

## Fluoridated Water Consumption by Mexican Children and Its Relation with the Presence of Caries and Dental Fluorosis.

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**Abstract: Introduction.** Caries and dental fluorosis represent a public health problem; their relation with the fluoride levels consumed must be analyzed and reported. **Objective.** To analyze the levels of fluoride in the water consumed by school-age children. From the obtained results, to establish its relation with the prevalence and severity of fluorosis and dental caries. **Materials and methods.** A total of 52 samples were collected from four different water sources. The prevalence and severity of fluorosis were determined through the Dean index, and the ICDAS was used for the classification according to depth in 64 children. A descriptive and multivariate statistical study was conducted. **Results.** The highest values of fluorides in water were those obtained in well water with 1.63 ppm, followed by spring water with 1.47 ppm. The following relations were found: (a) when the child mentions not drinking water from a purification plant, this is related to the presence of caries and fluorosis; (b) in children who do not drink from a spring or the faucet, but they drink purified water, fluorosis and caries are absent. **Conclusions.** The levels of fluorides in spring and tap water exceeded the permitted limits, and their consumption is related to the presence of fluorosis and caries.

**Key words:** Dental caries, fluorosis, Mexico, pediatric dentistry, public health.

## Consumo de agua fluorada por niños mexicanos y su relación con la presencia de caries y fluorosis dental.

**Resumen: Introducción.** La caries y la fluorosis dental son un problema de salud pública, su relación con los niveles de fluoruro que se consumen deben de ser analizados y reportados. **Objetivo.** Analizar los niveles de fluoruro en el agua que consumen niños en edad escolar. A partir de los resultados obtenidos establecer su relación con la prevalencia y severidad de fluorosis y caries dental. **Material y métodos.** Se tomaron en total 52 pruebas de cuatro diferentes fuentes de agua. Se determinó la prevalencia y severidad de fluorosis mediante el índice de Dean y se utilizó ICDAS para identificar la caries, que posteriormente se clasificó según su profundidad a 64 niños. Se realizó estadística descriptiva y multivariada. **Resultados.** Los valores más altos de fluoruros en agua fueron los obtenidos en el agua de pozo con 1,63 ppm, seguido por el agua de manantial con 1,47 ppm. Se encontraron las siguientes relaciones: a) cuando un niño refiere no tomar agua de una purificadora esto se relaciona con la presencia de fluorosis y caries, b) en los niños que no toma agua del manantial ni de la llave, pero si toma agua de la purificadora, la fluorosis y la caries están ausentes. **Conclusiones.** Los niveles de fluoruros en el agua de manantial y de la llave rebasaron los límites permitidos y su consumo se relaciona con la presencia de fluorosis y caries.

**Palabras clave:** Caries dental, fluorosis, México, odontopediatría, salud pública.

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## Consumo de água fluoretada por crianças mexicanas e sua relação com a presença de cárie e fluorose dentária.

**Resumo: Introdução.** A cárie e a fluorose dentária são um problema de saúde pública, sua relação com os níveis de fluoreto consumidos deve ser analisada e reportada. **Objetivo.** Analisar os níveis de fluoreto na água consumida por crianças em idade escolar. A partir dos resultados obtidos, estabelecer sua relação com a prevalência e severidade de fluorose e cárie dentária. **Material e métodos.** Foram coletadas em total 52 amostras de quatro fontes diferentes de água. A prevalência e severidade de fluorose foram determinadas mediante o índice de Dean e o ICDAS foi utilizado para identificar a cárie, que posteriormente foi classificada conforme sua profundidade, em 64 crianças. Realizou-se estatística descritiva e multivariada. **Resultados.** Os valores mais altos de fluoretos em água foram os obtidos na água de poço com 1,63 ppm, seguida pela água de nascente com 1,47 ppm. Foram encontradas as seguintes relações: a) quando uma criança relata não beber água de uma purificadora, isso está associado à presença de fluorose e cárie, b) nas crianças que não bebem água de nascente nem da torneira, mas sim da purificadora, a fluorose e a cárie estão ausentes. **Conclusões.** Os níveis de fluoreto na água de nascente e da torneira ultrapassaram os limites permitidos e seu consumo se relaciona com a presença de fluorose e cárie.

