BRIEF COMMUNICATIONS

Dental Fluorosis in 12- and 15-Year-Olds at High Altitudes in Above-Optimal Fluoridated Communities in Mexico

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Abstract

Objective: *The purpose of this study was to determine the prevalence and severity of dental fluorosis in Mexican adolescents.* ***Materials and Methods:*** *A cross-sectional epidemiological study was carried out in 1,024 adolescents 12 and 15 years old residing in three naturally fluoridated locales at high altitudes above sea level (>2,000 m or >6,560 ft) in Tula de Allende, Hidalgo, Mexico. Participants had lived in those communities from birth to their sixth birthday. Both the Modified Dean Index and the Community Fluorosis Index were calculated.* ***Results:*** *The overall fluorosis prevalence was 83.8 percent. Fluorosis prevalence in El Llano (3.07 ppmF), San Marcos (1.38 ppmF), and Tula Centro (1.42 ppmF) was 94.7, 89.8, and 81.9 percent, respectively. Overall, the Community Fluorosis Index was 1.85. We observed a high prevalence of dental fluorosis – mostly very mild (35.9 percent), but also uncommonly severe (20.6 percent).* ***Conclusions:*** *At least 8 out of 10 adolescents had some level of fluorosis, and such prevalence is considered to be a dental public health problem. A relationship between fluoride concentration in water in each community and fluorosis was observed. The high fluorosis prevalence and severity might possibly be associated with the high altitude of the communities.*

Key Words: dental fluorosis, high altitude, epidemiology, adolescents, Mexico

Introduction

Dental caries has been considered a dental public health problem in Mexico, and it is often concentrated in low-socioeconomic status populations (1). While fluoride is accepted as an effective method to prevent caries, excessive concentrations can cause dental fluorosis if ingested during certain developmental periods in the formation of teeth, by and large until the age of 6 years (susceptibility window for the highest risk of developing dental fluorosis). Fluorosis is understandably more common in above-optimal and optimally fluoridated areas than in areas with a low concentration of fluoride in drinking water; however, fluorosis also occurs, and has increased, in nonfluoridated communities. This effect has been explained by the exposure to multiple fluoride sources in food, beverages, and oral hygiene agents (2,3). Increased fluorosis experience among children residing at high altitudes above sea level has also been reported; at high altitudes [altitude of above 2,000 m (6,560 ft)], fluorosis prevalence is higher compared with communities at lower elevation (4,5). Although the mechanism for this phenomenon is not well known, diverse explanations span from altered kidney physiology (where renal low pH facilitates fluoride absorption) to concurrent iodine deficiency in the area, which potentiates the adverse effects of fluoride.

Dental fluorosis in Mexico has traditionally been reported in communities where the fluoride concentration in water for human consumption was relatively high, especially in Central and Northern Mexico (6). The objective of the present study was to determine the prevalence and severity of fluorosis in 12- and 15-year-olds from three naturally fluoridated locales at high altitudes in Tula de Allende, in the state of Hidalgo, Mexico.

Materials and Methods

The undertaking of this study adhered to the ethical regulations stipulated by the Universidad Autonoma del Estado de Hidalgo.

Tula de Allende is one municipality in the state of Hidalgo. The communities of Tula Centro and El Llano are at an altitude of 2,040 m (6,690 ft) and San Marcos is at 2,050 m (6,725 ft). Weather is mild semiwet with rain in summer and semidry throughout the remainder of the year, with an average temperature of 17 °C (63 °F). Average fluoride concentrations in water obtained from the Drinkable Water Commission and Tula's sewer system were 1.42 ppmF for Tula Centro, 1.38 ppmF for San Marcos, and 3.07 ppmF for El Llano.

