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Impact of diseases of the hard tissues of teeth on oral health-related quality of life of schoolchildren in area with a high concentration of fluoride in drinking water

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Objective: To assess the impact of caries, Molar Incisor Hypomineralization (MIH), and fluorosis on the Oral Health-Related Quality of Life (OHRQoL) of schoolchildren aged 8-10 years living in area with different fluoride levels in the drinking water. ***Subject and Methods:*** The prevalence of caries and fluorosis were assessed among 663 Mexican schoolchildren using the International Caries Detection and Assessment System (ICDAS II) and the Thylstrup and Fejerskov Index (TFI), respectively. MIH was recorded using the European Academy of Pediatric Dentistry (EAPD) criteria and OHRQoL using the Child Perceptions Questionnaire (CPQ_{8-10}). Poisson regression models were used in data analysis. ***Results:*** Schoolchildren presenting two of the three conditions (cavitated lesions and TFI≥4, cavitated lesions and MIH or TFI≥4 and MIH) experienced worse quality of life than children who did not [RR=4.18; (95% CI 3.83, 4.56)]. Children with all three conditions had worse quality of life than children who did not [RR=5.64; (95% CI 5.13, 6.20)]. ***Conclusions:*** Fluorosis, MIH, and caries have a negative impact on the OHRQoL of schoolchildren living in area with a high concentration of fluoride in their drinking water.

Keywords*: Dental caries, Molar Incisor Hypomineralization, dental fluorosis, OHRQoL, children.*

Introduction

OHRQoL is a complex and multidimensional indicator of the continual process of cognitive, emotional, social, and language development throughout childhood (Barbosa and Gavião, 2008). It is related to emotional, psychological, functional, and social factors and the experience of the pain and discomfort (acute or chronic) in the orofacial region that affect individuals' well-being (Bennadi and Reddy, 2013).

Oral conditions can affect an individual's self-image, self-esteem, mastication, respiration, and daily activities, such as attending school and seeing family and friends (Rozier and Pahel, 2008). Oral disorders such as caries, Molar Incisor Hypomineralization (MIH), and fluorosis can have a negative impact on quality of life during childhood (Leal *et al*., 2012; Li *et al*., 2014).

Dental caries is a multifactorial disease occurring in school-age children, with epidemiological data showing that its prevalence in Mexico ranges from 22%-79% (García Pérez *et al*., 2021; Velázquez Monroy *et al*., 2003; Villalobos-Rodelo *et al*., 2007). Caries has a negative impact on children's quality of life in terms of oral symptoms (problems with chewing), functional limitations (problems with speaking), and emotional and social well-being (low self-esteem and impacts on friendships) (García-Pérez *et al.*, 2017). Children with untreated caries have a poorer perception of OHRQoL, due to pain and problems with eating and sleeping, which tends to worsen with the progression of the caries (Corrêa-Faria *et al*., 2018).

Other oral disorders, such as dental fluorosis and MIH also present in school-age children. Dental fluorosis is a condition characterized by staining and hypomineralization of the enamel due to excessive ingestion of fluorides during amelogenesis and has been studied in most detail in permanent teeth (Pérez-Pérez *et al*., 2017). In Mexico, the prevalence of this condition ranges from 15.5% to 81.7% in areas with low/optimal levels of fluoride in the drinking water (<1.5 ppmF) and from 92% to 100% in areas with the highest levels (>1.5ppmF) (Aguilar-Díaz *et al.*, 2017). Similarly, MIH is an enamel condition characterized by white to brown lesions, mainly affecting the first molars and permanent incisors. The prevalence of MIH in Mexico ranges from 15.8% to 42.4% (Gurrusquieta *et al*., 2017; Irigoyen-Camacho *et al*., 2020), while, in areas with higher levels of fluoride (>1.5ppmF) in the drinking water, it ranges from 10.4 to 12.4% (Fernandes *et al*., 2021; Sosa-Soto *et al*., 2021). Both conditions can cause aesthetic problems and damage self-esteem, thus having a negative impact on the OHRQoL of schoolchildren (Aguilar-Díaz *et al*., 2011; Gutierrez *et al*., 2019).

