DENTAL FLUOROSIS IN RELATION TO ALTITUDE AND FLUORIDE IN DRINKING WATER IN UGANDA

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SUMMARY: The prevalence and severity of dental fluorosis among 10-14 year old children (n = 294) in four rural areas of Western Uganda were recorded using the TF index. The children, who were permanent residents in the areas, were exposed to drinking water containing either 0.5 or 2.5 mgF/L and were living at altitudes of 900 m and 2200 m (0.5 mgF/L) or 1750 m and 2800 m (2.5 mgF/L). In the 0.5 mgF/L areas, 25 % of the children (n = 81) living at 900 m had dental fluorosis as compared to 45% of the children (n = 82) at 2200 m above sea level (χ^2 =7.48). In the 2.5 mg F/L areas, 67% of the children (n = 67) living at 1750 m had dental fluorosis as compared to 84% of the children (n = 64) at 2800 m above sea level (χ^2=5.25). Regression analyses showed that the fluoride intake from the drinking water explained most of the severity of dental fluorosis. Altitude had a significant (P < 0.05) effect, but explained only 2-3% of the variance in dental fluorosis.

Key words: Dental fluorosis; Prevalence; Altitude; Magadi.

INTRODUCTION

The association between dental fluorosis and the fluoride content of the drinking was established already 60 years ago and is still valid.[1] Thus there is no doubt that the endemic dental fluorosis found in the African Rift Valley primarily is caused by the high fluoride concentration in the drinking water.[2-5] However, several studies have come up with results that cannot be explained solely on the basis of the fluoride content of the ingested water.[6-13] Besides the fluoride in the drinking water, factors such as temperature,[14-17] altitude of residence,[9,18] diet,[9,13,19] nutritional status,[20,21] and dentifrice[22-28] have been reported to influence dental fluorosis.

Most of the reports on dental fluorosis in the Rift Valley area are from Kenya, Tanzania and Ethiopia. Only one study on the prevalence and severity of dental fluorosis in Uganda seems to have been carried out,[2] and great variation in the prevalence of dental fluorosis was found, even in areas with the same fluoride concentration in drinking water. That study was performed in 4 districts. Variations in ethnic and social background, diet, and altitude may have contributed to the heterogeneous findings.

Due to these heterogeneous results the aim of this paper is to report the prevalence and severity of dental fluorosis among Ugandan children, who are relying on either high- or low-fluoride levels in the drinking water, and who are living at different altitudes.

MATERIALS AND METHODS

The survey was conducted in Western Uganda, which geologically is a part of the great African Rift Valley. Two village schools were selected in the Kisoro district; Mutolere (1,750 m above sea level) and Kabindi (2,800 m), and two villages in the Kasese district; Mpondwe (900 m) and Kyabayenze (2,200 m). Mutolere and Kabindi

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had piped water from the same source. Also Mpondwe and Kyabayenze shared a common water supply. The fluoride contents of the waters were unknown at the time of examination in 1996. The piped water systems had been operating since 1962 (Kisoro) and from 1982 (Kasese).

A total of 294 schoolchildren (Mutolere = 67, Kabindi = 64, Mpondwe = 81 and Kyabayenze = 82) were randomly selected for the examination (Figure 1). Children included in the study had to fulfill the following criteria: aged 10-14 years, born and raised in the village, absence from the village for not more than 1 month a year during the first 6 years of life and use of drinking water from the same source during the first 6 years of life.

Permission to carry out the study was obtained from the relevant health and school authorities, and informed consent was given by the parents of the children. Clinical examination was done by the principal investigator (MCR) under field conditions following the criteria specified by WHO.[29] By the clinical examination, the child was sitting on an ordinary chair outside the school building with indirect natural daylight as the source of illumination. Cotton rolls were used to wipe the teeth dry and control saliva. Assessment of dental fluorosis was done according to the Thylstrup and Fejerskov index (TFI) modified in 1988.[30]

After the clinical examination, the child and his/her mother were interviewed according to a structured questionnaire in order to get information on residence, dietary habits during the early childhood, oral hygiene practices. Based on the amount of liquid, cups per day, consumed and the fluoride level in the drinking water, the fluoride exposure during early childhood was estimated.

Samples of drinking water and *magadi*[1] were collected and analyzed for fluoride. Chi-square (χ^2) statistics were used to assess significant differences between groups, and multiple regression analyses to determine factors related to dental fluorosis. The significant level was set at 5%.

RESULTS

The fluoride concentration of the drinking water in Kisoro (Mutolere and Kabindi) was 2.5 mg F/L, and in Kasese (Mpondwe and Kyabayenze) 0.5 mg F/L, cf. Figure 1. The fluoride concentration in the magadi samples ranged from 2.8 to 17.1 (mean 8.5) mg F/kg, cf. Table 1. The distribution of children according to sex showed no significant difference in each of the respective areas (Figure 1). There was no significant difference (χ^2 = 3.0, df = 1) between males and females in the prevalence of dental fluorosis.

TABLE 1 Fluoride concentration in magadi from Uganda.

Sample	mg F^-/kg Magadi	
	Sample	Average
1	2.8	
2	5.5	8.5
3	17.1	

In areas with 0.5 mg F/L in the drinking water, 25 % of the children at 900 m had dental fluorosis as compared to 45 % at 2,200 m above sea level (χ^2 = 7.48, df = 1). In areas with 2.5 mg F/L in the drinking water, 67 % of the children had dental fluorosis

[1] The Ugandan Magadi (Kutwe salt) is a Trona collected from shores of Lake Kutwe. The salt is very popular used in the local households as tenderizer and taste improver in food.

