Original Article

Relationship Between Fluoride Concentration In Drinking Water Wells And The Degree Of Dental Fluorosis In Students Aged 12-15 Years

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Abstract

Objective. To evaluate the relationship between fluoride concentration in drinking water wells and the degree of dental fluorosis in 504 students aged 12-15 years from different schools in Arequipa.
Methods. In this observational epidemiologic study, we evaluated water samples that were subjected to laboratory analysis to determine the amount of fluoride in mg/l. The average age of the participants was 13.55.
Results. There were normal fluoride concentrations in three wells in Pachacutec and two wells in Tiabaya. The highest frequency would have a mild degree of fluorosis followed by a very mild degree; 5 out of 100 students would have a severe degree of anomaly. In the water wells with the highest fluoride concentration, without exceeding the allowed limits, the degree of severe fluorosis was more frequent than in other concentrations. As fluoride concentration decreases, the degree of normal fluorosis increases and the severe degree decreases to 0, but it is not permissible according to the standards set internationally. **Conclusion.** The higher concentration of fluoride in drinking water is directly related to the higher degree of fluorosis.

Keywords: Fluorosis; water; fluoride concentration; water wells; water fluoridation

Introduction

Fluoride is considered an oligo-element essential to nutritional health, moreover to prevent tooth decay and can avoid some degenerative and metabolic diseases. Studies have shown that fluoride intake, especially from early childhood to adulthood confers protection against caries both for baby and permanent teeth (3).

The US National Academy of Sciences suggests a fluoride intake of 1.5 to 4.0 mg per day; in general, an average fluoride intake of 2.0 mg (4). Dean and col (9) recognize fluoride as a synonym of preventive dentistry since 0.7-1.2 ppm concentrations in drinking water decrease the prevalence of tooth decay without producing morphological changes in the tooth enamel. The fluoridation of drinking water consists of the measurable addition of fluoride concentration to adapt the fluoride concentration to an optimum rate of prevention of tooth decay. In 1980, Newbrun defined community water fluoridation as the base for the prevention of tooth decay due to its low cost (6).
The addition of fluoride into flowing water is the most effective solution to prevent tooth decay, reducing to 60% when toddlers (2-3 years old) drink water and up to 50% when children (4 years old) drink water (7).

Since the enamel surface is in contact with the buccal cavity, teeth are in contact with the external area and are affected by the demilitarization caused by cryogenic; thus, it is the most exposed area to the flour concentration. Dental fluorosis is a hypomineralization condition of enamel since the excessive fluoride intake during its development. This is frequent in permanent teeth and it can be serious in teeth that mineralize. It occurs in both areas where the water has a high fluoride concentration as in countries where the water has been artificially fluoridated in optimal doses (2); thus, its severity is directly related to the doses of fluoride intake and its manifestation ranges from fine, barely perceptible white marks to brown coloration in the enamel surface (2). Therefore, the risk factors related to its appearance could be genetics, intake of fluoridated water and the level of mothers' education (28).

In 1934, Dean aimed to establish an evaluation and classification of dental fluorosis. The author considered epidemiological studies which related the degree of the anomaly with the level of fluoride in the public water supply, obtaining a better value when evaluating the different programs and the optimal doses of fluoride, in an attempt to establish the ideal fluoride concentration to obtain a maximum reduction of tooth decay but without considering the dental fluorosis with evident clinical manifestations (14). Likewise, the author established a classification based on the degree of different structural macroscopic changes in the enamel. This classification considered seven categories ranging from normal (0) to severe (7). In 1942, Dean modified from the practical point of view, including the evaluations "moderately severe" and "severe". There were different authors (Móller, Smith, Horowitz, Thylstrup, Fejerskov, Levine and Pedrys) that through repetitive studies, have tried to establish new indexes that provide scientific rigor and omit the disadvantage of the Dean's Fluorosis Index (14).