**Palavras-chave:** Cárie dentária, fluorose, México, odontopediatria, saúde pública.

### Introduction

Worldwide, dental health problems are particularly frequent among low-income children since, in many countries, they do not receive oral health care.<sup>1</sup>

While fluoride is considered an excellent protector against caries, its excessive consumption by humans could cause dental and skeletal fluorosis, gastrointestinal disorders, and renal dysfunction.<sup>2</sup> Moreover, the ingestion of fluoride for long periods of time during the formation of the tooth enamel produces clinical changes such as the appearance of very thin white lines and serious structural defects. The severity of the changes depends on the quantity and the period of exposure to the ingestion of fluoride.<sup>3</sup>

The systematic exposure of the population to fluorine through its addition to drinking water has been documented as an efficient, safe, and economic way

of preventing caries (e.g., fluoridation of salt and milk).<sup>1,4</sup> Nevertheless, the lack of drinking water leads the inhabitants of the communities, mainly rural, to consume water from diverse natural sources, whose ion levels are not controlled.

Although the World Health Organization (WHO) recommends that the concentration of fluorine ions in drinking water must be between 0.5 ppm and 1.0 ppm<sup>5</sup>, the Mexican Official Standards NOM-127-SSA1-1994<sup>6</sup> and NOM-179-SSA1-2020<sup>7</sup> specify that the optimal fluoride concentration in drinking water must be ideally of 1.5 mg/L, and that the monitoring frequency must be monthly for superficial supply sources, and semestral for underground supply sources. In the case of the parameters exceeding 10% of the permissible limit, water must receive the corresponding treatment for removal.

In Mexico, the prevalence of fluorosis in the population varies. It has been reported that the prevalence ranges from 15.5% to 81.7% in areas where the

fluoride level is optimal; nevertheless, in zones with levels higher than the permissible, the prevalence increases, reporting 92% to 100%.<sup>8</sup> Furthermore, it has been reported that there are some geographical zones with very marked endemic hydrofluorosis<sup>9,10</sup> principally in the northern and central states of the country, especially Chihuahua,<sup>11</sup> Durango,<sup>12</sup> and Aguascalientes.<sup>2</sup> In the state of Hidalgo, prevalences of 68% to 78% have been reported in regions with fluoride levels in the water higher than the allowed.<sup>13</sup>

The groundwater composition is determined mainly by its time of residence in the aquifer and by the characteristics of the materials through which it circulates, as well as by the presence of ions.<sup>14</sup> When the water passes through the soils by percolation, it dissolves various compounds, among them, fluorine compounds, which results in fluoride concentrations in the aquifers, which increase in the presence of cesium, lithium, chlorine, bromine, and hot springs and groundwater.<sup>15</sup>

The Mexican Ministry of Health recommends that the population not use fluorinated salt in zones where the fluoride concentration in the water exceeds the established limit.<sup>7,16</sup> Considering the lack of published information about the presence of fluorides in the water extracted from the subsoil of this geographical zone, it was decided to conduct the present study in the municipality of Metepec, in the State of

Hidalgo, where the population consumes water from four different sources: springs, faucets (tap water), and from two water purification plants. Because of the above, the objective is to answer the following question: What is the relation between the presence of caries and fluorosis and the level of fluorine ions in the water consumed by children in the community of La Victoria in the municipality of Metepec, Hidalgo?

## Materials and Methods

A correlational, transversal, non-experimental study was performed. With the aim of describing in detail and in an ordered way the methodology used in this work, in the following paragraphs, we start by describing the population in which the research was carried out; later, the two stages of the study are presented.

