Prevalence and Severity of Dental Caries in Adolescents Aged 12 and 15 Living in Communities with Various Fluoride Concentrations

América Patricia Pontigo-Loyola, DrO; Carlo Eduardo Medina-Solis, MSc; S. Aida Borges-Yañez, DrO; Nuria Patiño-Marín, DSc; Arturo Islas-Márquez, DDS; Gerardo Maupome, PhD

Abstract

Objectives: *To determine the experience, prevalence, and severity of dental caries in adolescents naturally exposed to various fluoride concentrations.* ***Methods:*** *A cross-sectional census was conducted on 1,538 adolescents aged 12 and 15 years living at high altitude above sea level (>2,000 m or >6,560 ft) in above-optimal fluoridated communities (levels ranging from 1.38 to 3.07 ppm) of Hidalgo, Mexico. Sociodemographic and socioeconomic data were collected using questionnaires. Two previously trained and standardized examiners performed the dental exams.* ***Results:*** *Caries prevalence was 48.6 percent and mean of decay, missing, and filling teeth (DMFT) for the whole population was 1.15 ± 1.17. In terms of severity, 9.6 percent of the adolescents had DMFT ≥ 4, and 1.7 percent had ≥7. The significant caries index (SiC) was 2.41 in the group of 12-year-olds, and 3.46 in the 15-year-olds. Higher experience and prevalence were observed in girls, in children with dental visit in the past year, those in the wealthiest socioeconomic status (SES) (quartiles 2, 3, and 4), those whose locale of residence is in San Marcos and Tula Centro, and in fluorosis-free children and those with moderate/severe fluorosis. In an analysis of caries severity (DMFT ≥ 4), both adolescents with very mild/mild and moderate/severe dental fluorosis have higher caries severity.* ***Conclusions:*** *The results indicated that caries experience, prevalence, and severity as well as SiC index among 12- and 15-year-old adolescents were relatively low. Sociodemographic and socioeconomic variables commonly associated with dental caries were also observed in Mexican adolescents. Unlike other studies, we found that caries increased with higher SES. Fluoride exposure (measured through fluorosis presence) does not appear to be reducing the caries prevalence (DMFT > 0) or caries severity (DMFT ≥ 4) in these high-altitude communities.*

Key Words: dental caries, DMFT index, oral epidemiology, adolescents, Mexico

Introduction

The total adolescent population [individuals from 10 to 19 years old, according to the World Health Organization (WHO)] increased in the second half of the twentieth century from 5 to 21 million in Mexico, contributing 22 percent of the total population growth. Adolescents are among the healthier population groups, with low rates of mortality and being low utilizers of health services. However, exposure to several risk factors starts in adolescence and may lead to diverse chronic and degenerative diseases in adulthood. Although public health programs and policies have recognized adolescents as a vulnerable group, their health needs and rights are often overlooked in public policies or in the health sector agenda, except when their behaviors are considered prone to risk (1).

WHO recommends performing oral health epidemiological studies in certain key age groups: adolescents from 12 and 15 years old and in children 5 to 6 are two of these. Most of the studies in Mexico about dental caries have focused on children younger than 12 years old (2–7), thus neglecting adolescents. The importance of detecting the most prevalent of chronic oral diseases in childhood and adolescence resides in its cumulative nature (8). The clinical importance and social cost of dental caries are substantial. Dental caries is the most common infectious oral disease in children despite being potentially preventable, and may require expensive treatment when the disease has progressed to a more advanced stage (6–9).

From an epidemiological point of view, dental caries is widely disseminated across the world and may be considered a public health problem in Mexico (2–7). In Latin America, the prevalence of dental caries in adolescents aged 12 and 15 is higher than 70 percent, with a mean decay, missing, and filling teeth (DMFT) higher than 1.5 (9–13). Even though there are only a few studies on adolescents, some reports have identified different socioeconomic and sociodemographic variables associated with caries, such as age (11–13) and being female (4,9). Socioeconomic status (SES) [measured using

Send correspondence and reprint requests to Carlo Eduardo Medina Solis, MSc, Privada de Altillo s/n entre Av. Central y Pedro Moreno. Colonia San José. CP. 24040, Campeche, Campeche, México. Tel/Fax: 52(981) 8110215; e-mail: cemedinas@yahoo.com. Manuscript received: 6/25/06; accepted for publication: 9/29/06.

