

Marginalization and fluorosis its relationship with dental caries in rural children in Mexico: A cross-sectional study

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Objective: Examine the association between marginalization and fluorosis with caries experience in Mexican rural children aged 8-12, in Oaxaca, Mexico. **Methods:** Cross-sectional study of 283 rural schoolchildren selected from two locations with high and medium levels of marginalization where the water fluoride concentration ranged from 2.0 to 2.5 ppm/F. Caries was evaluated using the DMFT index and dental fluorosis with the Thylstrup-Fejerskov Index (TFI). Socioeconomic data were collected from participants' parents, with data on the children's characteristics collected from them via a questionnaire. **Results:** The prevalence of caries was 72.4% (DMFT \geq 1) in the permanent dentition. The prevalence of fluorosis was 98.0% (TFI \geq 4=71.4%). 54.8% of the children brushed their teeth two or more times daily. In logistic regression children living in high levels of marginalization were more likely to present caries (OR=2.11, 95% CI 1.13 – 3.93) than children living in medium levels. Children with severe fluorosis (TFI \geq 4) (OR=1.93, 95% CI 1.06 – 3.53) were more likely have caries than those with TFI <3. **Conclusion:** Rural children with a high level of marginalization and fluorosis (TFI \geq 4) were more likely to present caries. Poor oral hygiene and low dental service levels were found in both marginalized areas. Populations with medium/high marginalization are more susceptible to caries.

Keywords: dental caries, dental fluorosis, marginalization, rural children

Introduction

Marginalization is a multidimensional and structural phenomenon that refers to the exclusion of people within a society, inequality in the distribution of progress and the exclusion of various social groups from both the process and benefits of development (Baah *et al.*, 2019). At an individual level, marginalization is the result of the exclusion of an individual from participation in society, with marginalized people mainly experiencing complex economic situations, social inequality, a lack of access to healthcare and discrimination (Singh *et al.*, 2017; Rosenberg and Andersson, 2000). Marginalization and poverty are related phenomena that present due to a lack of economic income, with both tending to be concentrated in certain populations for which there is no economic dynamic promoting the creation of the employment required by society (Aguilar-Ortega, 2016).

Various aspects of the physical and social environment influence health and wellbeing, among which, area of residence, education, exposure to violence and access to medical attention are highlighted (Marmot and Bell, 2016). Moreover, one of the most important factors in marginalization is the large, persistent and generalized socioeconomic health differences found in different populations, wherein people with low incomes are more likely to live in areas of residence presenting poverty (Präg *et al.*, 2016). These marginalized populations face situations

of elevated social vulnerability which do not result from individual choices, but from a production model that does not provide the same opportunities to all.

Data collected at a global level (UN-Habitat Global Housing Strategy Framework) report that 783 million people live below the international poverty line, with, in 2013, more than 860 million of people living in precarious settlements, an increase of 135 million on the figure from the year 2000. Moreover, more than 1.1 billion individuals lack access to drinking water and 2.6 billion people have no access to adequate healthcare facilities.

In Mexico, the *Encuesta Nacional de los Hogares* (ENH or National Household Survey) 2016 estimated that, of 34.1 million homes, 21.7% were found in rural and 78.3% in urban locations. Children and adolescents represent 32.8% of the population, with rapid growth.

In Mexico (Gutiérrez *et al.*, 2016a, b) and other countries, both health and access to healthcare services are better for those of a high socioeconomic level. These differences are explained not only by the level of access to healthcare services but also by the social determinants of health (Walker *et al.*, 2014; Martens *et al.*, 2014).

Dental caries is a significant public health problem affecting all the population due its high prevalence and incidence. In Mexico, the prevalence of dental caries is approximately 80% among schoolchildren aged 12 years (Irigoyen *et al.*, 2000). Low levels of dental care

and high sugar consumption are associated with caries in the marginalized child population of India (Baah *et al.*, 2019), while an association is reported between a low socioeconomic level and caries in Mexican children (Irigoyen *et al.*, 1999).