### *Population and Hydrography of the Locality*

The municipality of Metepec represents 0.4% of the state population, and inside, there is the community of La Victoria, which belongs to the federative entity of Hidalgo, Mexico, with 556 inhabitants. This community has a health house and a dental office. It has a telesecundaria\*, an elementary school, and a kindergarten, all of them with public funding. The most frequent indigenous languages are otomí and náhuatl.<sup>17</sup>

The locality has a piped water supply composed of a network of pipes throughout the locality, being its main source of piped

\*TN. A telesecundaria is a Mexican secondary school modality characterized by the use of free textbooks together with complementary printed, audiovisual, and IT materials. The schools of this kind are located mainly in rural communities and small towns around the country.

water supply (with chlorinated polyvinyl chloride tubes), coming from a well. In addition, there are two more water purification plants (businesses dedicated to selling drinking water, generally in 20 L jugs) in the community, and a small water reservoir.<sup>17</sup>

### First Stage

In the first stage, a periodic sample from the four main sites of water consumption used by the community population (the spring or pipes, the stream, the purification plant 1, and the purification plant 2) was conducted (Figure 1).

The fluoride levels in the water were measured with a low-range fluoride colorimeter (Hanna Instruments) acquired specifically for this project, which uses the SPADNS method of the American Chemical Society.<sup>18</sup> The principle of this method is based on the reaction between

the fluoride ions and the Zirconyl-SPADNS-Fluoride complex. This method covers the determination of fluorides in an interval from 0 mg/L to 1.4 mg/L. When increasing the content of fluoride, the color intensity diminishes, so the absorption is inversely proportional to the concentration of fluorides.<sup>18</sup> The results are shown in mg/L (ppm) of fluoride.

### Second Stage

The “Progreso y Libertad” elementary school in the locality of La Victoria, which belongs to Metepec, Hidalgo, was visited for the collection of data. With the authorization of the institution’s principal, the parents and teachers in charge were contacted to be invited to participate in the study. A talk was offered to them, in which it was explained in detail the whole procedure, and an informed consent form was provided to be consulted at home. The parents who accepted the participation of their children were invited to be present during both

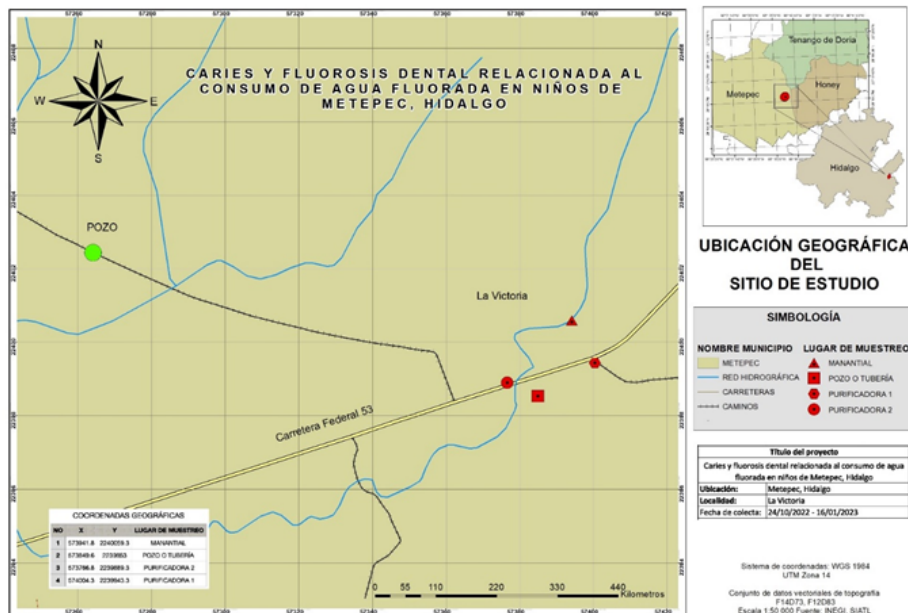


Figure 1. Geographical location of the site of study and the places of sampling

visits, and the consent was signed; all the tutors spoke Spanish. The procedure was explained to the children, and all of them participated voluntarily.

Initially, the students were asked with a series of questions (Table 1) related to the principal consumption of water of the student population. For this, the research team was provided with an exclusive space in the multi-purpose room of the elementary school.