Different questionnaires have been developed to determine the OHRQoL of school-age children (Jokovic *et al*., 2004; Scott *et al*., 2021). One of the most commonly used is the Child Perceptions Questionnaire (CPQ), an instrument validated in Spanish (Aguilar-Díaz and Irigoyen-Camacho, 2011; Del Carmen *et al*., 2013) that can be used with eight-to-fourteen-year-old children in Mexico. Is also a commonly used subjective indicator

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that closely correlates with clinical oral health status and is divided into four domains: oral symptoms; functional limitations; social and, emotional well-being. The CPQ also includes sub-subscales that address interactions in school and recreational activities and was developed and validated, in the English language, in Canada, wherein their psychometric properties were deemed satisfactory, thus indicating their validity (Torres *et al*., 2009).

Two studies have researched the impact of two conditions (caries-fluorosis and MIH-caries) on the OHRQoL of schoolchildren, both of which found a significant reduction in OHRQoL with caries, fluorosis, and MIH (García-Pérez *et al*., 2017; Michaelis *et al*., 2021). Considering the high prevalence of caries, fluorosis, and MIH in Mexican children, it is of interest to research the impact of these conditions on OHRQoL, taking into account the different levels of severity, using methods that are easily applied and understood on a population level. In addition, the assessment of OHRQoL can help to improve the evaluation of dental treatment strategies and other and oral health initiatives. Therefore, the present study aimed to determine caries, fluorosis, and MIH, using indices that are easy to apply and understood by dental practitioners.

As OHRQoL plays an important role in understanding patients' subjective evaluation' and experience' of oral health, it is essential to understand the relationships between clinical conditions and OHRQoL. Oral health can be influenced by various social determinants that can compromise oral functionality, well-being, and quality of life in children. Understanding the relationship between these factors and OHRQoL enables the effective design and implementation of interventions to improve peoples' experience of oral health. Thus, this study aimed to assess the impact of caries, MIH, and fluorosis on the OHRQoL of 8-10-year-old schoolchildren living in area with different level of fluoride in the drinking water. The underlying hypothesis was that children with all three conditions (cavitated lesions, MIH and TFI ≥4) would have worse OHRQoL (that is, higher CPQ scores).

Material and methods

The study was carried out in adherence with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement. The cross-sectional study on which the present analysis was based was conducted from October to December 2021. The research protocol applied was approved by the Ethics Committee of the Faculty of Higher Studies Iztacala at the National Autonomous University of Mexico (CE/FESI/012022/1444). Both the leadership teams at the primary schools sampled and the participants' parents were informed of the protocol, with those parents who agreed to their children's participation signing the informed consent form.

The study site, located in the municipality of Ayala in the state of Morelos, was selected using the 2021 edition of the annual report on poverty and social inequality in Mexico produced by the *Instituto Nacional de Estadística y Geografía* (INEGI or National Institute of Statistics and Geography). That report shows that 15.1% of Mexicans do not have access to health services, 26.8% do not have access to basic services (drinking water, drainage, and electricity) in the household, 26.9% do not have access to food, 20.7% present educational inequality, and 53.3% live in moderate to extreme poverty (INEGI, 2021). The fluoride concentration in the drinking water was determined using an electrode (Thermo Scientific Orion Star™, Waltham, MA, USA), while the samples were analyzed in accordance with the relevant Official Mexican Standard (NMX-AA-077-SCFI-2001). The fluoride level of the drinking water sampled from the study area was measured at 1.0-1.39 ppm/F.

The inclusion criteria for the study were as follows: schoolchildren of either gender aged 8-10 years; written parental authorization to participate; the four upper and lower incisors and the first four permanent molars fully erupted; and the parents/guardians of the participant residing at the same address. The exclusion criteria were as follows: declining to cooperate with the OHRQoL questionnaire; the presence of a craniofacial deformity; a history of dental trauma; current orthodontic treatment; or not cooperating during the oral examination.

