Prevalence of dental fluorosis in Mexico 2005-2015: a literature review

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Abstract

Objective. To perform a literature review regarding current dental fluorosis prevalence in Mexico reported from 2005 to 2015. **Materials and methods.** A comprehensive scientific literature review, in both English and Spanish, was performed in four databases up to June 2015. Search terms: fluorosis or dental fluorosis (mesh), prevalence (mesh), distribution (mesh), cases (mesh), epidemiology (mesh), Mexico. **Results.** 17 publications were included. Reported prevalence of dental fluorosis in Mexico ranged from 15.5 to 100%. Most of the studies were conducted in areas where water fluoride levels are low or optimal (≤1.5ppmF) and in which a prevalence of 15.5 to 81.7% was observed. In areas with higher levels of naturally fluoridated water (>1.5ppmF), prevalence ranged from 92 to 100%. Fluorosis severity ranged from questionable to severe. **Conclusion.** High prevalence of dental fluorosis was observed even in areas where fluoride concentration in water was low or optimal. In addition to fluoride in groundwater, there are multiple risk factors that should be controlled.

Keywords: dental fluorosis; prevalence; epidemiology; Mexico

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Resumen

Objetivo. Realizar una revisión de la literatura sobre la prevalencia de fluorosis dental en México reportada durante 2005-2015. **Material y métodos.** Se realizó una revisión exhaustiva hasta junio de 2015 en cuatro bases de datos de literatura científica en inglés y español. Términos de búsqueda: fluorosis o fluorosis dental (mesh), prevalencia (mesh), distribución (mesh), casos (mesh), epidemiología (mesh), México. **Resultados.** Se incluyeron 17 publicaciones. La prevalencia reportada en México fue de 15.5 a 100%. La mayoría de los estudios se realizaron en áreas donde el nivel de flúor en agua es bajo u óptimo (<1.5ppmF), en las cuales se observó una prevalencia de 15.5 a 81.7%. En las zonas con mayor nivel de flúor (>1.5ppmF) en agua natural fue de 92 a 100%. La gravedad de fluorosis varió de dudosa a severa. **Conclusión.** Existe una alta prevalencia de fluorosis dental incluso en zonas donde la concentración de fluoruro en el agua es baja u óptima. Además de fluoruro en el agua, existen múltiples factores de riesgo que deben ser controlados.

Palabras clave: fluorosis, dental; prevalencia; epidemiología; México

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Dental fluorosis (DF), as it was called by Trendley Dean in 1937,[1] is caused by an excessive ingestion of fluoride which leads to multiple changes in the developing enamel altering its structure. In mild cases, chalky white opaque areas are observed, in moderate cases spots may be brownish,[2] and in severe cases enamel is fragile which can lead to fracture and loss of tissue.[3]

DF is observed in specific geographical areas in the world[4] showing an endemic epidemiological pattern affecting millions of people; this alteration can be considered an indicator of excessive fluoride exposure. Dental caries reduction has been accompanied by an increase in DF prevalence,[5] ranging from 7.7 to 80.7% in areas where there is fluoridated water and from 2.9 to 42% in areas without it.[6]

In Mexico, groundwater supplies most drinking water, and current knowledge of the geology indicates that there are some areas where natural concentration of fluoride is elevated, exceeding the normative amount.[7] According to the Mexican norm, the maximum permissible concentration of fluoride (F) in water for human consumption is 1.5 ppm.[8] In our country, five million people are affected by the high F content in household-use groundwater[9] as in Durango city, where almost 95% of the population was exposed to fluoride concentrations in drinking-water $\geq$ 2 ppm.[10]

In Central and Northern Mexico, there are extensive areas of endemic fluorosis. The national survey (1997-2001) reported a prevalence ranging from 0 to 88.8% and three states free of DF.[11] In 2004 Soto-Rojas[12] performed a review and identified 19 communities with endemic DF. According to the permanent phase information of the Surveillance System of oral diseases Sivepab (*Sistema de Vigilancia de Enfermedades Bucales*) reported prevalence in adults was 4.1% and it is mentioned that in the younger age groups (under 25 years), the proportion of DF has increased.[13] The aim of this manuscript is to review recent published data regarding DF prevalence in Mexico to determine the current reported status of this dental condition.