Dental fluorosis is a hypomineralization of the enamel characterized by greater level of porosity on the enamel surface caused by high levels of fluoride consumption during tooth formation. It is characterized by porous areas and, in more serious cases, the loss of enamel structure, which could lead to the loss of the anatomical form of the tooth. A systematic review reported the prevalence of dental fluorosis in Mexico to vary from 15.5 to 100%. In areas where water fluoride levels are low or optimal (<1.5ppmF) the prevalence was 15.5 to 81.7%. In areas with high levels of naturally fluoridated water (>1.5ppmF), the prevalence was 92 to 100% (Aguilar-Díaz *et al.*, 2017). Serious forms of fluorosis (TF \geq 4) were associated with the child's mother having a low educational level and other indicators of low socioeconomic status (Pérez-Pérez *et al.*, 2017).

Unfortunately, little research has reported the relationships between the degree of marginalization, fluorosis and dental caries, which restricts understanding of the pattern of the state of oral health in marginalized areas. Moreover, few data are available on the state of oral health in children living in areas with different degrees of marginalization or in rural areas. Thus, this study aimed to examine the association between marginalization and fluorosis with caries experience in Mexican rural children aged 8-12, in Oaxaca, Mexico.

Methods

The water fluoride concentrations were determined using a specific electrode (Thermo Scientific Orion Star™, Waltham, MA, USA), while samples were analyzed according to the Official Mexican Standard NMX-AA-077-SCFI-2001. The fluoride level of the drinking water in the study area was between 2.0-2.5 ppm/F.

This cross-sectional study was carried out in the state of Oaxaca, the state with the second highest level of poverty in Mexico. In 2016, 70.4% of the population was living in poverty and 26.9% in extreme poverty (National Council for the Evaluation of Social Development Policy) (CONEVAL, 2016). Two communities, located in the centre and south of the study area, with an altitude between 1500-1600 metres above sea level were selected. In Mexico, rural localities are those with a population of fewer than 2500 inhabitants (CONAPO, 2015). Approximately 23% of the population lives in rural areas. The localities are under developed: 13.3% of people over 15 years of age are illiterate, 38% of the population is in conditions of food poverty, the infant mortality rate is 19%, 45.3% received piped drinking water, 51.0% have a drainage system and 28.8% have access to health services.

The sample size was set in order to estimate an Odds Ratio (OR) = 1.5, with 80% power, an alpha of 0.05 and a probability of 0.35 for caries. Considering the probability, children living in places with medium and high degrees of marginalization are likely to have caries.

Government statistics used to calculate the marginalization rate comprise a summary measure that enables both the differentiation of the different geographical units of the country, according to the overall impact of the deficiencies experienced by the population due to the lack of adequate housing and property, and the identification of the territorial disparities between these units. This index is constructed from nine socioeconomic indicators that point to the lag or deficit in communities the relative deprivation in each federal entity or municipality. The absence of any of the nine indicators denotes that the well-being of the population is retarded to some degree. With the level of marginalization classified by the index as *Very Low*, *Low*, *Medium*, *High* and *Very High*, the two locations selected for the present study were considered as having medium and high levels of marginalization.

Local authorities and the children's parents were informed of the study objectives and procedures, with those parents who agreed to the participation of their children signing the informed consent form. The inclusion criteria were: children aged between 8 and 12 years old; of either gender; with written authorization to participate in the study. Four hundred consent forms were distributed to schoolchildren in the study area, of which 350 were signed by parents, giving a non-response rate of 12.5%. Data for 283 children were analyzed, with 67 schoolchildren excluded based on having a change of residence for more than six months up to the age of seven or having an orthodontic appliance fitted.