The following independent variables were obtained through an interview with the child: age; gender (boy/girl); toothbrushing frequency (number of times a day) dichotomized into < 2 or ≥ 2 times a day; Clinical examination recorded the debris and calculus indices of the Simplified Oral Hygiene Index (OHI-S), dichotomized into poor and good hygiene. An abbreviated OHI-S recorded six surfaces selected from four posterior and two anterior teeth (World Health Organization, 2013).

Dental fluorosis was assessed using the TFI for the buccal, occlusal, and lingual surfaces of the erupted permanent teeth using categories that ranged from 0-9 based on the histological changes produced by different degrees of dental fluorosis (Thylstrup and Fejerskov, 1978). TFI scores were categorized into TFI=0, TFI 1–3, and TFI ≥4 based on the two teeth with the most severe fluorosis, with Category 4 and higher (TFI ≥4) including children with both moderate and severe fluorosis, was used as the cutoff value. Dental caries was assessed in the primary and permanent dentition using ICDAS II, which includes non-cavitated and cavitated carious lesions. The ICDAS II detection codes for coronal caries range from 0 to 6 depending on the severity of the lesion. Higher ICDAS II scores indicate more severe untreated carious lesions (Ismail *et al*., 2007).

Due to the impracticality of drying the teeth for oral examinations, it was decided that ICDAS II Code 1 would be excluded. The following cut-off points were used to allow comparability of the results with other studies: caries free (ICDAS II 0); incipient lesions (ICDAS II 2–3); and, cavitated lesions (ICDAS II ≥4) (primary + permanent dentition).

MIH was assessed on vestibular, occlusal/incisal, and palatal surfaces of all erupted permanent molars and incisors using the EAPD criteria (Weerheijm *et al*., 2003). A child was classified as having MIH when any of the first permanent molars showed signs of the condition. Mild MIH was considered present when demarcated enamel opacities were lacked post-eruptive loss of enamel, if there was occasional sensitivity to external stimuli but not brushing, and the incisor discoloration prompted only mild aesthetic concerns. Moderate MIH was determined with a yellow or brown demarcated opacity of >1 mm affecting less than one third of the tooth surface; two or

more white or creamy demarcated opacities of >1 mm and affecting at least one third but less than two thirds of the tooth surface (which may present a rough enamel surface); post-eruptive enamel breakdown ≤2 mm in diameter; or, atypical restorations involving at least one third but less than two thirds of the affected tooth surface. Severe MIH was recorded when, in addition to demarcated opacities there was post-eruptive enamel breakdown or persistent/ spontaneous hypersensitivity affecting function (Irigoyen-Camacho *et al*., 2020; Lygidakis *et al.,* 2008). The severity of the MIH was determined based on the most severe defect in the first permanent molars or incisors.

The outcome variable, patient OHRQoL, was determined using the Spanish version of the CPQ_{8-10} (Aguilar-Díaz and Irigoyen-Camacho, 2011), which consists of 25 items enquiring about participants' experiences during the last four weeks using Likert scales (0–4). All the response codes in the questionnaire are added together, giving a score ranging from 0 to 100 across four domains of oral symptoms; functional limitations; emotional well-being; and, social well-being. Higher CPQ_{8-10} scores denote greater negative impacts of the oral conditions on the child's quality of life. In addition, the $CPQ_{8–10}$ has two global questions, one of which is related to the general perception that the child has about the state of their oral health, while the other relates to the extent to which the child's oral/ oro-facial condition affects their general well-being. The CPQ_{8-10} was completed by children in the classroom and was completed in approximately 15 min.