Materials and methods

A comprehensive scientific literature research review up to June 2015 was performed. We searched in four databases: ProQuest, Pubmed, OVID and LILACS. Terms used were fluorosis or dental fluorosis (mesh), prevalence, distribution, cases, epidemiology and Mexico. Restriction years of publication were 2005 to 2015 and only Spanish and English literature was included; case reports, letters to the editor, news or commentary pieces, and clinical descriptions were excluded.

There were 20 initial articles identified from ProQuest, 18 from Pubmed, 17 from OVID, and four from LILACS. Once duplicate references were removed, 25 remained but nine were deemed irrelevant and were excluded based on their abstract. Most of them focus on the evaluation of fluoride content in different products (i.e. water, soft drinks, salt), not on DF prevalence. With the document printed, a manual search in the reference list of chosen articles was performed and seven more were selected judged as relevant based on their titles. All these manuscripts were evaluated and fully read to detect those that:

1. Included clinical examinations, describing DF index used
2. Described the index standardization process to diagnose the presence and gravity of DF

Finally, six studies were excluded because no mention of standardization for clinical assessment was reported. Therefore 17 studies were included in this review (figure 1).

Results

Of the 17 manuscripts included, we divided them into three groups according to the natural fluoride concentration in the water of the study area: three were conducted in areas or communities where water fluoride content is above 1.5 ppm, four more which included different communities that ranged from <1.5 to >1.5 F ppm, and the rest of them were performed in areas where F in water was below optimal (n=10) (table I).

Studies in communities where water fluoride content is above 1.5 ppmF

In 2011, three studies were published, one of them performed in a community in the state of Querétaro; situated 1 900m above mean sea level (AMSL), where fluoride concentration was 1.9 ppm in drinking water. DF prevalence was 98%, 47% being severe;[14] Community Dean Index (CDI) was 3.06. Authors observed greater caries prevalence in those children with higher severe fluorosis.

In the same year, Aguilar-Díaz and colleagues[15] reported a 92% prevalence in San Luis Potosí, situated 1 864m amsl. Only anterior teeth were examined with the Thylstrup & Fejerskov index (TFI). Authors found that moderate or severe DF has an adverse effect in children's quality of life, specially affecting social and emotional wellbeing.

In 2015, Jarquín-Yañez[16] found a prevalence of 100% in children aged 6 to 12 living in a community in

