

The association between the prevalence of dental fluorosis and the socio-economic status and area of residence of 12-year-old students in Uruguay

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ABSTRACT

Objective: This study investigates the association between the prevalence and severity of dental fluorosis, the socio-economic status (SES) and area of residence among 12-year-old schoolchildren in Uruguay.

Material and methods: The study was descriptive, cross-sectional, explanatory and observational. Subjects considered eligible were born in 1999 and had their parents' or guardian's prior consent. A questionnaire was used to identify SES according to Centro de Investigaciones Económicas Institute on four levels. Dental fluorosis was determined using the Thylstrup-Fejerskov (TF) index.

Results: Of the 1544 students examined, 45.0% showed dental fluorosis. A TF index 1–2 was recorded in 29.3% of the subjects, TF 3 in 20.9%, TF 4 in 6.7% and TF 5–9 in 2.1%. In area 1 (the capital Montevideo city), 84.8% of the subjects had dental fluorosis, a value that was significantly higher than in the inland region (area 2, 24.4%) and border departments (area 3, 22.5%) ($\chi^2 = 27.92$, $p < .0001$). Students from families with a low socio-economic level showed less prevalence of dental fluorosis than those with a high level ($\chi^2 = 14.58$, $p = .002$).

Conclusion: Significant differences exist in the prevalence of dental fluorosis in relation to place of residence and socio-economic level.

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Introduction

Fluoride has proven to be an effective agent for the control of dental caries for over five decades. During this period, fluoride has been increasingly available for populations with and without fluoridated drinking water in toothpastes, mouthwashes, carbonated beverages and infant formulas, as well as in professional dental products. Salt fluoridation, which has cariostatic potential similar to water fluoridation [1], was introduced in Uruguay in 1991 for combatting dental caries and can be another source of fluoride exposition in early childhood. At that time, the concentration of fluoride in public drinking water was studied, and the limit above which fluoridated salt should not be distributed was set at 0.6 ppm. Five places had water that was already naturally fluoridated at levels that did not allow for more fluoridation and thus were excluded from the sale of fluoridated salt.

The decline in the prevalence of dental caries as a result of the widespread use of fluoride has led to an increase in the prevalence of dental fluorosis [2] and may be considered to be a public health issue depending on how severely it affects a subject. The increase in mild and very mild forms of fluorosis is proportionally higher in non-fluoridated areas



than in fluoridated areas due to increased ingestion of multiple available sources of fluoride [3].

Studies on dental fluorosis have not been carried out in Uruguay. Therefore, the aim of this study was to investigate the prevalence and severity of dental fluorosis across the country and in relation to socio-economic status (SES) among 12-year-old schoolchildren in urban areas of Uruguay.

Materials and methods

Subjects

A descriptive, cross-sectional, explanatory and observational study of 12-year-old schoolchildren in public and private Uruguayan primary schools was carried out. Schools were randomly selected from the urban areas using random weighted sampling according to the population value. Urban areas were considered to be areas with more than 5000 inhabitants. The subject sample was stratified according to three geographic areas. Montevideo, the most densely populated department, was established as area 1; area 2 was made up of the 14 departments not sharing a land border with Brazil, excluding Montevideo; and area 3 included the

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Table 1. Prevalence of dental fluorosis in the different geographic areas of Uruguay (number of subjects and percentage).

Fluorosis	No. of subjects	Geographic area		
		Montevideo (1)	Inland (2)	Border departments (3)
No	849 (55%)	78 (15.2%)	631 (75.0%)	140 (74.9%)
Yes	695 (45%)	436 (84.8%)	211 (25.1%)	47 (25.1%)
Total	1544	514 (33.3%)	842 (54.6%)	187 (12.1%)

four departments sharing a land border with Brazil. The inclusion criteria were that the student subjects who were born in 1999 had to be born and raised in the area, provide a written informed consent form signed by a parent or guardian and be present at the time of the survey. Children were excluded if they refused to participate, did not have the written consent of the parents or guardians for the oral examination to be conducted or had fixed orthodontic devices. The final sample size was calculated to make estimates with a 95% confidence interval (CI) and with a non-participation rate of 30%. In total, 1544 12-year-old school pupils from 42 schools (35 public and 7 private) were invited to participate in the study representing all departments in the country. The study was evaluated and approved by the Ethics Committee of the School of Dentistry at the University of the Republic Uruguay (UDELAR), number FO001512-10.