The oral examinations were performed by two examiners, both experienced dentists, at each school using a mouth mirror, artificial light and a WHO probe. Before the examination the child brushed their teeth to remove plaque or food remnants. The two dentists were previously trained and calibrated, via a process consisting of two steps (theoretical and clinical), for MIH, caries, and dental fluorosis, while their inter and intra-examiner agreement for caries, MIH, and dental fluorosis corresponded to a Cohen's kappa coefficient of 0.86, 0.84 and 0.83, for dental caries, fluorosis, and MIH, respectively. The school-age children were highly vulnerable to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection (Rathore, 2020; Liu *et al*., 2020). Given the risk of infection, standard protection measures were implemented for the oral examinations were used, including good hand hygiene (Ijaz *et al*., 2021) and Lysol™ and sodium hypochlorite applied to clean and disinfect the work surfaces. After the examination, the surfaces were deep cleaned and the dental instruments cleaned, sterilized, and carefully stored. Examiners wore N-95 masks, single-use gloves, gowns, and protective glasses or face shields. Only one child was allowed to enter the classroom per examination, in order to avoid the unnecessary gathering of groups of people. On entering the premises, school authorities took each child's temperature and asked them questions about their health, namely whether symptoms of cough and fever had presented, in either themselves or a family member, in the last 14 days. A positive response to any of the questions led to the postponement of the oral examination for at least four weeks.

The sample size was calculated in order to detect differences in OHRQoL scores among the children with caries, fluorosis, and MIH and those without these conditions using data from previous studies (García-Pérez *et al*., 2017; Gutiérrez *et al*., 2019), considering α=0.05 and β=0.10, the sample required for caries, fluorosis and MIH were 515, 613 and 634 children respectively. Thus 698 schoolchildren were invited to participate, of whom 663 accepted, a response rate of 90.5%. Twenty children chose not to participate and 15 participants were excluded.

The OHRQoL score (total CPQ_{8-10} score) was the dependent variable. Bivariate analyses, using Pearson's chi-square, were performed by sex, on age, toothbrushing frequency, OHI-S, caries, dental fluorosis, and MIH, and Mann-Whitney U and Kruskal-Wallis tests were used to compare the domains of the CPQ_{8-10} and the independent variables. Poisson regression models with robust variance were used to ascertain associations between the independent and dependent variables (Model 1). Poisson regression analysis also considered associations between OHRQoL and one or a combination of the conditions of interest (cavitated lesions, fluorosis, or MIH), adjusting for independent variables (Model 2). Overall, the OHRQoL score was compared in terms of the rate ratios (RRs) and 95% confidence intervals (95% CIs). Theoretically plausible interactions were also explored, between the three indicators of oral health and oral hygiene. Data analysis was performed using the Stata 15 program.

Results

The mean age of the 633 children was 9.2 (± 0.77) years, and 50.2% and 49.8% were boys and girls, respectively. Almost half (47.2%) brushed their teeth once per day or less, and 47.1% had poor oral hygiene as indicated by OHI-S.

Approximately one third (38.6%) had MIH, with 25.6% classified as moderate, 6.6% mild, and 6.3% as severe MIH in the permanent dentition. The prevalence of dental fluorosis in permanent dentition was 75.1% (TFI≥1), by severity 24.9% were TFI = 0, 52.9% TFI 1–3, and 22.2% were TFI ≥4. The prevalence of caries (primary + permanent dentition) corresponded to 15.4% caries free, 34.8% incipient lesions, and 49.8% cavitated lesions.

Bivariate analyses found MIH and dental caries to be similar in girls and boys (Table 1).

The prevalence of caries, MIH, and dental fluorosis, where in 1.2% presented MIH + TFI ≥4, 26.6% presented MIH + caries, 12.5% presented TFI ≥4 + caries, 6.7% presented MIH + caries + TFI ≥4, 4.2% MIH, 1.8% TFI ≥4, 38.9% caries, and only 8.1% sound tooth.

Regarding the two global questions of $CPQ_{8–10,}$ based on their general perception of the state of their oral health, 41.8% of the children rated it as very good/good, 27.9% as regular, and 30.3% as poor.