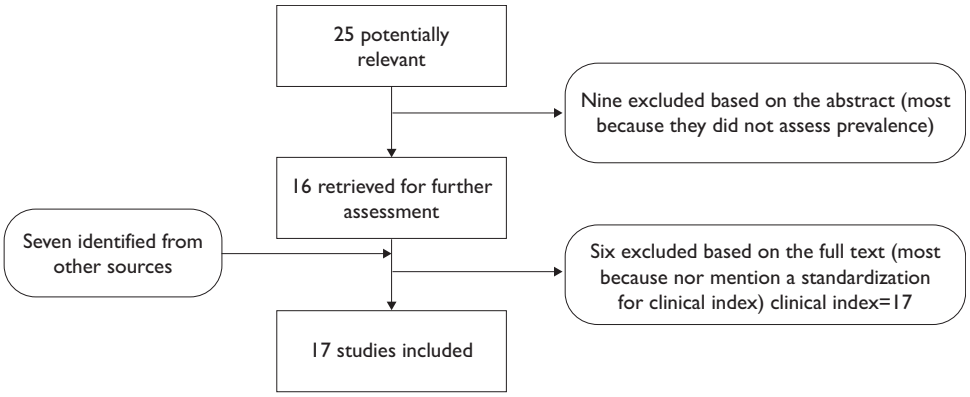

FIGURE 1. MANUSCRIPTS SELECTION PROCESS

Table 1

PREVALENCE OF DENTAL FLUOROSIS, REPORTED BETWEEN 2005-2015, IN MEXICAN COMMUNITIES

Author	*Publication year*	*State*	*n*	*Age*	*Index*	*ppmF in water*	*Prevalence %*	*Doubtful %*	*Very mild %*	*Mild %*	*Moderate %*	*Severe %*	*CFI*
Aguilar-Díaz	2011	San Luis Potosí	234	8-10	TFI	>1.5	92 *	NR	12.3	19.3	31.6	28.7	NR
Aguilar-Rodríguez	2007	State of Mexico	734	11-12	DMI	NR	70.84.	NR	NR	NR	NR	NR	0.73
Beltrán-Valladares	2005	Campeche	320	6-9	DMI	NR	53.6	NR	45	10		1.3	0.7
Casanova-Rosado	2013	Campeche	1 644	6-13	DMI	<1.5	15.5	NR	NR	NR	NR	NR	NR
Galicia-Chacón	2009	State of Mexico	455	6-13	Dean	0.21-0.88	73.4	7.5	34.5	36.3	2.6	0	1.18 +0.80
García-Pérez	2013	Morelos	457	8-12	TFI	0.70	39.4	NR	NR	NR	NR	8.0	NR
						1.5	60.5	NR	NR	NR	NR	25	NR
Irigoyen-Camacho	2010	Morelos	248	9-10	DMI	1.2-1.5	91.10	24.6	30.6	18.1	12.5	5.2	1.76
Jarquín-Yáñez L	2015	San Luis Potosí	111	6-7	TFI	4.54 (0.46)	100	NR	0	0	5	95	NR
Jiménez-Farfán	2011	Mexico City	1 942	11-12	Dean	0.18 to 0.44	60.1	35.4	42.2	17.2	7	0.06	0.96
Juárez-López ML	2011	Querétaro	154	10-13	Dean	1.9	98	NR	8	19	23.5	47.5	3.06+-1
Medina-Solis	2008	Hidalgo	1 538	12-15	DMI	0 .01-1.10	81.7	NR	37.4	14.7	10.5	19.1	1.75
Molina-Frechero	2012	Mexico City	111	11	DMI/ TFI	0.21-0.88	52.7	NR	39.6	7.21	4.51	1.8	0.53
Molina-Frechero	2005	Mexico City	216	10-11	DMI	<0.3	65.8	NR	19.4	11	3.7	0	0.53
Pérez-Pérez	2014	Oaxaca	917	8-14	Dean	0.43 (0.12)	80.8	19.7	41	16.4	3.5	0.4	NR
Pontigo-Loyola	2008	Hidalgo	1 024	12-15	DMI	3.07	94.7	NR	10.7	12.0	25.3	46.7	1.69
						1.38	89.8	NR	32	17.2	8.6	32	2.97
						1.42	81.9.	NR	38.9	15.2	11.3	16.4	1.85
Rodríguez-Dozal	2005	Chihuahua	251	5-60	Dean	0.70-1.50	77.4	NR	NR	NR	31.7		NR
						1.51-2.99	79.5	NR	NR	NR	43.1		NR
						3.00-5.99	85.5	NR	NR	NR	53.2		NR
						>6.00	84.3	NR	NR	NR	71.2		NR
Vallejos-Sánchez	2006	Campeche	1 373	6-12	DM	N/R	51.90	NR	84.7	13.1	1.7	0.6	NR

DMI= Dean modified index
Dean= Dean index
TFI= Thylstrup & Fejersjov index
NR= Not reported or not reported for the total studied population

San Luis Potosi where water fluoride content was 4.13 ppm, and 25% of them have a TF9, which represent a destruction of enamel surface.

Studies in communities where water fluoride content is equal or under 1.5 ppmF

In 2005, Molina-Frechero[17] reported a 34.2% prevalence in Mexico City (water fluoride content <0.3ppm); 19.4% very mild, 11.1% mild, and 3.7% moderate and no severe form was registered; Community Fluorosis Index (CFI) was 0.53. They concluded that the prevalence and severity of DF can be considered high in relation to the concentration of fluoride in the water within the study area. Authors mentioned that fluorosis magnitude cannot be attributed to the consumption of fluoride in the water. They suggested that other risk factors are interacting and if conditions continue like this, DF can become a major problem.