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different indicators or variables such as schooling of parents (4,7,14,15), occupation of parents (4), type of school attended (3), family income (14,16), ethnic group (12), and geographical area of residency (7)] has repeatedly been identified as negatively associated with dental caries prevalence (the better the SES, the lower the prevalence). Diverse strategies have been carried out to bring under control the dental caries problem, mainly by means of fluoridation in its various approaches (17,18). However, excessive use may cause dental fluorosis, and in some extreme situations it has been observed that individuals with severe fluorosis have more experience or severity of caries (19–21).

The objective of the present study was to expand the information with regard to adolescent oral health by evaluating experience, prevalence, and severity of dental caries in adolescents naturally exposed to various fluoride concentrations in Hidalgo, Mexico.

Methods

This study followed the ethical guidelines laid out for studies conducted at the Division of Postgraduate Studies, Dental School, National University of Mexico.

This cross-sectional census targeted schoolchildren from 12 and 15 years of age (n = 1,768) from elementary and junior high schools in three out of the six locales of the Tula de Allende municipality located in the state of Hidalgo, Mexico. Two locales are 2,040 m above sea level and a third one is at 2,050 m. Weather is mild semi-wet with rain in summer, and semi-dry the remainder of the year, with an average temperature of 17°C (63°F). Hidalgo is one of the many states included in the nationwide fluoridated domestic salt program that constitutes the backbone of the oral health prevention policy in Mexico.

A total of 1,538 adolescents (representing 86.9 percent of the population) from 25 schools met the inclusion criteria: 12 and 15 years of age and attending elementary or junior high school in Tula del Centro, San Marcos, or El Llano. They agreed to participate in this study, and their parents signed the informed consent forms. Schools that did not authorize participation in this study (mainly because of administrative barriers), adolescents with fixed orthodontic appliance or full metal crowns, and adolescents who did not agree to participate or whose parents did not sign the informed consent, were excluded from the study.

Data Collection. A pilot study was conducted to standardize the clinical criteria and to verify the duration of examinations. Oral exams were performed by two examiners, who were previously trained and standardized. WHO's criteria for detection of caries were employed (kappa interexaminer = 0.93; intraexaminer = 0.98). The modified Dean Index was used to measure fluorosis, which was differentiated from other opacities (kappa interexaminer = 0.90; intraexaminer = 0.97). Dental exams were carried out under daylight, using a number five mirror, after plaque removal by toothbrushing. Every permanent tooth was included as long as it had least 50 percent of the crown erupted. A questionnaire was developed and tested and was addressed to the mothers/guardians to establish sociodemographic, socioeconomic, and behavioral variables.

Variables and Analysis. From the clinical examination, the experience of caries in the permanent dentition was calculated (DMFT index), the prevalence of caries (percentage of individuals with DMFT > 0), and two levels of severity of caries (percentage of subjects severely affected: DMFT ≥ 4 and DMFT ≥ 7). The significant caries index (SiC) was also calculated because the DMFT presents limitations in its distribution: the SiC refers to the third of the population more severely affected by dental caries. We also calculated the DMFT in this subgroup (22).

For later analyses, the dependent variable was the presence of dental caries in permanent dentition (DMFT > 0). Independent variables included were sex, age, dental visits, SES, locale of residence, and dental fluorosis (included as a marker of exposure to fluorides). Adolescents were assigned to one of the three communities if they lived there since birth, resided there continuously until at least age 6, and did not live more than 1 year outside the locale where they were born. There was also a category consisting of children from other Tula de Allende locales as well as children who did not ful-fill the previous residence criteria. Depending on the locale of residence, adolescents were thus assigned to one of the following categories: (0) Tula del Centro, (1) El Llano, (2) San Marcos, and (3) other.

The SES was constructed using schooling and occupation of both parents, variables commonly used in oral epidemiology studies. These variables were combined using the polychoric correlation of the principal component analysis (23), as the variables were categorical. The first component explained 52.0 percent of the variability and was divided into quartiles, with the fourth quartile representing the highest SES. Given that some mother and father information was missing (12 and 77 individuals, respectively), SES was only calculated for 1,452 (94.4 percent) adolescents.

With the information described, a database was constructed using SPSS® (SPSS, Inc., Chicago, IL). A univariate analysis was conducted to determine simple and absolute frequencies (for categorical variables) and mean and standard deviation (for continuous variables). In the bivariate analysis the distribution of caries across the variable's categories is reported without statistical test because of the census nature of study.

Results

Seven schools did not grant permission to participate in the study. In addition, 91 schoolchildren were excluded: 43 had fixed orthodontic appliances, two had anterior full crowns, 40 dropped out of school before the exam took place, and six

did not assent to the oral exam. Nonresponse rate for the exams was 5.6 percent. Out of the 1,538 adolescents, 49.9 percent ($n = 768$) were women; 44.7 percent were 12 years old and 55.3 percent were 15 years old. Description of variables included in this study is in Table 1.