Most (59.4%) of the children described a negative impact of their oral condition on their quality of life. Table 2 summarizes the overall $CPQ_{8–10}$ and four domain scores in relation to the dental fluorosis, MIH dental caries status of the children. Children with dental caries and MIH had higher overall CPQ_{8-10}, oral symptoms, functional limitation, emotional and social wellbeing scores. While dental fluorosis was associated with higher overall $CPQ_{8–10}$, the four domain scores were unrelated to the presence of this condition.

Children with moderate/severe MIH had worse quality of life than those without [RR=1.61 (95% CI 1.56,

Table 1. Distribution of dental fluorosis, Molar-Incisor Hypomineralization (MIH), and dental caries in 663 schoolchildren aged 8-10 years.

	Boys (n=330) *%*	*Girls (n=333)* *%*	*Total (663)* *%*	*p**
Age				
8 years	20.6	22.5	21.6	0.768
9 years	36.1	33.3	34.7	
10 years	43.3	44.2	43.7	
Toothbrushing frequency				
≥ 2 times a day	48.2	57.4	52.8	0.018
< 2 times a day	51.8	42.6	47.2	
Oral hygiene (OHI-S)				
Good hygiene	52.7	53.2	52.9	0.913
Poor hygiene	47.3	46.8	47.1	
Dental fluorosis (TFI)				
TFI 0	19.4	30.3	24.9	
TFI 1 – 3	58.2	47.8	52.9	0.003
TFI 4 – 6	22.4	21.9	22.2	
MIH				
No	62.7	60.1	61.4	0.481
Yes	37.3	39.9	38.6	
Severity MIH				
No	62.6	60.1	61.4	0.812
Mild	7.0	6.3	6.6	
Moderate	24.6	26.7	25.7	
Severe	5.8	6.9	6.3	
Dental caries (ICDAS II)				
Caries free (ICDAS 0)	16.7	14.1	15.4	0.272
Incipient lesions (ICDAS 2-3)	36.7	33.0	34.8	
Cavitated lesions (ICDAS ≥4)	46.6	52.9	49.8	

*Chi-square test; TFI= Thylstrup & Fejerskov Index.; ICDAS II: International Caries Detection and Assessment System of primary + permanent teeth.

Table 2. CPQ8–10 scores by dental fluorosis, Molar-Incisor Hypomineralization (MIH) and dental caries status in 663 schoolchildren.

		Total score CPQ *mean (SD)*	*Oral symptoms* *mean (SD)*	*Functional limitation* *mean (SD)*	*Emotional well-being* *mean (SD)*	*Social well-being* *mean (SD)*
Dental fluorosis TFI*						
	TFI ≤4	27.3 (23.2)**	7.3 (6.3)	6.4 (6.9)	6.9 (6.9)	12.3 (14.7)
	TFI ≥4	41.5 (19.0)	7.1 (6.4)	6.3 (7.2)	6.8 (7.3)	13.4 (15.2)
Dental caries∞	Caries free	18.7 (20.2)**	5.4 (5.4)**	4.6 (5.7)**	5.2 (5.8)**	9.0 (12.5)**
	Incipient lesions	25.3 (20.3)	6.2 (5.8)	5.0 (6.4)	5.5 (6.5)	9.2 (13.4)
	Cavitated lesions	37.8 (23.3)	8.6 (6.7)	7.9 (7.5)	8.4 (7.4)	15.9 (15.7)
MIH*	No	24.2 (20.6)**	6.3 (6.1)**	5.2 (6.5)**	5.9 (6.6)**	9.5 (13.4)**
	Yes	40.4 (23.4)	8.8 (6.5)	8.1 (7.4)	8.6 (7.2)	17.4 (15.7)

** p≤0.001 *Mann-Whitney U Test, ∞Kruskal-Wallis test; TFI= Thylstrup & Fejerskov Index; ICDAS II: International Caries Detection and Assessment System of primary + permanent teeth; MIH: Molar-Incisor Hypomineralization.