In 2005, Beltran and colleagues[18] reported a 56.3% prevalence in Campeche City, in children who were part of a preventive program that included topical fluoride gel applications. Authors report that self-administered fluoride, such as fluoridated table salt, increased the risk of fluorosis 2.13 times compared to fluoride applied by a dentist or rinses. A higher risk of DF was also observed when the mother or guardian had less schooling. Other risk factors identified were the use of fluoridated toothpaste before two years of age. The additional effect of self-applied fluoride drops was 6.15 times more than the effect of fluoride applied by a dentist or the use of rinse in this group.

In 2006, also in Campeche, a prevalence of 51.9% was registered. The most common degree was very mild (84.7%), followed by mild (13.1%), moderate (1.7%), and severe in 13.1% of the cases. Similar results to those reported by Beltran were found; children from the state of Campeche born between 1990 and1992 were more likely to present DF compared to those born from 1986 to 1989. Additionally, children who started using toothpaste, or received fluoride, before the age of four years were at greater risk.[19]

In 2007, in the State of Mexico, Aguilar-Rodriguez[20] reported a prevalence of 70.84%. When including the questionable category; they observed that this percentage is 22.2% higher than that found in 2002 in the same area. Authors reported that fluoridated salt is distributed and other fluoride sources which increase the ingestion of this element exist. In addition, there are preventive programs that include application of fluoride in gel or mouth rinse. The CFI found was 0.73.

In 2009, in Nezahualcoyotl, State of Mexico, Galicia-Chacon[21] reported a prevalence of 73.4%. Percentages of fluorosis severity are not reported. Significant association was found among DF and the consumption of "hidden fluorides" such as bottled water, tea, and soft drinks (RM = 1.554, 95%CI = 1.016-2.378, $p < 0.05$).

In Tenextepango, Morelos, Irigoyen and colleagues[22] observed a prevalence of 91.1% in children (mean age 9.9 years) when considering the questionable category and 66.5% when excluding it. Distribution of DF was: 24.6% questionable, 30.6% very mild, 18.1% mild, 12.5% moderate and 5.2% severe. Authors observed that children of mothers with incomplete elementary school were more likely to present more severe forms of fluorosis.

Jimenez-Farfán[23] found a prevalence of 95.6% (60.1% when eliminating the questionable category) in Mexico City with most of the cases being questionable or very mild. CFI reported was 0.96, which according to the Dean and Murray criteria,[24] represents a public health problem. Authors of this study proposed that fluoride content in bottled beverages could be contributing to high DF prevalence.

In 2013, Casanova-Rosado and colleagues[25] reported a prevalence of 15.5% in Campeche where not high amount in water exist. They found an association among age and DF; cohort of children born from 1986 to 1988 had less chance to present DF than children born between 1989 and 1992. Those born chronologically closer to the initiation of the National Program of salt fluoridation were at greater risk.

In Mexico City, Molina-Frechero[26] reported a prevalence of 53%; 39.6% being very mild, 7.21% mild, 6.3% moderate or severe. Higher prevalence of DF was observed in children receiving topical fluoride applications compared to children not receiving such applications. Additionally, in children who began brushing their teeth before the age of four had fluorosis, compared to children who did not brush their teeth before the age of four.

In Oaxaca, Pérez-Pérez[27] found a DF prevalence of 81%. The most common category was very mild (41%), 16.4% mild, 3.5% moderate, and severe form represented 0.4%. Age and poverty was associated with DF severity; children with lower poverty showed higher prevalence of mild or higher levels of DF. Moderate and severe DF was associated with soft drink consumption (table II).