This cross-sectional study undertaken in 1999 targeted a pool of

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Table 1
Prevalence of Dental Fluorosis by Sex, Age, and Locale of Residence in Schoolchildren in Tula de Allende, Hidalgo, Mexico

	With and without fluorosis *n*	Without fluorosis *n* (%)	With fluorosis *n* (%)	*P*-value
Sex				
Girls	533	84 (15.8)	449 (84.2)	$\chi^2 = 0.17$
Boys	491	82 (16.7)	409 (83.3)	$P = 0.68$
Age				
12 years				
Girls	241	31 (12.9)	210 (87.1)	$\chi^2 = 0.94$
Boys	238	38 (16.0)	200 (84.0)	$P = 0.33$
15 years				
Girls	292	53 (18.2)	239 (81.8)	$\chi^2 = 0.86$
Boys	253	44 (17.4)	209 (82.6)	$P = 0.35$
Locale of residence in the first 6 years of life (fluoride in drinkable water)				
El Llano (3.07 ppmF)	75	4 (5.3)	71 (94.7)	$\chi^2 = 12.26$
San Marcos (1.38 ppmF)	128	13 (10.2)	115 (89.8)	$P < 0.01$
Tula Centro (1.42 ppmF)	821	149 (18.2)	672 (81.9)	
Total	1024	166 (16.2)	858 (83.8)	

1,768 adolescents 12 and 15 years of age from all of the elementary and junior high schools in the three communities (7). Seven schools (with 139 subjects) did not participate in the study because of logistic limitations. A total of 1,629 adolescents attending the remaining 25 schools were examined, with 91 excluded. Excluded participants could not be examined because 43 had fixed orthodontic appliances, two had metal crowns, 40 left school before the oral exam took place, and six refused to be examined. A total of 1,538 participating adolescents lived in any of the three communities. They had lived in their respective communities since birth, resided there continuously until at least age 6, and had not lived more than 1 year outside the locale of their birth. Schoolchildren of the urban communities represented 92.7 percent ($n = 949$) of the final sample (Tula Centro 80.2 percent, and San Marcos 12.5 percent). El Llano, a rural community, had only 7.3 percent of the schoolchildren.

Dental examinations were performed by two examiners (kappa intraexaminer = 0.97 and interexaminer = 0.85) using a flat mirror under daylight in an appropriate place in each school. The Modified Dean's Index was used, where 0 = no fluorosis or questionable, 1 = very mild, 2 = mild, 3 = moderate, and 4 = severe. The index was administered to all permanent teeth present in the mouth. The two teeth with the worst score were used for the person-level score. Where two teeth were not affected to the same degree, the less-involved tooth of the two exhibiting the worst scores was used to assign a person-level score. Fluorosis was differentiated from other opacities. Every permanent tooth present was included in the exam, as long as it had at least 50 percent of the clinical crown erupted. Other variables collected were sex, age, and locale of residence. Frequency and distribution of dental fluorosis values were obtained, and the Community Fluorosis Index (CFI) was calculated. Mann–Whitney's, Chi-square, and Kruskal–Wallis tests were performed in STATA 8.2 (StataCorp, College Station, TX, USA) to ascertain the statistical significance of the differences between groups.

Results

The final study population was 1,024 adolescents, of which 52 percent ($n = 533$) were included in the analysis. Females accounted for 46.8 percent of the 12-year-old and 53.2 percent of the 15-year-old adolescents (Table 1). For the two age groups, girls had more teeth (fully) erupted than did boys ($P < 0.05$). Dental fluorosis was present in 83.8 percent of the 1,024 study participants. With regard to severity, *very mild* fluorosis occurred in 35.9 percent of the children, whereas 20.6 percent were classified in the *severe* fluorosis category (Tables 1 and 2).

The prevalence and severity were similar across sex and age groups ($P > 0.05$); however, when comparing across locales, differences were observed ($P < 0.05$) (Tables 1 and 2). It is important to mention that the *severe* category was observed more frequently in El Llano than San Marcos locales, and, unexpectedly, more frequently in San Marcos than in Tula Centro at 46.7, 32.0, and 16.4 percent, respectively. The CFI was 1.85 for all communities. CFI for 12- and 15-year-old adolescents was 1.91 and 1.80, respectively. The Tula Centro locale presented a CFI of 1.69, whereas the CFI for San Marcos and El Llano were 2.20 and 2.97, respectively.