1.66)]. Furthermore, those with cavitated lesions (ICDAS II ≥4) had worse quality of life than those without caries [RR=1.87 (95% CI 1.78, 1.96)]. Participants with dental fluorosis (TFI ≥4) experienced more impact on their quality of life than those without fluorosis [RR=1.31 (95% CI 1.26, 1.36)] (Table 3, Model 1).

Only the children with cavitated carious lesions (n=432) were included in Model 2 (Table 3). Children with two conditions (cavitated lesions and TFI ≥4, cavitated lesions and MIH, or TFI ≥4 and MIH) had higher CPQ scores than did the children without [RR=4.18 (95% CI 3.83, 4.56)]. Finally, children with all three conditions

Table 3. Poisson regression analysis for predictors of oral health-related quality of life (CPQ8–10) in 663 schoolchildren.

	Model 1 (n=663)	*Model 2 (n=432)*
Predictor	*Robust Rate Ratio (RR) (95% CI)*	*Robust Rate Ratio (RR) (95% CI)*
Sex (Men ref.)		
Women	0.88 (0.85 – 0.90)	0.87 (0.84 – 0.90)
Age (Continuous)	1.06 (1.05 – 1.08)	1.03 (1.01 – 1.05)
Dental fluorosis (TFI=0 ref.)		
TFI 1–3	0.80 (0.77 – 0.82)	–
TFI ≥4	1.31 (1.26 – 1.36)	–
Dental caries (Caries free ref.)		
Incipient lesions	1.41 (1.33 – 1.48)	–
Cavitated lesions	1.87 (1.78 – 1.96)	–
MIH (No MIH ref.)		
Mild	1.39 (1.32 – 1.47)	–
Moderate/severe	1.61 (1.56 – 1.66)	–
Oral Hygiene (Good ref.)		
Poor	1.01 (0.99 – 1.04)	1.10 (1.06 – 1.13)
Presence (Sound tooth ref.)		
1	–	2.60 (2.37 – 2.83)
2	–	4.18 (3.83 – 4.56)
3	–	5.64 (5.13 – 6.20)

1=Cavitated lesions, or TFI ≥4, or MIH; 2=Cavitated lesions – TFI ≥4, or Cavitated lesions – MIH, or TFI ≥4 – MIH; 3=Cavitated lesions – MIH – TFI ≥4.

(cavitated lesions, MIH and TFI ≥4) had worse quality of life than those who did not have such a combination [RR=5.64 (95% CI 5.13, 6.20)]. In addition, children with poor oral hygiene had higher CPQ scores than those with good oral hygiene [RR=1.10 (95% CI 1.06, 1.13)]. Possible interactions were assessed, but were not found (p>0.05).

Discussion

Children with two or three of cavitated lesions, moderate/severe MIH, and/or dental fluorosis had worse OHRQoL than those without. Various studies have reported the negative impact of caries, MIH, and fluorosis as individual conditions on OHRQoL (Gurrusquieta *et al*., 2017; Gutiérrez *et al*., 2019; Mota-Veloso *et al*., 2016). However, few studies have investigated the impact of the combination of two conditions (caries and MIH or fluorosis) on the OHRQoL of children of this age, with one study finding that caries plus fluorosis was related to worse OHRQoL in schoolchildren aged 8-12 years (García-Pérez *et al*., 2017). Moreover, Michaelis et al. (2021) reported that MIH and caries was related to worse OHRQoL in children aged seven to ten years old.

Dental fluorosis is caused by the excessive ingestion of fluoride during amelogenesis, where in the prolonged exposure to fluoride affects the deepest layers of enamel (which contain fewer minerals and more proteins), damages the enamel surface, and, as a result, leads to moderate-to-severe levels of dental fluorosis. As a consequence, teeth may erupt with loss of enamel continuity and fractures (DenBesten and Li, 2011). Enamel damaged by MIH has reduced quality and quantity of its mineral content (Ca and P) and higher concentrations of carbon and carbonate and protein content than enamel, resulting in more porosity and cracks, and deeper perforations (Farah *et al*., 2010a; 2010b).