Clinical assessment

Four calibrated dentists, one dentist per child, examined the children for dental fluorosis at the school with the students in a supine position. Prior to the clinical examination, professional brushing and flossing were done by a dental hygienist. Cotton rolls were used to control moisture, and gauze pads were used to dry dental surfaces. After tooth cleaning and drying, all buccal tooth surfaces on permanent teeth were examined under artificial light for the presence and severity of dental fluorosis using the Thylstrup–Fejerskov (TF) fluorosis index [4]. The TF index has 10 classes from 0 to 9 depending on the severity, from normal (TFI = 0), mild (TFI = 1–3), moderate (TFI = 4–5) to severe (TFI = 6–9). The most severe TF value of symmetrical bilateral buccal surfaces was recorded as the representative value of the subject. Training and calibration in the use of the TF index had been done before data collection began by assessing photographic images showing varying degrees of dental fluorosis. An intraexaminer reproducibility assessment was conducted through double examinations of five subjects at an interval of one week. The intraexaminer Cohen's kappa coefficient for dental fluorosis was 0.76 (range 0.71–0.82) and was considered as good according to Fleiss' guide [5].

The socio-economic status

A questionnaire was used to identify the SES of the families of the students using the index of socio-economic level (INSE) presented by the Centro de Investigaciones Económicas (CINVE) Institute as an independent variable. This SES indicator is used for market research and public opinion and is a numerical scale that allows socio-economic

stratification. The SES indicator is a summarized version of nine variables: (1) the occupation of the head of household; (2) the level of education (at least one person holding a higher-education qualification); (3) the number of employed persons in the household; (4) the number of bathrooms in the house; (5) whether the household employs domestic help; and (6) whether the household has a fridge-freezer, (7) a colour TV, (8) a car or (9) an international credit card. In this study, four SES levels were used: class 1 (high), 2 (upper middle), 3 (middle) and 4 (low).

Statistical analysis

The chi-square test and Mann–Whitney *U* test were used to analyze the prevalence of dental fluorosis and the independent variables. Intervals for the mean were calculated with a confidence level of 95%. A difference was considered to be statistically significant for *p*-values <.05 or if the confidence intervals did not overlap. All analyses were performed using IBM SPSS statistics software version 19 (Chicago, IL, USA).

Results

Of the 1544 adolescents examined, 849 (55%) showed no dental fluorosis, whereas 695 (45%) had some degree of fluorosis (Table 1). The area most affected was Montevideo, with a prevalence of fluorosis of 84.8%. In the inland areas and in the departments bordering Brazil (areas 2 and 3), the prevalence was approximately 3 times lower (25.1% and 25.1%, respectively). The average severity of the dental fluorosis score (TF) in area 1 was 1.22 (CI 95% 1.15–1.30); in area 2, 0.38 (CI 95% 0.34–0.43); and in area 3, 0.42 (CI 95% 0.30–0.54). The differences in the TF scores between area 1 compared with areas 2 and 3 were statistically significant (*p* < .0001 Mann–Whitney *U* Test).

In the Montevideo area, 81.3% of the children had a TF score of 1 or 2 (Table 2). In the inland and border departments (areas 2 and 3), the frequencies of a TF score of 1 or 2 were significantly lower at 24.4% and 22.5%, respectively ($\chi^2 = 27.92$, *p* < .0001). TF scores of 3 or 4 were observed mostly in areas 1 and 3 compared to area 2 (2.5% and 2.6% compared with 0.7%). The highest severity of fluorosis (TF scores 5–9) was observed in Montevideo in 1% of the subjects.

Among the SES, the severity of fluorosis according to the TF score was higher among the children with high SE values (class 1; 59.7%) than in class 4, where 57.5% displayed no fluorosis (Table 2). The difference of 17.2% in the frequency of no fluorosis between SE classes 1 and 4 was statistically significant ($\chi^2 = 14.58$, *p* = .002). In the inland area of the country (area 2), there was a 4–5 times higher percentage of children in all SES classes with no dental fluorosis compared with children in both areas 1 and 3 (Table 3).

Canelones in the inland area along the coast can be considered to be part of the Montevideo area, as many Uruguayans have moved there. Therefore, these two neighbouring departments were combined and analyzed statistically. It was observed that 67.4% of the children in the

Table 2. Distribution of dental fluorosis score (TF) in the three areas and in the four SES groups (number of subjects and percentage).