In most Latin American countries, the population growth rate exceeds the economic growth rate, which leads the living conditions of large sectors of society, including drinking water fluoridation, to deteriorate. This phenomenon affects directly the health care systems since it produces an inadequate coverage of health care systems, mainly the fundamental basic requirements of the population. Numerous institutions recommend improving it through highly effective and low-cost prevention programs adapted to the social and economic reality of each country.

In a country development like Peru, there is a huge need for dental treatments where the human resources and the costly materials limit the application of preventive measures against tooth decay, especially through water fluoridation since most diseases and infections are with efficacy and low-cost measures. Regarding oral health, the most diffused measures for the prevention of tooth decay and periodontal diseases are by removing the dental plaque and application of fluoride Ion in drinking water and other means like salt fluoridation.

This study aims to evaluate the relationship between fluoride concentration in drinking water wells and the degrees of dental fluorosis in students aged 12-15 years.

METHODS

The methodological approach taken in this study is an observational epidemiologic.

Sample population

This study was carried out in Arequipa, Peru in 2012. We considered 504 students aged 12-15 years, who were selected randomized from different schools of the following regions: La Bedoya, La Tomilla, Sahaca, Tiabaya, P.J. Mariscal Castilla de Pachacutec and Pachacutec semi-rural. The sample was divided into two categories, the first was composed of students aged 12-15 years from different regions according to the sources of water supply and the second was the water supply of the students' families. We considered only students that live in the regions mentioned, enrolled in the 2012 academic year and drink the water of the region. We excluded students with an oral pathology treatment and who live in a different region of the school.

Procedure

We evaluated the fluoride concentration in drinking water according to the water supply and the school. We selected randomized a school in each region where the fluorosis condition in students was evaluated.

For data collection, an epidemiologic report, oral health surveys of parents and laboratory analysis records were used as instruments. Regarding the degree of exposure of students to drinking water with the fluoride concentration according to the region, we performed an oral clinical exam and a survey after parents signed the informed consent form.

Sample taking of sources of water supply was performed by using sterilized hermetic polyethylene bottles in equal amounts. Regarding the water body or flowing water, we moved the bottle countercurrent and below the surface. Samples were taken in both surface water or groundwater and preserved in isothermal containers according to the recommendation by the BHIOS Laboratories. Each sample was coded and sent to the
laboratory without indicating its origin.

Regarding the wells, we can state that each one is different among them. Some of them are more than 40 m deep and others only 5 m. The respective analysis was taken in each well. Some of them are protected with cement, wood, or ashlar and water are sucked by pumping through a windmill or by hand, using pulleys, ropes or bucket.

Samples were taken to the BHIOS laboratories for analysis and fluoride concentrations were recorded. We used SPANDS method to determine fluoride; then, the clinical observation technique was used, in which the fluoride indexes of each water supply were recorded.

Concerning the students, we evaluated them in an environment that had the basic requirements for dental evaluation with natural light.

The researcher was evaluated by professor from the Universidad Peruana Cayetano Heredia. Each patient underwent a clinical examination for 2 months with 20 clinical examinations per day. Finally, we proceed according to the inclusion criteria and performed the clinical analysis of dental fluorosis, in which dental arches were evaluated (teeth 1.7, 1.4, 1.1 .2.7, 2.4, 2.1, 3.7, 3.4, 3.1, 4.7, 4.4, 4, 1). We cleaned the vestibular surface of the tooth selected with a cotton tissue and performed the dental fluorosis analysis by using artificial light. We considered the Dean's Fluorosis Index to measure fluorosis (Table 1)

Statistical Analysis

We used the descriptive analysis with measures of central tendency as the average and median. Dispersion measures such as the range, standard deviation to numeric variables and categorical variables as percentages. We used the chi-

squared test and Spearman's Rank-Order to establish the relationship. All statistical test was conducted with a significance level of 5%. Data analysis was performed through SPSS software v. 19.0 for Windows.

RESULTS

The average age of the adolescents in this study was 13,26±1,87 years old (12-15 years old). 65.48% correspond to male students and 34.52% correspond to female students.