Studies including communities with fluoride water concentration that ranged from <1.5 to >1.5 ppm/L

In 2005, Rodriguez and colleagues[28] observed 33 rural communities in Chihuahua with a general prevalence

Table II

Characteristics of the state: salt distribution, altitude, ppm of F in water, and prevalence reported by National Survey of Caries and Fluorosis (NSCF) 2001 and that reported in literature between 2005-2015

State	*Salt distribution*	*Altitude (amsl)*	*ppmF in water*	*NSCF 2001 at 12 years*	*Prevalence reported 2005-2015*
San Luis Potosí	Partial	1 864	>1.5 4.54(0.46)	62.7 (58.0, 67.2)	92 to100
State of Mexico	Partial	2 250	0.21-0.88	N/R	70.84 to 73.4
Campeche	Yes	370	<1.5	15.1 (11.6, 19.4)	15.5 to 53.6
Morelos	Yes	1 511	0.56-0.76 (0.70)	3.2 (2.6, 5.1)	39.4 to 91.10
Mexico City	Partial	2 250	0.18 to 0.88	7.4 (6.0, 9.1)	52.7 to 65.8
Querétaro	Partial	1 900	1.9	44.4 (40.0, 48.9)	98
Hidalgo	Partial	2 040	0 .01-3.07	40.4 (34.7, 46.6)	81.7 to 94.7
Oaxaca	Yes	1 557	0.43 (0.12)	19.3 (15.9, 23.2)	80.8
Chihuahua	Partial	1 440	0.70 - >6.00	48.8 (44.5, 53.1)	77.4 to 85.5

F: fluide

of 81.7%. Prevalence was 77.4%, when 0.70-1.50 ppmF, 79.5% in 1.51-2.99 ppmF, 85.5% when 3.00-5.99ppmF and 84.3%, when >6 ppmF was in water. Fluorosis severity was associated with low calcium consumption and living in an area with greater fluoride in water.

In 2008, Pontigo Loyola and colleagues[29] reported an overall fluorosis prevalence of 83.8% in three communities in the State of Hidalgo, located >2 000m amsl. Prevalence found in each community was 89.8 (1.38 ppmF), 81.9 (1.42 ppmF) and 94.7 (3.07 ppmF). Severe cases represented 20.6 %. The CFI was 1.85 for all communities concluding that DF represents a public health problem in these localities. Nonetheless, authors recognized that in one of the communities, studied results were based on numbers too small to trust the validity in their significance.

In 2008, in the state of Hidalgo, Medina-Solis and colleagues[30] found a prevalence of 81.7%. Most cases were very mild or mild but an important percentage of adolescents (29.6%) presenting DF in moderate or severe forms. General CFI was of 1.75. In this population, the most affected teeth in both upper and lower arches were posterior ones.

García-Pérez[31] observed a DF prevalence of 39.4% in a community in the state of Morelos (0.70ppmF in water) and 60.5% in a locality with 1.50 ppmF. First, upper and lower molars were affected more strongly, followed by central incisors. In addition, 25% showed DF level TFI>3. The type of water used for drinking was an associated risk factor. 65.0% of children who drank tap water were affected compared to 47.1% of those who drank bottled water.

Discussion

Most of the studies were conducted in areas where water fluoride levels were optimal or below. Contrasting with the review performed by Soto and colleagues[12] in 2004 where most studies he found were performed in areas where water fluoride levels were above optimal.

General prevalence of DF in Mexico, according to the studies included, ranged from 15.5 to 100%, similar to that found by Soto[12] who reported a prevalence of 30 to 100%. Nonetheless, if we compare reports only from areas with >1.5 ppmF in water in the San Luis Potosí[13] and Querétaro areas, the prevalence of DF ranged from 92 to 100% and Soto found (>1.5ppmF) a prevalence of 30 to 100% for these areas. This situation may represent an increase of cases of this alteration. The epidemiology system for oral diseases (Sivepab) also proposed an increase in DF prevalence, especially in the younger age groups (under 25 years).[13] In Brazil, similar tendencies exist, showing an increase of 230% from 2003 to 2010.[32]

Prevalence in zones where fluoride in water was optimal or below (<1.5ppmF) ranges between 15.5 to 89.8%, the highest (>80%) were reported in Hidalgo,[29] Oaxaca[27] and Morelos.[22] In these two last states mentioned fluoridated salt distribution is allowed,[33] this should be revised and adjustments performed to avoid an extra source of fluoride in these populations. As Official National Norm (NOM-040-SSA1-1993) stipulates that It should not be consumed salt iodized table fluoridated in the states where the drinking water contains natural fluoride concentration equal to or greater than

0.7 parts per million (ppm), which is considered optimal for the prevention of dental caries, therefore should not be consume systemic fluoride supplements given the fact that has been observed that the combined use of these two sources of fluoride (water-salt) is sufficient to produce an increase of fluorosis.