TF ^a	Area			Socioeconomic status (SES)			
	Montevideo	Inland	Border departments	1	2	3	4
0	78 (15.2)	631 (75.0)	140 (74.9)	15 (40.3)	62 (43.4)	177 (53.8)	595 (57.5)
1	278 (54.0)	107 (12.7)	25 (13.1)	14 (38.5)	51 (35.2)	93 (28.4)	251 (24.2)
2	141 (27.3)	98 (11.7)	18 (9.4)	8 (21.2)	29 (20.2)	53 (16.0)	167 (16.1)
3	12 (2.3)	4 (0.5)	2 (1.1)	0 (0.0)	2 (1.2)	4 (1.1)	13 (1.2)
4	1 (0.2)	2 (0.2)	3 (1.5)	0 (0.0)	0 (0.0)	0 (0.0)	5 (0.5)
5–9	5 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.6)	4 (0.4)

^a0 = no fluorosis; 1–3 = mild; 4–5 = moderate; 6–9 = severe.

Table 3. Children with no fluorosis in the three geographic areas in relation to SES (number of subjects and percentage).

Geographic area	Socioeconomic status (SES) ^a			
	1	2	3	4
Montevideo	3 (17.0)	3 (12.4)	28 (16.0)	39 (6.6)
Inland	10 (69.2)	46 (73.7)	127 (72.1)	447 (75.2)
Border departments	2 (13.8)	9 (13.9)	21 (11.9)	108 (18.2)

^aClass 1 (high); 2 (upper middle); 3 (middle); 4 (low).

combined area had dental fluorosis, while in the Inland and Border departments, 81.1% of those examined did not have dental fluorosis. A statistically significant association between high levels of fluorosis and living in the area of Canelones and Montevideo was observed ($p < .0001$) (Table 4).

Discussion

This study found that overall 45% of 12-year-old Uruguayan children showed signs of dental fluorosis. This finding is in line with studies from some other developed countries. In a study from a non-water-fluoridated city in Sweden, the prevalence of fluorosis was 49% in children 7–9 years of age [6]. In 10 to 15-year-old schoolchildren in Brazil, the prevalence of fluorosis was 48.5% [7]. Other studies using Dean's criteria for fluorosis instead of the TF index show that the prevalence of dental fluorosis in the USA was 40.7% among adolescents aged 12–15 years in a 1999–2004 survey [8]. A study from Mexico City reported that 59% of participants aged 10–12 showed dental fluorosis [9].

The prevalence of fluorosis was not similar when examining 47 schools across the country. Montevideo, the capital, was the area with the highest prevalence, where 85% of the children had some degree of fluorosis. The coastal area of Canelones, the neighbouring department of Montevideo to the east, has been increasingly populated by Uruguayans who have moved to this area from their Montevideo homes. It is therefore interesting to note that even if the neighbouring district of Canelones were included, the combined area showed a high percentage of children having fluorosis (67%), further indicating a significant association between high levels of fluorosis and living in this area (Table 4). The high prevalence differed significantly from the inland and border department areas, where approximately 25% were affected by fluorosis. This low prevalence of fluorosis is in accordance with results from many countries in Europe [10].

Most of the children in all areas exhibited mild or very mild signs of fluorosis (TF 1 and 2), levels which appear to have little effect on children's oral health-related quality of

life [11,12]. At these acceptable levels of fluorosis, the benefits of lower caries prevalence using fluoride may outweigh the mild signs of fluorosis. Cleaning and especially drying of the teeth before the examination as recommended when using the TF index may partly explain the high prevalence of very mild fluorosis (TF 1) and made the fluorosis more apparent and indicative of early biological changes. At higher TF scores (TF 3 and higher), the occurrence of dental fluorosis can cause aesthetic problems to the patient and be of appreciable parental concern [13]. The prevalence of fluorosis with aesthetic concern was 3.5% in Montevideo, whereas in the inland districts it was only 0.7%. In Montevideo, 1% of the children had severe forms of fluorosis (TF scores 5–9), suggesting an excessive ingestion of fluoride during tooth development.

There is no water fluoridation in Uruguay except in some places with natural fluoride in the water, which were not included in this study. Thus, the children were not exposed to fluoridated water in their first 3–4 years of life which is the critical period of tooth development when high ingestion of fluoride will increase the risk of fluorosis. Instead, other sources of fluoride are available, e.g. fluoride toothpastes, fluoridated salt and fluoride supplements. Greater use of dental care products has been suggested as a possible reason for the higher prevalence of fluorosis [2]. Several studies have demonstrated that standard fluoride toothpastes are the main contributor to the total intake of fluoride in young children [14,15] and that swallowing toothpaste is associated with an increased risk of fluorosis [16]. Even toothpastes with low contents of fluoride may result in a certain level of fluorosis [17]. Some studies have shown that 60–70% of the toothpaste applied to the toothbrush is swallowed unintentionally by preschool children [18,19]. In 1991, fluoridated salt was introduced in Uruguay for combatting dental caries, as this distribution form of fluoride has shown 44–84% reduction in caries in countries such as Mexico and Jamaica [1]. Fluoridated salt has since been available on the market

Table 4. Distribution of dental fluorosis score (TF) in the combined departments of Montevideo and Canelones in relation to the inland and border departments (number of subjects and percentage).