The following variables were included: age (in years); sex (boy/girl); toothbrushing frequency (number of times a day) dichotomized into (< 2 or \geq 2 times a day); use of fluoride toothpaste (yes/no/do not know); consumption of fluoridated salt (yes/no); soft drink consumption (seldom/a few times per week/at least once per day); consumption of sweets (seldom/a few times per week/at least once per day); mother's level of education (technical diploma or university/secondary school/primary school/lower); employment status of the head of the family (employed/unemployed/retired/other); Marginalization Index (medium/high) and time since last dental visit \geq 6 months (yes/no).

The clinical examinations were conducted by one dentist using dental mirrors (# 5), WHO probe and artificial light, with the teeth brushed before the examination. The dentist conducting the oral examination had already been standardized with the gold standard, obtaining Cohen's kappa coefficients for intra-rater reliability of 0.81 and 0.84, for fluorosis and dental caries, respectively. The examination adhered to the corresponding infection control standards. Participants' dental caries status in the permanent dentition was determined using the World Health Organization (WHO, 1997) criteria to obtain a Decayed Missing and Filled Teeth (DMFT) score. Children having at least one or more decayed tooth surfaces requiring restoration were regard as caries active. Dental fluorosis was recorded using the Thylstrup-Fejerskov (1978) Index (TFI). The buccal, occlusal and lingual surfaces of participants' erupted permanent teeth were examined, using scores of four and higher as a cutoff value to denote children with moderate and severe fluorosis respectively, based

on the two most severely affected teeth. Oral Hygiene was measured with the Simplified Oral Hygiene Index (OHI-S), dichotomized into poor and good (OHI-S ≥ 2 and <2 respectively)

The research protocol was reviewed and approved by the Ethics Committee of the Faculty of Dentistry at the National Autonomous University of Mexico (UNAM/PMDCMOS 221/2011). The research was conducted in full accordance with the World Medical Association Declaration of Helsinki. Informed consent was obtained from all study participants.

Bivariate analysis was performed to assess relationships between the independent variables in children with and without caries, using the Pearson Chi-squared test for categorical variables and the Kruskal-Wallis test for numerical variables. The association between marginalization and dental caries (DMFT ≥ 1) was tested in multiple logistic regression models adjusted for confounders, with the Odds Ratio (OR) calculated to a 95% confidence interval (95% CI). Model diagnostic tests were conducted using Hosmer-Lemeshow goodness of fit and the analysis of extreme values. Values of $p \leq 0.05$ were considered statistically significant. The analysis was performed using the Stata 15 program (Stata Corp, College Station, TX, USA).

Results

A total of 283 children were included, with a mean age of 10.6 (± 1.06). The percentage of girls and boys examined was 51.9% and 48.1%, respectively. Almost half (45.2%) brushed their teeth less than twice a day, 83.8% using toothpaste and 60.4% had poor OHI-S scores. Proportionately more girls brushed their teeth twice a day or more (52.2% vs 38.8%, $p = 0.023$). Many (95.4%) of the children consumed fluoridated salt. Most children's families (58.7%) were experiencing a high level of marginalization and 41.3% medium. Marginalization was not associated with gender.

The prevalence of caries (DMFT ≥ 1) in permanent dentition was 72.4% and mean DMFT was 3.30 (± 2.63). Mean DMFT was similar in girls and boys (3.41 ± 2.64 and 3.11 ± 2.63 respectively, $p=0.134$). The largest component of the DMFT score was decayed teeth with 71.6%, followed by filled teeth with 23.4% and 5.0% teeth. Caries was more prevalent in high than in low high marginalization children (81.9% and 59.0% respectively). The frequency distributions of DMFT scores in children in medium and high marginalization families are presented in Figure 1.

Poor oral hygiene was more common in children with caries than those without (65.8% vs 47.4%, $p=0.005$). The overall prevalence of fluorosis was 98.0%, with the children falling into the following categories by their most severely affected teeth: TFI 0=2.0%; TFI 1=3.8%; TFI 2=7.0%; TFI 3=15.8%; and TFI ≥ 4 =71.4%. The anterior and posterior teeth contributed similarly to the prevalence of fluorosis in both locations. Severe fluorosis (TFI ≥ 4) was more common in children with caries than without (76.6% vs 57.7%, $p=0.002$) (Table 1) and in high than low marginalized children (79.5% vs. 59.8%, $p<0.001$) (Table 2).