It is important to mention that prevalence observed is higher than that expected in these areas (optimal fluoridated) where very mild and mild DF prevalence from 7 to 16% is considered acceptable.[33] It is also higher than that reported in literature,[34] like the 39.7%,[35] (0.7-1.2 ppmF) or 29.8% (<0.7 ppmF) reported in Indian areas,[36] 63% in Colombia[37] or 58.9% in Brazil.[38] Also in Argentina where, with similar fluoride content in water, DF prevalence is lower[39] than that reported in Mexican communities. So it might be pertinent to suggest a reevaluation of the concept of "optimal" fluoride concentration in water proposed in norm which should be revised given the fact nowadays multiple sources of fluoride exist and may be used or misused when combined involuntarily.

Regarding fluorosis severity, we observed percentages in moderate or severe forms reaching 71.2% in Chihuahua[28] and 100% in San Luis Potosí[16] which is like that found in an Ethiopia community though in Mexican studied areas concentration of fluoride in water was not as high as that found in Ethiopia (8.5 ± 4.1 ppm) where prevalence of moderate or severe forms represented 74%.[40]

DF cannot be attributed to water fluoride content only, even if it is a major risk factor, but to a confluence of different risk factors[19] such as consuming boiled water, living at a high altitude,[29] having malnutrition, specially low calcium consumption,[27] also the age children started brushing with toothpaste at (especially before two years of age),[17] type of water used for drinking or cooking,[30] (i.e. using tap water which was highly prevalent in a population in San Luis Potosí),[16] and consumption of bottled beverages,[21] soft drinks,[22,26] and juices. As Perez-Perez[27] indicated that moderate and severe fluorosis was associated with soft drink consumption even when controlling for age, socio-economic status, and water fluoride concentration. Different studies[22,41,42] have found that some juices, nectars, bottled drinks, carbonated beverages and fruit juices have fluoride levels above that stipulated in national norm[8] and are distributed in several states such as San Luis Potosi, Guanajuato, Zacatecas, Queretaro and Jalisco.

Mothers' schooling was also associated; children whose mother did not complete elementary school were at greater risk.[17,21] Perez-Perez[26] observed an association among the mild fluorosis category with age and better socio-economic status after controlling for fluoride concentration in water. They explain that this could be due to families with more economic resources using (misusing) toothpaste at early ages. No association between tap water fluoride concentration and fluorosis severity was identified.

On the other hand, it is proposed that DF prevalence is higher in children who are part of a preventive program that includes fluoride applications.[25] Topical application should remain but is needed to control fluoride application frequency, presentations, concentration and techniques of use should be adjusted when used in young children.

Finally, we did not identify studies reporting DF in primary dentition. We believe those studies are needed because it is an important indicator of DF in permanent dentition, children with fluorosis in primary teeth are at higher risk of having DF in permanent dentition.

Conclusion

It is not possible to determine fluorosis prevalence in Mexico through these studies; nonetheless, it cannot be ignored that high prevalence was reported by 16 of the 17 studies reviewed and even in areas where fluoride concentration in water is optimal or below optimal. Common risk factors were the use of fluoridated toothpaste at an early age and consumption of bottled beverages/soft drinks, so more regulation of these and other different products that might containing fluoride is mandatory.

In order to reduce the risk to develop dental fluorosis, participation of multiple sectors is required including health, water, food and salt industry authorities. Also dental professionals must participate; they should have the ability and correct information to be able to properly instruct population about oral healthy practices; contributing to inform and educate caregivers, who must have adequate awareness and knowledge about dental fluorosis that allow them to acquired preventive behaviors. Also, a national evaluation of DF prevalence is needed in order to identify endemic areas and review salt fluoridated delivery thus reducing the risk of dental fluorosis.

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Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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