Table 2 shows the distribution of caries indices. Prevalence of caries was 48.6 percent and DMFT was 1.15 ± 1.72. With regard to caries severity, 9.6 percent of the adolescents had DMFT ≥ 4, whereas 1.7 percent had DMFT ≥ 7. In the distribution of components of the caries index, 72.2 percent of the index was ascribable to the "decayed" component. The SiC (mean DMFT among one-third of the population more severely affected by caries) was 2.41 at 12 years old and 3.46 at 15. Higher experience, prevalence, and severity of caries (as well as in the DMFT index components) were observed in adolescents aged 15 than in those aged 12.

In the bivariate analysis (Table 3), higher experience and prevalence was observed in girls, in children with dental visit in the past year, those in the wealthiest SES (quartiles 2, 3, and 4), those whose locale of residence is in San Marcos and Tula Centro, and in fluorosis-free children and those with moderate/severe fluorosis. Results of the analysis between the components of the DMFT index and the SES in quartiles are shown in Table 4. Similar distribution was found for the "decayed" and "missing" components, and more dispersion in the "filled" component. In the same way, the percentage of dental visits made in the past year was higher with increasing SES. Two considerations should be noted in Table 4. As mentioned in the Material and Methods section, SES was only calculated for 1,452 adolescents. However, no obvious DMFT differences between individuals with or without SES data were observed either separately or in the global index. The SES was distributed somewhat differently across locales.

When we compared high-severity caries group (DMFT ≥ 4 as cutoff point), we observed higher caries severity in children with fluorosis (9.6 percent in very mild/mild, and 10.6 percent in moderate/severe) than children without fluorosis (7.8 percent). Additionally, compared only DMFT = 0 versus DMFT ≥ 4 similar results were observed; prevalence of DMFT ≥ 4 in fluorosis-free children was 13.5, while 15.5 and 17.1 was observed in children with

Table 1
Description of Sociodemographic and Socioeconomic Variables of Adolescents Included in the Study

	n (%)
Age (years)	
12	688 (44.7)
15	850 (55.3)
Sex	
Boys	768 (49.9)
Girls	770 (50.1)
Dental visits (last year)	
No	1,306 (85.0)
Yes	231 (15.0)
Socioeconomic status*	
1 (Poorest)	377 (25.9)
2	358 (24.7)
3	357 (24.6)
4 (Wealthiest)	360 (24.8)
Locale of residence (first six years of life)	
Tula Centro (1.42 ppm F)	821 (53.4)
El Llano (3.07 ppm F)	75 (4.9)
San Marcos (1.38 ppm F)	128 (8.3)
Other locales (n/a)	514 (33.4)
Current locale of residence	
Tula Centro (1.42 ppm F)	791 (51.4)
El Llano (3.07 ppm F)	175 (11.4)
San Marcos (1.38 ppm F)	572 (37.2)
Fluorosis	
Fluorosis free	283 (18.4)
Very mild/mild	802 (52.1)
Moderate/severe	453 (29.5)

* The first component explained 52% of the variance in socioeconomic status.
n/a = not available.

Table 2
Distribution of DMFT Index and SiC according to Age ($n = 1,538$)

Age (years)	χDMFT	χDT	χMT	χFT	DMFT > 0 (%)	DMFT ≥ 4 (%)	DMFT ≥ 7 (%)	SiC
12 ($n = 688$)	0.90 ± 1.33	0.73 ± 1.19	0.04 ± 0.40	0.18 ± 0.71	42.6	7.0	0.4	2.41
15 ($n = 850$)	1.36 ± 1.95	0.90 ± 1.40	0.05 ± 0.27	0.36 ± 1.23	53.4	11.7	2.7	3.46
Total	1.15 ± 1.72	0.83 ± 1.31	0.05 ± 0.33	0.28 ± 1.04	48.6	9.6	1.7	2.99

χDMFT, mean of decay, missing, and filling teeth; χDT, mean of decay teeth; χMT, mean of missing teeth; χFT, mean of filled teeth; SiC, significant caries index (mean DMFT in the one-third of the population more severely affected by dental caries).