Afterwards, an exam of the oral cavity was performed, including only the intraoral soft tissue, to classify the dental caries in the children. For the identification of dental caries, the ICDAS method of visual

inspection was used.<sup>19,20</sup> After that, in order to classify them, the proposal by Higashida was used. This method, considering the affected tissue, classifies into: (a) degree 1, only the enamel is affected; (b) degree 2, the enamel and dentin are affected; and (c) degree 3, enamel, dentin, and pulp are affected.<sup>21</sup> During the same exam, the presence or absence of dental fluorosis was assessed. The latter was classified following the recommendations by the WHO, using the Dean index and considering the following categories: healthy, questionable, very mild, mild, moderate, and severe.<sup>22,23</sup> For this study, the upper central and lateral incisors, as well as the lower incisors, were considered.

Table 1. Questionnaire on water consumption sources

Water Consumption Sources	
Identification Number:	Date:
Student's Name:	
Question	Answers
1.- Where do you get the water that you drink?	Faucet Spring Purification plant 1 Purification plant 2
2.- Have you drunk water directly from the faucet?	Yes No
3.- How many times a week?	
4.- Have you drunk water from a spring?	Yes No
5.- How many times a week?	
6.- Have you consumed bottled/jug water from any of the purification plants?	Yes No
7.- When you run out of water from where you principally drink, where do you drink from?	Faucet Spring Purification plant 1 Purification plant 2

All measurements were made by the same person, the main researcher, who is a graduate in odontology and has expertise in the detection and classification of caries and fluorosis lesions, aiming at diminishing the measurement biases.

Prior to the assessment, the dentobacterial plaque was removed with a gauze to improve the direct observation of the dental surfaces. The observations were made with natural light, using a mouth mirror and a pediatric dental explorer to facilitate the classification and determine dental fluorosis, considering the clinical characteristics such as white and/or dark brown stains, deterioration, fragility, and loss of tooth structure, as well as symmetrical bilateral lesions with a horizontal pattern from one side to another of the tooth.

The procedures in this study did not cause any risk, since the participation was anonymous, voluntary, and confidential. The participants were informed about the procedure, and they were given time to consult, an informed consent form was signed by the parents, so the ethical considerations advocated in the Declaration of Helsinki, the General Health Law, and the National Commission of Bioethics (CONBIOÉTICA) manual were respected.

#### *Statistical Analysis*

The obtained data were captured in a Microsoft Excel® sheet to later be analyzed with R v. 4.3.024 and Stata 13®. Exploratory statistical analyses were made, both graphic and non-graphic, to determine the data distribution.<sup>25</sup> To study the statistical difference between the levels of fluorides in the four water samples, an analysis of variance ANOVA<sup>26</sup> was carried out. The selection of the

test was based on the normality and homogeneity of the data variances.<sup>27</sup> Based on the results of the variance analysis, the Tukey's Honestly Significant Difference Test<sup>28</sup> was performed to identify the differences between the water sources. To understand the nature of the relation between the presence of caries, fluorosis, and the water source per student, a multiple correspondence analysis was carried out. This statistical analysis allows to establish relations between categories, given the incidence of each one, expressed in contingency tables, denominated as Burt tables.<sup>29</sup>

## **Results**

### *First Stage*

In total, 52 samples were collected from the principal sources of water supply during the period from October 24th, 2022, to January 16th, 2023. The highest values were obtained in well water with a mean of 1.63 ppm, followed by spring water with a mean of 1.47 ppm, and the lowest were those obtained for water purification plants, with 0.71 ppm and 0.74 ppm. The water of the purification plants was within the allowed range during the whole study period (Table 2).