TF ^a	Geographic area	
	Montevideo/Canelones	Inland/Border departments
0	270 (32.6)	579 (81.1)
1	330 (39.8)	79 (11.1)
2	207 (25.0)	49 (6.9)
3	16 (1.9)	2 (0.3)
4	1 (0.1)	5 (0.7)
5–9	5 (0.6)	0 (0.0)

^a0 = no fluorosis; 1–3 = mild; 4–5 = moderate; 6–9 = severe.

and can be one source of fluoride exposition in early childhood. To what extent fluoridated salt can contribute to fluorosis is not fully known, but this possibility gains support from a study in Mexico, in which dental fluorosis was examined in 6- to 12-year-old children born after the implementation of a salt fluoridation programme in 1991 [20]. This study showed that 51.9% of the children had fluorosis, a proportion similar to the prevalence in our study. In addition to reporting a close relationship between exposure to toothpaste and dental fluorosis, they found that the fluoridated salt programme greatly increased the risk.

It is worth noting that the occurrence of dental caries has declined in Uruguay [21,22] due to the increased use of fluoride and to the implementation of dental caries prevention programmes in schools (*Programa de Salud Bucal Escolar*) through various measures including promoting of frequent use of fluoride at different concentrations. The incorporation of these programmes has brought benefits, but dental fluorosis also has begun to be detected in the country. The same trend has also been reported in other countries [9,23,24]. Although dental caries has declined in many countries, they are still a substantial problem for a relatively small segment of the population, a group that is over-represented by individuals from lower socio-economic classes [25].

The present study demonstrated that dental fluorosis was related to the SES of the families. The prevalence of fluorosis was significantly higher among children from SES class 1 than from class 4. This observation is similar to findings by Tabari et al. [2] and Tavener et al. [26] who reported that higher SES status was significantly associated with fluorosis. Additionally, Conway et al. [6] found that SES status and especially the educational level of the parents were the only factors relating to dental fluorosis in 7- to 9-year-old children living in a non-fluoridating city in Sweden. The importance of the educational level of the parents is also supported by studies showing that children of mothers with higher education levels were more likely to brush their teeth with fluoride toothpaste and to brush more frequently [27]. In the present study, there were 4–5 times more children in all SES classes with no fluorosis in the inland districts compared with the metropolitan area of Montevideo and the border departments. The reason why more adolescents in the lower socio-economic classes did not have fluorosis might be that they have less access to the fluoridated products being sold on the market to prevent dental caries.

Some limitations of this study need to be addressed. The prevalence of fluorosis was examined only in urban areas with more than 5000 inhabitants. Therefore, the situation in less-populated areas is not known. According to the TF index, the most severe TF value of symmetrical bilateral buccal tooth surfaces was recorded as representative of the subject. The maxillary incisors are generally the most affected teeth [4]. This may, however, give an underrepresentation of the magnitude of fluorosis in the dentition when many teeth are affected, especially the later-erupting permanent canines, premolars and second molars, which are susceptible to excessive ingestion of fluoride from 3 to 6 years of age. We

did not collect information on other risk factors that could have had an impact on the fluorosis, such as the use of infant formulas, beverages and oral hygiene habits. The strengths of the study are, first, the high number of children examined, who represented 3% of the total number of 12-year-old children in the country; second, the schools they belonged to represented all departments, with one-third from the Montevideo area and two-thirds from the inland and border departments, thus giving a good picture of the prevalence of fluorosis in the country; and third, the children had lived their whole life in the community and were therefore representative of the area.

Dental fluorosis in the areas studied does not currently constitute a public health concern, except in subjects with moderate to severe fluorosis. It is, however, important to control the fluoride ingestion during the period up to six years of age and to identify associated risk factors and various sources of fluoride that may have an effect on the condition. It is also important to detect the problem early, especially during the primary dentition stage, to avoid the risk of fluorosis in permanent dentition. In recommended doses, fluoride is considered to be safe in addition to being effective in preventing caries.

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Disclosure statement

The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

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