Both dental fluorosis and MIH occur during tooth development, with moderate/severe MIH more susceptible to dental caries. This may be due to their irregular surface, greater porosity, and a loss of tooth structure which exposes the dentine (Fagrell *et al*., 2008) once the tooth is subject to masticatory force. A possible consequence of the loss of enamel structure is the accumulation of a higher level of biofilm, making its removal more difficult during toothbrushing and, thus, causing a higher number of carious lesions in the affected teeth (García-Pérez *et al*., 2013). This may explain why children with all three conditions experienced worse quality of life than those only one.

Dental fluorosis, MIH, and caries can all diminish tooth function and aesthetics. Aesthetic perception can have measurable psychosocial effects on many children, thus negatively affecting their quality of life. For example, fluorosis and MIH can adversely affect the the smile, especially in seriously damaged anterior teeth, due to the the defects, color changes, tooth structure loss (enamel and dentine) and sensitivity (Fragelli *et al*., 2021; Li *et al*., 2021). Almost one quarter (22.2%) of our participants had fluorosis TFI≥4, 49.8% had cavitated carious lesions, and 31.9% had moderate/severe MIH. Cummulatively, these conditions had measurable negative impacts on the child's self-esteem and comfort at an early age.

Appearance is fundamental to daily activities such as attending school and maintaining social relationships. At an early age, children begin to compare the characteristics of their physique and personality with those of their peers. Between the ages of six and ten years, a child develops

their ability to make judgments about their appearance, thoughts, and emotions. Furthermore, at this age, the aesthetics associated with health begin to be incorporated into the mind of the child and integrated into their concept of self-esteem (Rebok *et al.*, 2001). The understanding of these concepts may be affected by the child's gender, with girls appearing to experience a more negative impacts on their OHRQoL in one study (Calis *et al*., 2009).

Globally, there are few reports of the prevalence of MIH in areas with different levels of fluoride in the drinking water. Such reports describe prevalence from 7.6% in Dubai (Ahmad *et al*., 2019), 7.3% in India (Krishnan *et al.*, 2015), 9.8% Brazil (Fernandes *et al*., 2021) to 12.4% in Mexico (Sosa-Soto *et al*., 2021). The present study found a 38.6% prevalence of MIH, which is consistent with previous findings in Mexican children (15.8%, 20.3%, 31.9%, and 40.4%) (Gurrusquieta *et al*., 2017; Gutiérrez *et al*., 2019; Irigoyen-Camacho *et al*., 2020, respectively). The differences found by studies in the prevalence of MIH with different levels of fluoride can be attributed to the sample size, the diagnostic criteria, and the use of different indices for evaluating the condition. Finally, Fernandes et al. (2021) found prevalences of 44.8% and 52.8% for fluorosis and caries, respectively among school children receiving fluoride levels >0.7ppm in their drinking water. Similar results were found in the present study with 1.0 – 1.39 ppm/F in the drinking water.

The cross-sectional design of this study prevents conclusions about the cause-and-effect relationship between the independent variables and OHRQoL. One advantage was that the data collection was standardized by two trained examiners who were experienced in the use of indicators for caries, MIH, and dental fluorosis. Moreover, the CPQ_{8-10} questionnaire has been validated in Spanish and has the advantage of being designed to measure OHRQoL of children of the age studied here.

In conclusion, dental fluorosis, MIH, and dental caries predicted worse OHRQoL among schoolchildren living in an area with a high concentration of fluoride in the drinking water. These results highlight the importance of the early detection of oral conditions that present in the child population. Appropriate treatment for fluorosis, caries and MIH may also improve the quality of life of affected children.

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Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

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Ethical approval: All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual subjects participating in the study.

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