Science of the Total Environment 541 (2016) 512–519

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Nutritional status and dental fluorosis among schoolchildren in communities with different drinking water fluoride concentrations in a central region in Mexico

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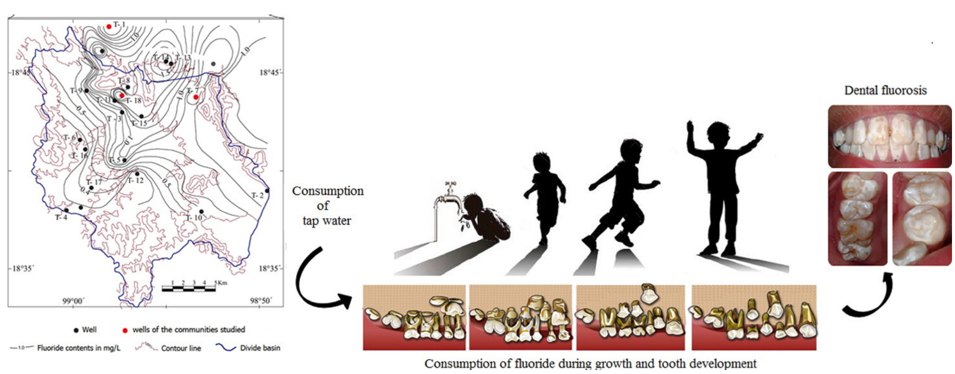
HIGHLIGHTS

- Children exposed to water F ≤ 0.70 mg/l had a low occurrence of moderate/severe fluorosis.
- About a third of children exposed to water F = 1.60 mg/l had moderate/severe fluorosis.
- Children showing undernutrition were more likely to have moderate/severe fluorosis.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 8 August 2015
Received in revised form 16 September 2015
Accepted 16 September 2015
Available online xxxx

Editor: D. Barcelo

Keywords:
Undernutrition
Dental fluorosis
Fluoride

ABSTRACT

Poor water quality and under nutrition are important factors affecting the health of many communities in developing countries. The aims of this study were: i) to describe the fluoride water concentration and the hydrogeological conditions in a region of a state located in the central in Mexico ii) to measure the association between undernutrition and dental fluorosis in children living in communities with different drinking water fluoride concentrations in a state located in the central region of Mexico.

Methods: Field work was performed in the region to identify the prevailing groundwater flow characteristics and water wells were sampled to analyze water fluoride concentration. Children were selected from three communities that had different drinking water fluoride concentrations (i.e., 0.56, 0.70 and 1.60 mg/l). Fluoridated salt was available in these communities. The Thylstrup–Fejerskov Index (TFI) was used to assess dental fluorosis. Categories four or higher of this index involve changes in the entire tooth surface (ITF ≥ 4). The weight and height of the children were measured. The assessment of undernutrition was based on the World Health Organization criteria: children were classified as being at risk of low-height (Height-for-Age Z score < −1.0 SD) and having

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http://dx.doi.org/10.1016/j.scitotenv.2015.09.085

low-height (Height-for-Age Z score < −2.0 SD) for age and sex, the same cutoff points of the Z score were used to classify "risk of low-weight" and" low-weight children".

Results: In the region the mineralization of the water captured by the wells is the result of a reaction with volcanic materials. The water fluoride concentration in the region ranged from 0.2 to 1.6 mg/l. A total of 734 schoolchildren participated in the study. The percentage of children in fluorosis categories (ITF ≥ 4) was 15.9%, 21.1% of the children were at risk of low height-for-age, and 8.0% had low height-for-age. The percentage of children with fluorosis (ITF ≥ 4) was 6.3%, 9.1% and 31.9% (p 0.001) and low high-for-age was 2.9%, 2.5% and 8.4% (p 0.001), for the communities with F concentrations of 0.56 mg/l, 0.70 mg/l and 1.6 mg/l, respectively. The logistic regression model showed an association between dental fluorosis (TFI ≥ 4) and low height-for-age (OR 2.09, p = 0.022) after adjusting for sex, number of teeth erupted, source of drinking water, use of fluoridated toothpaste and tap water fluoride concentration in the community.

Conclusion: Children with low height-for-age were more likely to have dental fluorosis in the TFI categories that affect the entire tooth surface. The results suggest that subpopulations with chronic undernutrition are more susceptible to dental fluorosis.

1. Introduction

Fluoride (F) is a trace element important for human health and is obtained primarily through consumption of water. Assessing high concentrations of fluoride in groundwater involves identifying the sources and understanding the processes of transporting and precipitation. Consequently, many studies have been performed regarding the concentration of fluoride and its water–rock interactions in aquifers in different geological scenarios (Nordstrom et al., 1989; Gaciri and Davies, 1993; Saxena and Ahmed, 2001, 2003), it has been found that there are high concentrations of fluoride in groundwater in areas where the bedrock has minerals enriched with fluorine. This compound is gradually dissolved and becomes one of the main trace elements in water (Handa, 1975, Bårdsen et al., 1996).