In logistic regression adjusted for age, sex, mother's level of education, dental visits (≥ 6 months), oral hygiene (OHI-S), toothbrushing frequency and fluorosis (Table 3), children with a high level of marginalization were more likely to present caries [OR=2.11 (CI95% 1.13 – 3.93) $p=0.019$] than children with a medium level. Children with severe fluorosis score were more likely to present caries than children with less fluorosis [OR=1.93 (CI95% 1.06 – 3.53); $p=0.031$]. Children with poor oral hygiene were more likely than children with good oral hygiene to have caries [OR=1.84 (CI95% 1.04 – 3.25); $p=0.036$]. Additionally, children with dental visits <6 months were more likely to present caries than children with visits at longer intervals [OR=1.87 (CI95% 1.04 – 3.36); $p=0.036$].

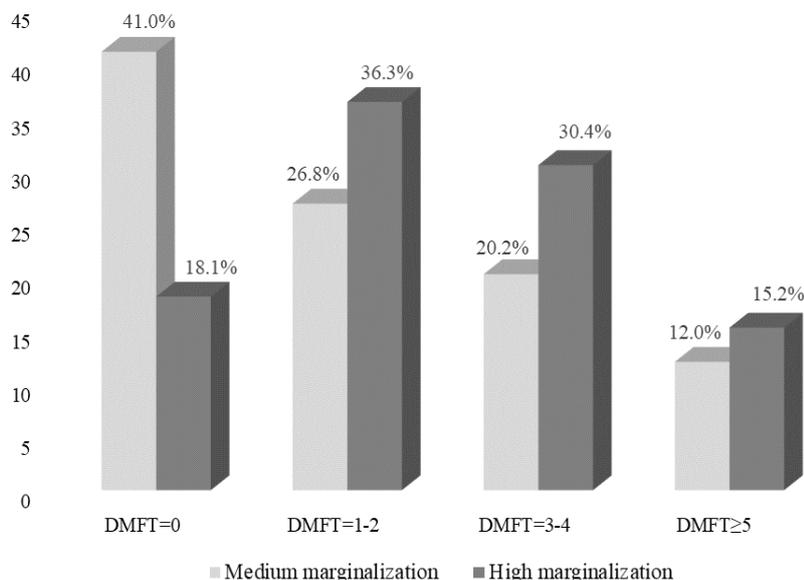


Figure 1. Frequency distribution of DMFT scores in rural children with medium and high marginalization.

Table 1. Characteristics in rural children aged 8 to 12 years with and without caries.

	DMFT=0 n=78	DMFT≥1 n=205	Value p*
Age	10.5 (±1.08)	10.7 (±1.20)	0.172
Sex			
Male	38 (48.7)	109 (53.2)	0.503
Female	40 (51.3)	96 (46.8)	
Toothbrushing frequency			
≥ 2 times a day	43 (55.1)	85 (41.5)	0.039
< 2 times a day	35 (44.9)	120 (58.5)	
Oral hygiene (OHI-S)			
Poor hygiene	37 (47.4)	135 (65.8)	0.005
Good hygiene	41 (52.6)	70 (34.2)	
Use of fluoride toothpaste			
Yes	65 (83.3)	172 (83.9)	0.908
No/do not know	13 (16.7)	33 (16.1)	
Consumption of soft drinks			
Seldom	7 (9.0)	30 (14.6)	0.064
Sometimes per week	51 (65.4)	145 (70.8)	
> Once per day	20 (25.6)	30 (14.6)	
Consumption of sweets			
Seldom	8 (10.2)	30 (14.6)	0.344
Sometimes per week	40 (51.3)	113 (55.1)	
> Once per day	30 (38.5)	62 (30.3)	
Mother's level of education			
Primary or less	50 (64.1)	142 (69.3)	0.016
Secondary	17 (21.8)	54 (26.3)	
Technical or University	11 (14.1)	9 (4.4)	
Employment reference person			
Employed	70 (89.7)	188 (91.7)	0.603
Unemployed	8 (10.3)	17 (8.3)	
Dental visits ≥6 months			
No	38 (48.7)	137 (66.8)	0.005
Yes	40 (51.3)	68 (33.2)	
Dental fluorosis TFI			
TFI <4	33 (42.3)	48 (23.4)	0.002
TFI ≥4	45 (57.7)	157 (76.6)	