Discussion

Results from the present study are in agreement with numerous reports in which fluorosis prevalence was positively associated with water fluoride concentration. The fluorosis prevalence observed in our study was 83.8 percent. Some studies

Table 2
Modified Dean Index Scores' Distribution in Relation to Sex, Age Group, and Locale

	None *n* (%)	Very mild *n* (%)	Mild *n* (%)	Moderate *n* (%)	Severe *n* (%)
Sex*					
Girls	84 (15.8)	200 (37.5)	74 (13.9)	72 (13.5)	103 (19.3)
Boys	82 (16.7)	168 (34.2)	82 (16.7)	51 (10.4)	108 (22.0)
Age group*					
12 years old	69 (14.4)	170 (35.5)	74 (15.4)	68 (14.2)	98 (20.5)
15 years old	97 (17.8)	198 (36.3)	82 (15.1)	55 (10.1)	113 (20.7)
Locale†					
El Llano	4 (5.3)	8 (10.7)	9 (12.0)	19 (25.3)	35 (46.7)
San Marcos	13 (10.2)	41 (32.0)	22 (17.2)	11 (8.6)	41 (32.0)
Tula Centro	149 (18.2)	319 (38.9)	125 (15.2)	93 (11.3)	135 (16.4)
Total	166 (16.2)	368 (35.9)	156 (15.2)	123 (12.0)	211 (20.6)

*Mann–Whitney; $P > 0.05$.
†Kruskal–Wallis; $P < 0.001$.

undertaken in Mexico and other places of the world at high altitudes above sea level have found that the experience of dental fluorosis is significantly higher than in communities at sea level with comparable fluoride concentrations (3-5,8). In a previous study in Mexico City (2,240 m) and Veracruz (sea level), the authors observed that fluorosis prevalence in Mexico City was significantly higher than in Veracruz ($P < 0.0001$). While there were statistical differences in one of the fluorosis risk factors between the two communities, the observed difference in fluorosis prevalence was still significant when data were analyzed after adjusting for the reported differences in that factor. It was concluded that the difference in fluorosis prevalence in Mexico City and Veracruz could not be explained by the differences in fluoride content of the salt or water samples, self-reported exposure to fluorosis risk factors, or estimated fluoride intake (5).

Like the vast majority of the Mexican population, most adolescents in Hidalgo are exposed to fluoride in toothpastes, in food and beverages, in school-based fluoride rinse programs, and to fluoride naturally available in water (3,5). The hypothesized relationship between iodine deficiency and increased prevalence of fluorosis appears to be relevant to Hidalgo (see http://indorgs.virginia.edu/iccidd/mi/idd_111.htm, IDD Prevalence and Control Program Data, ICCIDD Data, Mexico). Various other factors might be at play in the situation described (such as nutritional status, fluid consumption, etc.) and thus they should be considered in future study designs. The sizeable CFI figures found (between 1.69 and 2.97) emphasize the need to implement epidemiologic surveillance systems to establish the trends, and approaches are needed to tackle this obvious public health challenge.

The conclusions from the present study, undertaken in communities at high altitudes above sea level, are that: a) while the prevalence of dental fluorosis observed was high, in the majority of the cases it was *very mild*. However, *severe* fluorosis was the second category in the percentage of adolescents affected. [Note that more severe figures for one community, El Llano, were based on numbers too small to allow complete confidence in their significance (Table 2)]. b) Based on the CFI, the observed fluorosis prevalence levels represent a significant public health problem in these locales. c) We confirmed a relationship between fluoride level in water and fluorosis prevalence, including a modifying role ascribed to elevated altitude. If all of the fluoride sources are indeed leading to higher dental fluorosis prevalence levels, it is crucial to implement the appropriate quality control measures and modified industrial standards to control fluoride availability in oral hygiene products, beverages, and food consumed in the relevant communities. All of these measures should be based on sound epidemiological follow-up to ascertain that the commonly accepted caries-preventive effect of fluorides is optimized while minimizing the dental fluorosis side effects – including the concern that beyond a certain level of fluorosis severity, caries experience may also increase (9). This improved focus of the preventive program would be in sync with the applicable Mexican standards (NOM-013-SSA2-1994), which state that the use of fluorides for caries prevention should be accompanied by efforts to minimize its role as a risk factor of dental fluorosis.

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