Samples from Pachacutec wells registered the highest fluoride concentration (0.98 mg/L) and Tiabaya wells (0.79 mg/L). Meanwhile, La Tomilla wells registered the lowest concentration (0.22 mg/L) (Table 2).

The low fluorosis was the most frequent (29.76% in students) and very low fluorosis (27.58% data not shown).

When comparing fluoride concentration with fluorosis, we can notice that the number of normal patients is higher than the cases in which [F] is lower. Meanwhile, the case of severe fluorosis is contrary and most of the cases it was registered in [F], without a significant difference between man and woman (p=1.00) (Table 3). There was no evidence of significant difference regarding age, however, adolescents (12 and 13 years old) presented fluorosis with a higher frequency and the degree of severity was less frequent and more frequent in normality (p=0.94) in students (14 and 15 years old).

Regarding the presence of fluorosis according to the boiled water consumption, 44% of adolescents included in the study that consumes not boiled water develop moderate fluorosis. Meanwhile, those who consume boiled water present 17.41% of this anomaly (χ^2=0,02) and comparable values in others fluorosis levels. Table 4 shows the frequency of water fluoridation influence the presence of fluorosis, where less or higher fluoridation increases the number of adolescents with a dental anomaly (p<0,05; χ^2<0,05).
Finally, the Dean's Fluorosis Index was established according to the presence of fluoride in water. As [F] increases in water, the Dean's Index increases. The fluorosis ranged from normal to very low. The total Dean's Fluorosis Index was 1.66 (Table 5).

DISCUSSION

When evaluating the students, 29.76% presented a low and a very low degree of fluorosis. Therefore, 5 of 100 students would have a severe grade of fluorosis. In the study performed by Gálvez (29), the direct relationship between the normal concentration of fluoride in water, the prevalence of tooth decay and the presence of enamel opacities were identified as dental fluorosis. Dean and col (30) pointed out the presence of a relationship between the fluoride concentration in water and the prevalence of tooth decay since the fluoride concentration in water increases (1.0 mgF/L), the number of wounds in the permanent teeth decreases, generating the prevalence of dental fluorosis. Due to these observations, it has driven the necessity to adapt the fluoride levels in the water of the communities to optimal levels for the prevention of tooth decay, which fluctuates between 0.6 and 1.2 mgF/L, depending on the geographical altitude and the average maximum temperature per year.

When establishing the relationship between fluoride concentration in water wells and the degree of fluorosis of students, do not exceed the limits established but presented a higher frequency the severe fluorosis degree. When the fluoride concentration decreases, the fluorosis degree increases from normal to severe. Therefore, we should consider if the established values of fluoride concentration are the estimated since different concentrations (high or normal) or different degrees of fluoride have been identified.
It is worth mentioning that groundwater from natural sources has a high quantity of fluoride; therefore, water should be subjected to an efficient process for the removal of fluoride to a quantitatively acceptable and do not present a risk

to public health. Even if fluoride is considered an efficient measure to prevent or reduce tooth decay rates, its high concentration can be dangerous for oral health and the (31).

There is a standard that states water fluoridation to prevent high caries rates; however, this method is no longer applied since in Europe there is a standard that prohibited water fluoridation to protect public health. In this regard, in countries such as Germany, Iceland,

Norway, Holland, Finland, Italy, Austria, Belgic, Denmark, Luxembourg, Sweden, Yugoslav and New Zealand, water fluoridation is banned. In the United States, there are measures to stop fluoridating water. Meanwhile, in Latin American countries such as Peru, the great amount of fluoride in water is good for health (32).

The results of this study do not agree with the time of exposure, which suggests that with more time of exposure (i.e. age), the degree of fluoride will be severe. Dental fluorosis affects more the permanent than temporal teeth since the greatest mineralization of the temporal teeth is performed during other processes such as gestation where the placental barrier plays an important role (33).

Regarding the frequency of tooth brushing, the consumption or not of boiled water and the frequency of fluoridation, there was no statistically significant relationship. The Dean's Fluorosis Index has a direct relationship with the fluoride concentration in water, so the higher concentration of fluoride, the higher the prevalence of dental fluorosis.