The results of the variance analysis (ANOVA) evaluate the differences in the arithmetic mean of three or more groups and can be consulted in Graphic 1. In this study, statistical significance between the four water sources was found with an F value of 148.4 and a P value less than 0.05. These results indicate the existence of significant differences between the

**Table 3.** Results of the measurement of fluorine in the water of La Victoria. October 2022-January 2023

Date of the sample obtention	Fluorine level for each source (ppm)			
	Spring water	Well water	Water from the purification plant 1	Water from the purification plant 2
	$\bar{x} = 1,47$ $\theta = 0,19$	$\bar{x} = 1,63$ $\theta = 0,2$	$\bar{x} = 0,71$ $\theta = 0,03$	$\bar{x} = 0,74$ $\theta = 0,04$
24/10/2022	1,40	1,23	0,65	0,80
31/10/2022	1,32	1,45	0,70	0,77
07/11/2022	1,02	1,77*	0,70	0,68
14/11/2022	1,49	1,37	0,69	0,72
21/11/2022	1,61*	1,59*	0,75	0,72
28/11/2022	1,59*	1,75*	0,71	0,75
05/12/2022	1,60*	1,69*	0,73	0,70
12/12/2022	1,55*	1,72*	0,69	0,78
19/12/2022	1,17	1,63*	0,70	0,80
26/12/2022	1,58*	1,77*	0,69	0,75
02/01/2023	1,62*	1,80*	0,70	0,70
09/01/2023	1,66*	1,43	0,71	0,77
16/01/2023	1,53*	1,93*	0,78	0,71

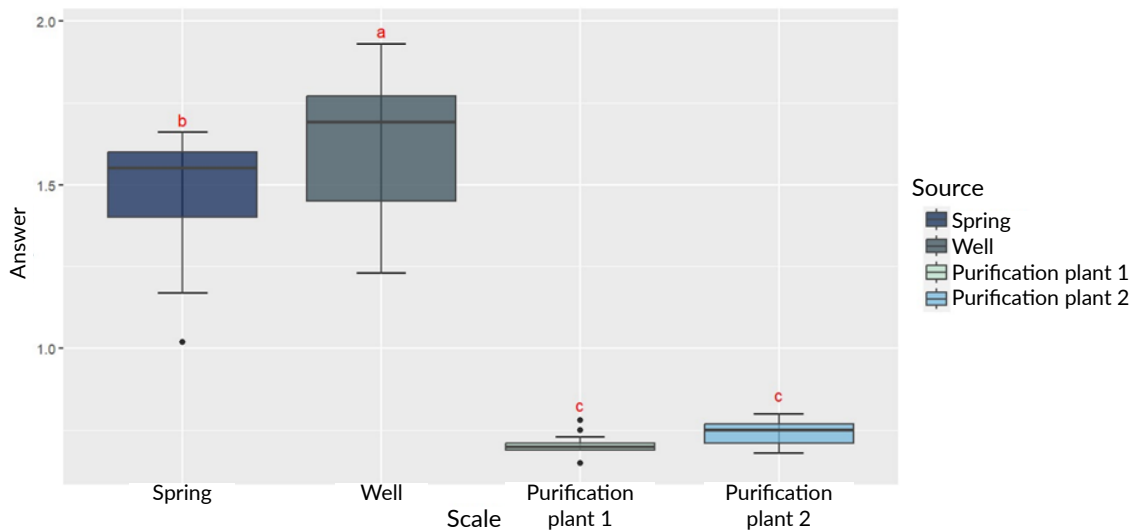
\* Value out of the range permitted by the NOM

Source: created by the authors

water sources in terms of their fluoride content. Tukey’s test revealed that the well source is the one that presents the highest concentration of fluorine ions,

followed by the spring. The purification plants had the lowest amount of fluorine ions, and they did not show statistical differences (Graphic 1).

**Graphic 1.** Fluorine ion levels in the water from different sources (ANOVA)



### Second Stage

A total of 64 students aged 8 to 12 years old were included (35 girls and 29 boys). The main water consumption sources reported by them were: directly from the faucet or a well (n=14, 21.8%), from a spring (n=27, 42.1%), and the rest from the purification plants or bottled water (n=23, 35.9%). Considering that, most of them reported having consumed water from the faucet due to the need or an extraordinary case (n=39, 60.9%).

Dental caries was present in 47 students (73.4%) and was classified according to the affected tissue<sup>19</sup> as enamel caries (n=25, 39%), caries in enamel and dentin (n=13, 20.3%), and enamel, dentin, and pulp (n=9, 14%).

