This indicates increased extension, as well as abrasion of the affected tooth's enamel, and emphasizes the importance of continuous monitoring of the oral health condition in this age group.

The occurrence of fluorosis has been attributed to multiple sources of fluoride ingested by the children[23]. Goiânia has fluoridated water at a concentration of 0.07 ppm since 1985, and toothpastes commonly used by the population also contain fluoride. Evidence that the prevalence of dental fluorosis has increased in areas with or without fluoridated water indicates the need for control of the various sources of fluorine consumption[23].

In a study conducted in Piracicaba, São Paulo, the average total dose of fluoride provided by the diet and the habit of brushing the teeth with fluoride dentifrice was 0.09 mg F/day/kg[24]. The acceptable intake dose is 0.05 – 0.07 mg F/kg of body weight. The diet accounted for 45% and the toothpaste for 55% of this dose. They have concluded that reducing the amount of dentifrice used in toothbrushing could benefit this population. Some studies reported an association between low parental level of schooling and higher risk of fluorosis[6,9], which can be linked to a lower level of information about the adverse effects of fluorine, when ingested in excess. In spite of this, the present study found no significant association between dental fluorosis and the mother's schooling level. In a study conducted in Goiânia in 2003[15], the students of private institutions had higher prevalence of fluorosis, whereas in Piracicaba the students of public schools and those with lower income had higher prevalence of fluorosis[9]. A study carried out in Fortaleza, Ceará, reported that children living in rented, assigned, or occupied housing were more likely to experience fluorosis than those who lived

from families who owned their houses[25]. This study found no difference in the prevalence of fluorosis when considering the administrative status of the educational institution or its geographical location in the city's HDs.

The hypothesis that the existence of the Toothbrushing Program in public schools would be associated with a higher prevalence of fluorosis was not confirmed. This result may be due to the low amount of fluorine exposure (approximately 1 year) offered by the program to the schoolchildren at the beginning of elementary school, which could have had some observable effect on permanent dentition at 12 years. In addition, there are reports of delays and inconstancy in the delivery of materials (toothbrushes and toothpastes) to the schools over the years of the program's existence.

The fluoridation of the water supply helps to reduce the social status gradient considering socioeconomic deprivation and caries experience[2]. Therefore, even if there is an increase of the concomitant risk for developing mild fluorosis, this measure should be maintained, because the population with limited access to fluoridated products cannot stop benefitting from the fluorine in the drinking water. Besides, there is evidence that mild fluorosis has no adverse impact on the quality of life in children and adolescents[11,26].

Some methodological aspects of the surveys that assess dental fluorosis deserve attention, because it is an essentially subjective assessment[7,27]. The percentage increase in the prevalence of fluorosis in Brazil between 2003 and 2010, for example, should be viewed with caution, because in 2003 the examiners of the survey were encouraged to evaluate the two most affected teeth with the proviso that if these two elements were similarly compromised, the value of the least affected between them should be registered[28]. On the other hand, in 2010 this exception was not highlighted, and the examiners were told to register a score for the two most affected teeth[29], which may have overestimated the prevalence for that year.

The variations of results in the literature about the relationship between dental fluorosis and socioeconomic factors are probably due to the different indexes used to assess fluorosis and also the different socioeconomic status measures used in the various studies. In this sense, it is necessary to establish more specific socioeconomic classification criteria to enable the comparison between future investigations.

Actions promoting guidance of caregivers about the risks of excessive fluorine intake by children and the regular monitoring of the degree of fluorosis of the young population are recommended. We have concluded that the prevalence of dental fluorosis was low in the studied population, with a predominance of the very mild degree, increased over a period of 7 years and was not associated with the individual and contextual factors investigated.

CONCLUSION

The prevalence of dental fluorosis was low, with predominance of the very mild degree, and increased during the 7-year study period. In addition, dental fluorosis was not associated with the individual and contextual factors investigated.

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