CONCLUSION

The results showed that degrees of fluorosis are directly related to the concentration of fluoride in drinking water, hence the higher concentration of fluoride, the higher frequency of severe fluorosis. We recommend further research focused on adapting the necessary measures to prevent oral diseases, reducing the damage and the costs to the population to guarantee public health without affecting the mental and economic stability of the population.

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TABLE 1. Dean's Fluorosis Index

Value	Criteria
0 Normal	No fluorosis detected
1 Questionable	Enamel presents slight white dots which do not justify code 0
2 Very mild	Opaque, white areas involving (25%) more of the tooth surface. White areas from 1 to 2 mm on the apex of each premolar and second molars
3 Mild	Opaque, do not exceed (50%) of the tooth surface
4 Moderate	All enamel appears affected. Opaque in the attrition areas is observed
5 Severe	Damage in all tooth surfaces, comprising even the anatomical shape. The tooth has a corroded appearance

TABLE 2. Fluoride concentration in water according to the origin sources in schools

SAMPLING	[F] WATER (MG/L)	SCHOOLS
Pachacutec I - P.J. Mariscal Castilla	0.98	(A) C.E.5678 – Pachacutec
Tiabaya - P.J. Pampas Nuevas	0.79	(B) C. E. 40084 – Tiabaya
Tiabaya: Reservorio 24 - "El Cural"	0.73	(C) C. E. 40085 – Tiabaya
La Bedoya	0.43	(D) Centro Educativo Parroquial Jesús de Nazareno (Paucarpata)
Pachacutec II-Semi Rural	0.32	(E) C.E.57000 – Pachacutec

La Tomilla

0.22

(F) Centro Educativo Parroquial León XIII (Cayma)

TABLE 3. Relationship between fluoride concentration in water and fluorosis

FLUOROSIS (%) / [F]	(%)	Normal	Questionable	Very mild	Mild	Moderate	Severe
A = 0.98	100.00	0	7.143	26.19	32.14	23.81	10.71
B = 0.79	100.00	3.57	9.52	26.19	30.95	21.43	8.33
TOTAL							
C = 0.73	100.00	8.33	10.71	26.19	29.76	19.05	5.95
D = 0.43	100.00	10.71	13.10	27.38	29.76	15.48	3.57
E = 0.32	100.00	11.90	15.48	28.57	28.57	13.10	2.38
F = 0.22	100.00	14.29	16.69	30.95	27.38	10.71	0

A. WELLS: Pachacutec I-P.J. Mariscal Castilla**; B. WELLS:** Tiabaya-P.J. Pampas Nuevas; **C.- WELLS:** Tiabaya: Reservorio 24-"El Cural"; **D. WELLS:** La Bedoya; **E. WELLS:** Pachacutec II-Semi Rural; **F. WELLS:** La Tomilla. (p=0,98)

TABLE 4. Relationship between fluoridation and the degree of fluorosis

FLUOROSIS (%) / FLUORIDATION	TOTAL (%)	Normal	Questionable	Very mild	Mild	Moderate	Severe
Never	100.00	7.50	12.50	27.50	30.00	17.50	5.00
One	100.00	8.26	11.98	27.69	29.75	17.36	4.96
Two	100.00	8.14	12.21	27.33	29.65	17.44	5.23

Three	100.00	8.00	12.00	28.00 30.00	16.00	6.00

TABLE 5. Dean's Fluorosis Index based on the dosage in water

SCHOOLS	[F] Water (mg/L)	Dean's Fluorosis Index
C.E 5678 - PACHACUTEC	0.98	2.08
C.E. 40084 - TIABAYA PAMPAS NUEVAS	0.79	1.90
C.E 40085 - TIABAYA EL CURAL	0.73	1.72
C.E PARROQUIAL - JESUS DE NAZARENO- LA BEDOYA	0.43	1.54
C.E 57000 - PACHACUTEC II SEMIRURAL	0.32	1.42
C.E PARROQUIAL - LEON XIII LA TOMILLA	0.22	1.26
TOTAL		**1.66**