Excessive fluoride ingestion can cause dental fluorosis and skeletal fluorosis. The World Health Organization (WHO) in 2006 listed 28 countries for which there is epidemiological evidence of dental fluorosis and reported that approximately 70 million people may be affected worldwide (Fawell et al., 2006).

In Mexico, data from the National Survey of Dental Caries (ENCD-2001) found a wide variation in the prevalence of fluorosis across different regions (3.2% to 88.8%) (Irigoyen-Camacho et al., 2013). Dental fluorosis is a public health problem in some states of central and northern Mexico that have high concentrations of fluoride in the drinking water.

The prevalence of dental fluorosis is increasing in many countries (Buzalaf and Levy, 2011). Dental fluorosis is an irreversible condition of the dental structure that is caused by the intake of excessive levels of fluoride during tooth development. The mechanism of fluorosis involves an inadequate substitution of the organic enamel matrix by inorganic material, which results in the hypomineralization of the fluorotic enamel. (Wei et al., 2013). Dental fluorosis at low levels exhibits discrete changes in tooth color and is associated with a lower risk of dental caries. In contrast, severe forms of dental fluorosis result in the staining and pitting of the enamel, and in very severe cases, the deterioration of tooth structure may occur (Fejerskov and Larsen, 1994).

The fluoride exposure level above which dental fluorosis occurs is not clearly established. A daily intake of 0.1 mg/kg has been suggested (Forsman, 1977); however, doses ≤ 0.03 mg/kg have been found to produce dental fluorosis in African children (Baelum et al., 1987; Aoba and Fejerskov, 2002). In relation to water safety, the World Health Organization (WHO) guideline value for fluoride is 1.5 mg/l, (WHO, 2006a) a target of between 0.8 to 1.2 mg/l is recommended to maximize caries preventive benefits and minimize harmful effects, such as dental and skeletal fluorosis. Levels above 1.5 mg/l are associated with dental fluorosis in categories where loss of enamel appears (pitting) and deposits on bone; above about 10 mg/l crippling skeletal fluorosis appears (WHO, 2015). Despite more than 50 years of research it has been difficult to determine an "optimal" water fluoride concentration (Aoba and Fejerskov, 2002). In the U.S., the Health and Human Services Department established changes in the regulation of fluoridated water; it lowered the recommended level to 0.7 mg/l, which was the lower limit of the recommended range until 2011(0.7 to 1.2 mg/l) (USEPA, 2011).

Many factors influence the degree of fluorosis including regional altitude, individual metabolism (i.e., chronic and acute acid–base disturbances), genetic predisposition, and diet. Additionally, nutritional status has been suggested to affect fluoride metabolism and dental fluorosis (Buzalaf and Whitford, 2011).

Undernutrition results from food intake that is insufficient to meet energy requirements, which is accompanied by low body weight and chronic undernutrition that results in low height-for-age (i.e., stunting) (Lifshitz, 2009). The United Nations International Children's Emergency Fund (UNICEF, 2014) estimated that globally, 161 million children under five years of age had low height-for-age. In Mexico, according to the National Health and Nutrition Examination Survey (ENSANUT 2012), chronic undernutrition (measured by the relationship between height and age) has declined; however, its prevalence is still high (13.6%) among children under 5 years of age, which represents approximately 1.5 million children in Mexico (Rivera-Dommarco et al., 2013).

Few studies have assessed the association between undernutrition and fluorosis. Some studies in developing countries located in areas with high water fluoride levels have identified an association between the prevalence of enamel defects and undernutrition (Rugg-Gunn et al., 1997).Children with undernutrition suffer from alterations in calcium level, low micronutrients, low protein and low energy intake. (Aoba and Fejerskov, 2002).

The aims of this study were i) to describe the fluoride water concentration and the hydrogeological conditions in a state located in the central region of Mexico ii) to measure the association between undernutrition and dental fluorosis in children who live in communities with different drinking water fluoride concentrations in a state located in central Mexico.

2. Material and methods

This cross-sectional study's research protocol was reviewed and approved by the Ethics Committee of the Division of Graduate Studies and Research, Faculty of Dentistry, National Autonomous University of Mexico, and ethical aspects of the project were considered.

2.1. Study region

The region studied is situated in Morelos, a central State of Mexico. This region is located in the central-east area of this state. It is a plateau with an average elevation is 1200 m above sea level (MASL); on the North and West sides, the relief is constituted by rocks of marine limestone origin and sandy limestone of the Cretaceous age. On the West,