The total number of cases of fluorosis found during the oral inspection was n=34 (53.1%). They were grouped according

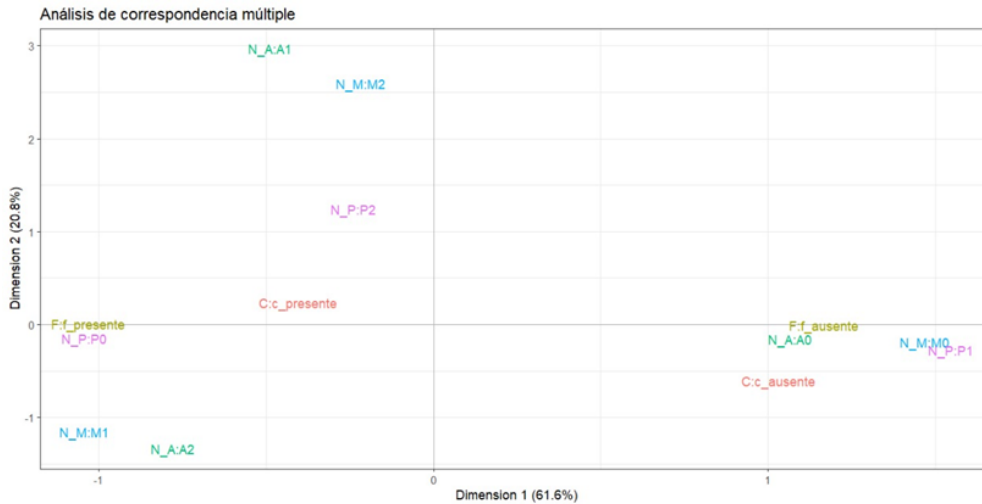
to the Dean's index<sup>22</sup>: questionable n=8 (23,5%), very mild n=13 (38,2%), mild n=6 (17,6%), moderate n=4 (11,7%), and severe n=3 (8,8%). The breakdown of the results is presented in Table 3.

Regarding the multivariate analysis (Graphic 2), three groups of clearly associated variables can be seen. The first group includes the variables: presence of fluorosis and presence of caries (f\_presente) (c\_presente) when the child mentions not drinking water from a purification plant (N\_P:P0). This is, not drinking water from a purification plant is related to presenting both caries and fluorosis. The second association of variables is: absence of fluorosis and absence of caries (F:f\_ausente) (C:c\_ausente) when the boy or girl refers not drinking water from the faucet (N\_A:A0) nor from a spring (N\_M:M0) but they do drink water from a purification plant

**Table 3.** Frequency of caries and fluorosis in the sample of students

	Sixth-grade students n= 20	Fifth-grade students n= 15	Fourth-grade students n= 18	Third-grade students n= 11	Total
<b>Caries level by depth</b>					
Enamel (1)	7	7	6	5	25
Enamel, dentin (2)	6	2	3	2	13
Enamel, dentin, pulp (3)	3	3	2	1	9
<b>Fluorosis classification (Dean)</b>					
Normal	10	7	9	4	30
Questionable (1)	1	3	1	3	8
Very mild (2)	4	3	3	3	13
Mild (3)	3	1	2	---	6
Moderate (4)	2	---	1	1	4
Severe (5)	---	1	2	---	3

**Graphic 2.** Multivariate analysis of the water source and the presence of caries and dental fluorosis



(N\_P:P1). In other words, when the child does not drink spring or tap water but drinks water from a purification plant, fluorosis and caries are absent. Therefore, is dental caries only related to the exposure to fluoride?

Additionally, two interesting relations were established through this analysis: the first