Discussion

In this study, children with a high level of marginalization were more than twice as likely to have dental caries than those with less marginalization, after adjustment for other risk factors. In addition, children with severe fluorosis (TFI ≥4) were more likely to have caries than those without.

Marginalization is a multicausal structural phenomenon, with multiple geographical dimensions found in many developing countries. In Mexico, despite the development of various programs, together with the creation of large-scale healthcare institutions, marginalization still affects numerous locations, particularly in the south and south east of the country, which are confronted by higher levels of poverty and inequality.

Research has revealed different associations between marginalization and caries. In an uncontrolled study of 6-15-year-old marginalized children in Ethiopia, 74.0% had signs of caries (Burnett *et al.*, 2016). Conversely, Singh *et al.* (2017) reported low caries levels in children in marginalized areas, with only 26.7% presenting caries in the primary and 19.3% in the permanent dentitions. Similarly, in 5 to 12-year-old Indian children, 70.3% of the marginalized population presented untreated caries (Singh *et al.*, 2011).

The association between the presence of caries and marginalization seen in this study may be partly explained by limited access to healthcare services as 71.7% of the children with a high level of marginalization had not visited the dentist in the last year. The poor oral hygiene in

Table 2. Characteristics of rural children with medium and high marginalization

	Medium n=117	High n=116	p*
Age	10.6 (±0.85)	10.7 (±1.31)	0.626
Sex			
Male	65 (55.6)	82 (49.4)	0.307
Female	52 (44.4)	84 (50.6)	
Toothbrushing frequency			
≥ 2 times a day	58 (49.6)	70 (42.2)	0.218
< 2 times a day	59 (50.4)	96 (57.8)	
Oral hygiene (OHI-S)			
Poor hygiene	60 (51.3)	112 (67.5)	0.006
Good hygiene	57 (48.7)	54 (32.5)	
Use of fluoride toothpaste			
Yes	98 (83.8)	139 (83.7)	0.995
No/do not know	19 (16.2)	27 (16.3)	
Consumption of soft drinks			
Seldom	15 (12.8)	22 (13.2)	0.004
Sometimes per week	71 (60.7)	125 (75.3)	
> Once per day	31 (26.5)	19 (11.5)	
Consumption of sweets			
Seldom	19 (16.2)	19 (11.5)	0.383
Sometimes per week	64 (54.7)	89 (53.6)	
> Once per day	34 (29.1)	58 (34.9)	
Dental visits ≥6 months			
No	56 (47.9)	119 (71.7)	<0.001
Yes	61 (52.1)	47 (28.3)	
Dental fluorosis TFI			
TFI <4	47 (40.2)	34 (20.5)	<0.001
TFI ≥4	70 (59.8)	132 (79.5)	
Dental caries			
DMFT=0	48 (41.0)	30 (18.1)	<0.001
DMFT≥1	69 (59.0)	136 (81.9)	

marginalized children could also be related to low access to oral health information or lack of financial income to buy oral hygiene aids.

Healthcare inequalities are an obstacle to overcoming poverty and achieving sustainable development. It is important, in a population, to ensure homogeneous access not only to healthcare services but also to the same opportunities, as the elimination of differences in the child population will have a positive impact on an individual's adult life and the gradual closure of socio-economic gaps (Gutierrez *et al.*, 2016a, b). In the present investigation more than 60% of rural children with high marginalization have not visited the dentist in the last 6 months. It is important to introduce new strategies that help reduce social inequalities in health, in addition to allowing health services to be adapted to the needs of the population with the aim of achieving equity in health.