Table 3
Bivariate Analysis of Logistic Regression between Caries Prevalence (0 = DMFT = 0, 1 = DMFT > 0) and Independent Variables Selected

	χDMFT ± SD (% > 0)
Age (years)	
12	0.90 ± 1.33 (42.6)
15	1.36 ± 1.95 (53.4)
Sex	
Boys	1.10 ± 1.62 (46.8)
Girls	1.21 ± 1.80 (50.4)
Dental visits (last year)	
No	1.10 ± 1.68 (46.9)
Yes	1.44 ± 1.88 (58.4)
Socioeconomic status*	
1 (Poorest)	0.95 ± 1.50 (42.7)
2	1.16 ± 1.76 (48.0)
3	1.14 ± 1.57 (51.5)
4 (Wealthiest)	1.31 ± 1.88 (51.9)
Locale of residence (first 6 years of life)	
Tula Centro (1.42 ppm F)	1.17 ± 1.82 (48.4)
El Llano (3.07 ppm F)	0.89 ± 1.13 (49.3)
San Marcos (1.38 ppm F)	0.86 ± 1.25 (43.8)
Other locales (n/a)	1.23 ± 1.70 (50.0)
Current locale of residence	
Tula Centro (1.42 ppm F)	1.29 ± 1.87 (51.7)
El Llano (3.07 ppm F)	0.95 ± 1.41 (44.6)
San Marcos (1.38 ppm F)	1.02 ± 1.55 (45.5)
Fluorosis	
Fluorosis free	1.16 ± 1.69 (50.5)
Very mild/mild	1.13 ± 1.71 (47.8)
Moderate/severe	1.19 ± 1.74 (48.8)

χDMFT, mean of decay, missing, and filled teeth ± standard deviation; n/a = not available.

Table 4
Analysis of Caries Index Components (Decay, Missing, and Filling Teeth) and Percentage of Dental Visits in the Last Year by Socioeconomic Status

Socioeconomic status	*n*	Decay	Missing	Filling	Visits
1 (Poorest)	377	0.76 ± 1.26	0.03 ± 0.20	0.16 ± 0.81	10.9%
2	358	0.81 ± 1.20	0.08 ± 0.42	0.21 ± 0.98	13.7%
3	357	0.91 ± 1.41	0.04 ± 0.20	0.25 ± 0.78	14.3%
4 (Wealthiest)	360	0.82 ± 1.36	0.04 ± 0.45	0.46 ± 1.28	23.1%
Total	1,452	0.82 ± 1.31	0.05 ± 0.34	0.27 ± 0.99	15.4

Visits represent the percentage of adolescents that have at least one dental visit in the last year.

very mild/mild and moderate/severe fluorosis.

Discussion

Data about oral health in adolescents is sparse in the scientific literature, not only in Mexico but also in general. In this context, one contribution of the present findings is to help fill the existing information gap for this age group. We will discuss the findings in terms of caries experience overall, caries and its distribution across socioeconomic and sociodemographic variables, and fluorosis status. First, we found that caries prevalence was close to 50 percent in this population – that is, one out of every two adolescents had at least one tooth decayed. This prevalence (42.6 percent), the DMFT index, (0.90 ± 1.33), and the SiC (2.41) observed in 12-year-old adolescents were lower than those reported in previous studies in Mexico – for example, the findings reported by Casanova et al. (4). A broad overview suggests that these results might be considered favorable in the context of other Latin American countries: one study from Costa Rica in 1999 reported DMFT averages of 2.46 and 4.37 in adolescents between 12 and 15 years old (11). In Nicaragua, Herrera et al. (9) reported caries prevalence of 54.5 percent, a DMFT of 1.51, and a SiC index of 4.12 in 12-year-old adolescents. In Brazil, Gushi et al. (12) reported DMFT average of 5.04 and a prevalence rate of 85.7 percent in 15-year-old adolescents, while Cangussu et al. (24) observed a caries prevalence of 51.0 percent with a DMFT of 1.44 among 12-year-old Brazilian adolescents, and 65.1 percent caries prevalence with a DMFT of 2.66 at age 15. In Guatemala, Archiva et al. (13) found a prevalence of caries at age 12 higher than 90 percent. Astroth et al. (10) reported caries indices of 4.08 and 6.04 for Panamanian adolescents aged 12 and 15, respectively, with a prevalence higher than 90 percent in the 12-years-old age group. The more consistent characteristic in Latin American studies on adolescents is the finding that the "decayed" component represents the largest percentage of DMFT – with the exception of recent studies by Solórzano (11) in Costa Rica and Gushi (12) in Brazil. Both observed a large contribution of the restorative experience – more than 60.0 percent of the DMFT index was made up by the "filled" component.