one is that when a child drinks spring water (N\_M:M1) as a first option, their second water consumption source is the faucet (NA:A2); the second is that when a child reports drinking tap water (N\_A:A1) as a first option, their second option would be spring water (N\_M:M2). A more detailed description can be found in Figure 2.

```

oj=read.csv("D:caries.csv", header= TRUE)
View(oj)

library(GDAtools)

tabla_Burt= burt(oj)
View(tabla_Burt)

library(ca)

res_acm<- mjca(oj, lambda="Burt")
res_acm

##
## Eigenvalues:
##      1      2      3      4      5      6      7      8
## Value 0.358994 0.120883 0.041061 0.031958 0.020664 0.006683 0.002139 0
## Percentage 61.64% 20.76% 7.05% 5.49% 3.55% 1.15% 0.37% 0%
##
## Columns:
##      C:c_ausente C:c_presente F:f_ausente F:f_presente N_A:A0 N_A:A1
## Mass 0.056250 0.143750 0.093750 0.106250 0.078125 0.040625
## ChiDist 0.846415 0.331206 0.724881 0.639601 0.732522 1.118598
## Inertia 0.040299 0.015769 0.049261 0.043466 0.041921 0.050833
## Dim. 1 1.032327 -0.403954 1.167905 -1.030504 1.064950 -0.488425
## Dim. 2 -0.608366 0.238056 -0.009737 0.008591 -0.153623 2.971080
##      N_A:A2 N_M:MO N_M:M1 N_M:M2 N_P:P0 N_P:P1 N_P:P2
## Mass 0.081250 0.068750 0.087500 0.043750 0.100000 0.071875 0.028125
## ChiDist 0.699391 0.928741 0.759634 1.008887 0.666492 0.953253 1.147524
## Inertia 0.039743 0.059301 0.050491 0.044531 0.044421 0.065312 0.037035
## Dim. 1 -0.779778 1.467561 -1.043805 -0.218558 -1.044684 1.546785 -0.238464
## Dim. 2 -1.337825 -0.187149 -1.152056 2.598205 -0.150756 -0.276803 1.243406

plot(res_acm)
    
```

**Figure 2.** Values and coordinates from the multiple correspondence analysis.

## Discussion

The results of this research work indicate the presence of high levels of fluorine ions in the water consumed directly from a well and from a spring in the community of La Victoria. These levels are associated with the presence of caries and fluorosis in students of the community's elementary school.

It is relevant to find a relation between the consumption of water from the establishments known as purification plants ("purificadoras" in Spanish), since this could indicate that the children recognize the local purification plants as the principal providers of water in their homes. Furthermore, the consumption of these plants is statistically related to the absence of fluorosis and caries in the children. There is no doubt that there are contextual factors, possibly socioeconomical in this regard, since drinking water from the faucet or from a spring is free or has a very low cost, while buying water from specialized suppliers may suggest a higher family income. This has been highlighted in research studies about social determinants of health.<sup>30</sup> Although this goes beyond the limits of this work, it must not be disregarded.

In Mexico, the highest values of fluorine ions in water are 0.7 ppm, establishing as a maximum limit the concentration of 1.5 mg/L in public and private supplies, similar to the criteria stipulated by the WHO, which indicates that the concentration of fluorides in drinking water must be between 0.5 and 1.0 ppm,<sup>5</sup> so the level of fluorine ions in spring and well or tap water may be producing an

increase of caries and fluorosis in children of La Victoria. Especially in those who are used to drinking water from a well or a spring. It is important to note that the water sources change according to the immediate necessities of the children, and although some mention that their main ingestion source is water from purification plants, they sometimes drink water from the faucet or from a spring due to accessibility.

Fluorosis has a direct impact on the dental organs, causing fractures or structural lesions related to the exposure and the quantity of liquid ingested during a specific amount of time. Nevertheless, it is necessary to consider that, for every patient, the water consumption doses vary; therefore, the ingested fluoride and the lesion level vary too. In this work, three cases of severe dental fluorosis appeared, none of them with fractures. The variability of the quantity of fluoride ingestion from other sources, such as toothpaste, salt, beverages, and food, as well as diverse contextual factors, may be associated with the severity of fluorosis in the sample.<sup>3,31-33</sup>

The results of this research agree with those reported for the state of Hidalgo and for northern states in Mexico. In a study about the state of Querétaro, the prevalence of severe fluorosis in adolescents was 37.1%, with 32 being the highest reported in Mexico.<sup>34</sup> The results of this work present a lower prevalence; however, it is necessary to consider that the sample was of underage students, which may be influencing, since studies made with adolescents in the state of Hidalgo report prevalences

similar to those of other states.<sup>13</sup> Studies carried out in adolescents showed a higher prevalence of mild and moderate fluorosis<sup>13</sup> in males, so future research must consider the gender variable in younger children.