Most children used toothpaste and almost half brushed their teeth at least twice a day, which is slightly less than in a study in a similar study in India (Singh *et al.*, 2011).

Another study of 6 to 12-year-old Mexican schoolchildren found low tooth brushing frequency to be associated with poor oral hygiene (Villalobos-Rodelo *et al.*, 2007),

The child participants in this study showed a high severity of dental fluorosis, likely attributable to the high natural fluoride concentrations of the local water, in addition to being exposed to multiple additional sources of fluoride, such as purified water, salt and toothpaste.

There were higher caries levels of caries amongst children with severe fluorosis. High marginalization was also associated with severe of fluorosis. Similar results have been found in other studies. For example, a study conducted in Ethiopia showed a positive association between the prevalence of caries and fluorosis in children (Wondwossen *et al.*, 2004). Another in Mexico with children aged 8-12 showed that fluorosis at moderate and severe levels was associated with a higher caries prevalence (García-Pérez *et al.*, 2013).

One possible explanation for the association between fluorosis severity and caries is that the porosity of teeth

Table 3. Logistic regression model for presence of dental caries (DMFT \geq 1) in rural children in Mexico.

Variables	Crude Odds Ratio (95%CI)	p	Adjusted Odds Ratio (95%CI)	p
Age†	1.17 (0.93 – 1.47)	0.172	1.09 (0.83 – 1.42)	0.519
Sex‡	0.83 (0.49 – 1.41)	0.503	0.89 (0.50 – 1.58)	0.693
Maternal education ¶	2.42 (1.03 – 5.67)	0.041	1.29 (0.49 – 3.35)	0.601
Dental visits (\geq 6 months) §	2.12 (1.24 – 3.60)	0.005	1.87 (1.04 – 3.36)	0.036
Oral Hygiene (OHI-S) •	2.13 (1.25 – 3.63)	0.005	1.84 (1.04 – 3.25)	0.036
Marginalization ∞	3.15 (1.83 – 5.41)	0.001	2.11 (1.13 – 3.93)	0.019
Dental fluorosis TFI \geq 4 #	2.39 (1.37 – 4.17)	0.002	1.93 (1.06 – 3.53)	0.031
Toothbrushing frequency**	1.73 (1.02 – 2.93)	0.040	1.48 (0.84 – 2.61)	0.170

Reference group: Age† = Continuous, Sex‡= Male, Mother's level of education¶= technical or university, Dental visits§ =Yes, OHI-S•= Good, Marginalization∞= medium, Dental fluorosis TFI \geq 4# = TFI<3, Toothbrushing frequency** \geq 2 times a day
Log likelihood = -148.77433, Hosmer-Lemeshow=0.194

severely affected by fluorosis may cause loss of dental enamel structure during masticatory force, exposing dentine and facilitating the accumulation of biofilm which is difficult to remove during tooth brushing (García-Pérez *et al.*, 2013; Fejerskov and Kidd, 2008).

The lack of access to healthcare affects, in large part, the population, mainly children, living in conditions of poverty and marginalization. Marginalization is related not only to the lack of opportunities and the inability to find or generate them, but also to the lack of access to goods and services fundamental for the wellbeing and development of the population.

This study was limited by a lack of socioeconomic data about the childrens' parents. While the children studied were not randomly selected, this is less likely to have affected the relationships between variables.

Conclusions

High level marginalization was associated with fluorosis with dental caries experience, adjusting for confounding variables. Moreover, poor oral hygiene and low level access to dental services were found in many children. Marginalization is a multicausal phenomenon requiring groups of actions that promote health and education and the diet of the most vulnerable sectors of the population (Aguilar-Ortega, 2016).

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