With regard to the modifying effect of different sociodemographic and socioeconomic variables, the findings from the present study support other studies. Variables such as age (4,7,11,13) and sex (4,9,14) played a substantial role in caries experience. In the case of SES, however, the situation was less clear. Some studies (16,25) have not found any definite relation between SES and dental caries, while other studies performed in Mexico and other countries (3–5,7,15) consistently demonstrated

an association between low SES (using different indicators) and caries prevalence both in children and in adolescents. In the present study, we observed the opposite trend: the better the socioeconomic position, the higher the prevalence of caries. Our initial interpretation speculated that variables used in the construction of the SES (schooling and occupation of the parents) had not been appropriate. When we re-ran the analysis with the variables "dental visits," "filled teeth," and SES, we found a positive relationship between the two variables, as reported in other studies of utilization of dental health care services (26) and other studies of caries (15,24). Based on the primary analysis and the confirmatory analysis, we conclude that the greater the SES, the higher the dental utilization and the number of filled teeth. Another explanation for these findings is that higher SES children may have been overtreated, that is, they receive more clinical courses of treatment than they strictly needed (Table 4). As far as the association between caries prevalence and use of dental services is concerned, we may speculate that children with higher treatment needs resort preferentially to restorative services – as would be the case of higher SES teenagers (with higher caries prevalence) receiving more restorative services.

The results showed that children with dental fluorosis have higher severity of caries (DMFT ≥ 4). These findings are consistent with the report by Vallejos et al. (19) in children with mixed dentition in Mexico, and with various international reports from less-developed countries and moderate-income countries. For example, in Ethiopia (20) a positive relation between DMFT ≥ 1 and the more severe levels of dental fluorosis (Thylstrup–Fejerskov ≥ 5) was reported, as well as in some communities with high concentration of fluorides in South Africa (21). Jackson et al. (27) summarized the current situation by indicating that, given the multiplicity of products with fluorides and fluoride sources available today, the risk of presenting mild fluorosis should be weighted simultaneously with the benefit of reducing dental caries experience. Dean originally established that the largest benefit of fluoride in water was accrued at about 1.00 ppm – obtaining the maximum reduction in dental caries while minimizing dental fluorosis and subsequently, Galagan et al. (28) determined the best concentration of fluoride to be between 0.7 and 1.2 ppm. More recently, Khan et al. (29) recommended that the concentration should take into account diverse aspects (such as weather) in each community. In the present study (looking at communities at high altitude generally), residing in a community with lower concentration of fluorides (1.38 ppm) was a protective factor when compared with the other two communities with higher concentrations. It is necessary to point out that, in general, a high prevalence of fluorosis was observed in all three communities (>80 percent), with almost a third of the overall study population having moderate to severe fluorosis. It remains speculative to consider that structural changes, characteristic of fluorosis beyond the mildest presentations, might be associated with undermining of the dental tissues. Whether these presentations contribute to caries progression is undecided (29).

There are certain methodological features that must be highlighted in the discussion of findings. The limitation of any cross-sectional design emphasizes the need to undertake a cautious interpretation of the results; because the study measures cause and effect at the same point in time, its design introduces the problem of temporal ambiguity and the inability to establish causal relationships. Also, while the study targeted a large number of schoolchildren in small-size locales in Mexico (oftentimes overlooked in past epidemiological surveys in Mexico, compared to large-city oral health surveys), the present results cannot be directly extrapolated to the country at large. Even though we had a high participation rate (>80 percent) we cannot completely eliminate the possibility of bias because of differential participation across teenagers. Additionally, the possibility of misclassification of enamel discolorations as fluorosis exists. The comparisons relating the SES in our study with those in other studies in Mexico and Latin America should be done carefully because different indicators and SES distribution were used within the communities studied.

Various conclusions can be derived from the findings, highlighting the considerable methodological strengths of our approach. The experience, prevalence, and severity of caries in adolescents aged 12 and 15 was relatively low when compared with studies carried out in Mexico and other Latin American countries. Certain key socioeconomic and sociodemographic variables were found to be related with dental caries. However, SES held the opposite relationship described in other reports: we found that the higher the SES, the higher the level of dental caries experience. We believe that factors such as diet in the context of socioeconomic level would need to be evaluated in a future study, to disentangle possible interactions between socioeconomic level and having a cariogenic diet. Finally, an association of severity of dental fluorosis and caries severity was observed. While fluorosis was very common, it was often mild or very mild. Certain ethical and health policy issues pertinent to the dosage and the overall balance between benefits and disadvantages of the salt fluoridation program need to be addressed.

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