It is important to consider that the obtained results are based on the measurement of exclusively the fluorine ions in the consumed water, and that the literature establishes that there are multiple sources of fluorine ingestion that may be related to the presence of oral conditions.<sup>31-33</sup>

Some limitations of this study that must be considered are that dental fluorosis is a chronic process, it starts from the beginning of the tooth development, and could be altered when, after dental eruption, teeth are in contact with high fluoride levels. Our study has a transversal design, that is, the patients underwent oral exploration. To establish a cause-effect association, longitudinal designs must be considered.

Another aspect that many research works, due to their nature, have not addressed is the inclusion of out-of-school children. It is possible that these sectors are poorer and have less access to preventive measures. In addition, it is necessary to note that the school did not have prevention programs against caries with topical fluorides, which should be part of a comprehensive policy of oral health care.

The findings of this work show that exposure to high fluoride levels in early ages caused dental fluorosis in

children of Metepec, Hidalgo. This can be concluded since in the children who reported drinking water with the allowed levels of fluorides, caries, and fluorosis were absent. A longitudinal analysis that addresses deeply all the dental pieces (permanent and non-permanent) would allow to obtain further conclusions.

The results of this study have a statistical basis. Nevertheless, it is fundamental to consider in future studies if behavioral and cultural variables have an effect on the prevalence of fluorosis. Similarly, the data presented in this work could be applied to the zone of La Victoria, Metepec, since the sampling was non-probabilistic. Finally, it was considered that there are not enough studies related to water and fluorosis in the state and the region, so it is necessary to follow up on these research works.

The results highlight:

- The prevalence of dental caries and fluorosis was present in 73.4% and 53.1% of the students, respectively.
- The presence of high levels of fluorine ions in the water consumed directly from a well or a spring in the community of La Victoria.
- There are significant differences between the water sources, regarding their content of fluorine ions. The highest values were those obtained for well water (which is later distributed and called "tap water"), followed by spring water, and the lowest values were obtained for purification plants.

- The main sources of water consumption reported by the students were: spring (42.1%), and the rest from purification plants or bottled water (35.9%), and directly from the faucet or a well (21.8%). Informing the population about the dangers of consuming spring water appears to be necessary.

The established relations were:

- Drinking water from the faucet or a spring is related to the presence of caries and fluorosis.
- An association between the absence of fluorosis and caries when the child mentions not drinking water from the faucet or a spring, but drinks water from a purification plant, was found.
- When a child drinks from a spring as their first option of water consumption, their second consumption source is tap water.
- When a child reports drinking tap water as a first option, their second option will be drinking water from a spring.

With the obtained results about the fluorine ion levels in the water consumed by children in the community of La Victoria, Hidalgo, it is recommended to diminish the total consumption of water taken directly from a well, since the fluoride levels in it are higher than those established by the Health Ministry. Based

on the results obtained from the analysis of various water consumption points of the community, it is widely recommended to drink purified water from the two options in the community, since their reported fluoride levels are within the normal parameter, so as to avoid evident damage in the future.

It is considered necessary to implement diverse actions of public health in the community, since spring water is the first water consumption source for children, and this is related to the presence of fluorosis and dental caries. The population must be encouraged to consume water with the permitted fluoride levels. Furthermore, it is necessary to point out that, as a literature review suggests<sup>8</sup>, other variables must be considered for the control and prevention of dental fluorosis.

## **Conclusion**

Fluoride levels in water from springs, wells, and available in faucets in homes are higher than those established in the Mexican regulation. In addition, there is a relation between the levels of fluorine ions in the water and the presence of caries and dental fluorosis in the studied children.

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The authors declare no conflicts of interest. There was no funding for this research.

### Abbreviations and Symbols:

NOM: Mexican Official Standards (Norma Oficial Mexicana in Spanish)

WHO: World Health Organization

mg: milligrams

L: Liter

ppm: parts per million

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