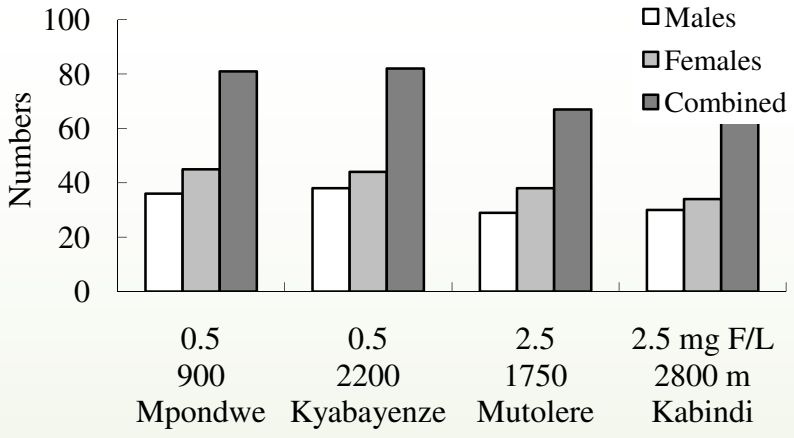

FIGURE 1. Distribution of children according to sex, area altitude and fluoride concentration in the drinking water.

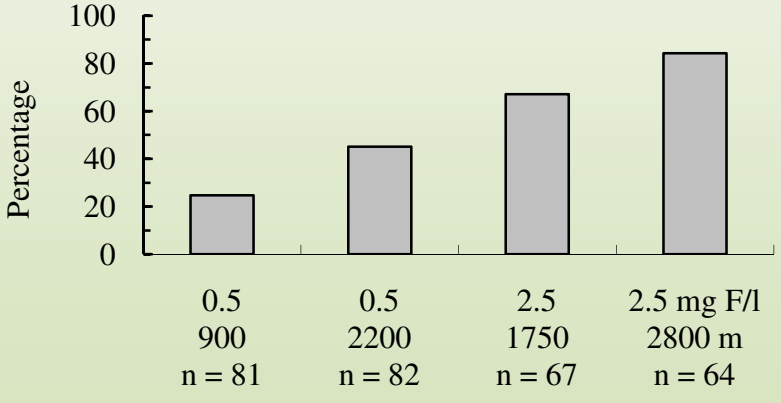

FIGURE 2. Prevalence of dental fluorosis (permanent teeth) according to altitude and fluoride in the drinking water.

at 1,750 m as compared to 84% of the children at 2,800 m above sea level ($\chi^2 = 5.25$, df = 1), cf. Figure 2.

The increasing prevalence by altitude and fluoride in water was also reflected in increased severity of dental fluorosis with altitude and fluoride concentration in the drinking water, cf. Figure 3.

The proportion of children with a daily water intake of ≥ 1.75 liters was higher ($\chi^2 = 8.4$, df = 1) in Kisoro as compared to Kasese, cf. Figure 4. Regression analyses showed that the fluoride exposure from the drinking water explained 68 % of the dental fluorosis in the Kisoro and 31 % in Kasese. Altitude only explained 2 % and 3 % in the respective districts. However, the effect of altitude was significant ($P < 0.05$,

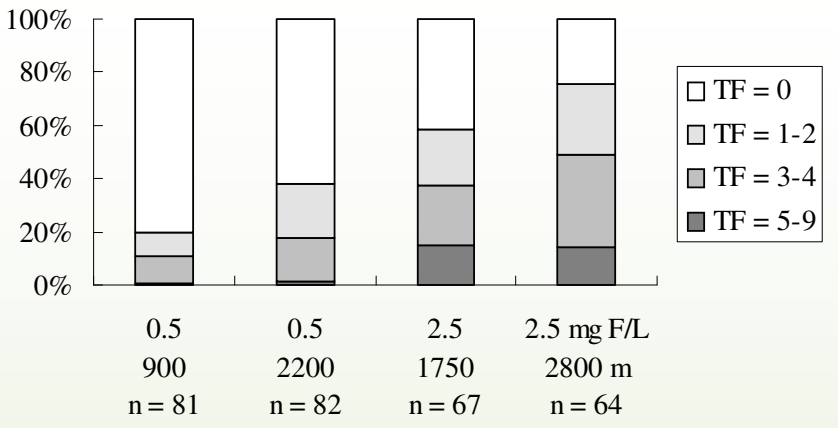

FIGURE 3. Frequency distribution of TF scores according to altitude and fluoride in the drinking water.

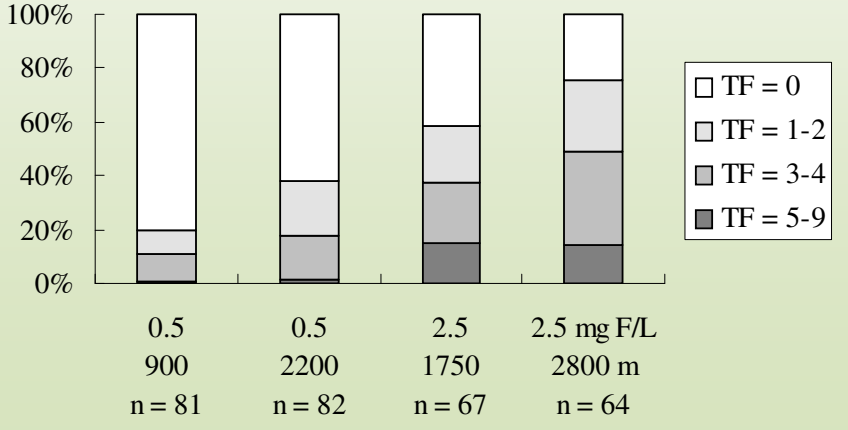

FIGURE 4. Frequency distribution of daily water intake (at 3 years of age) according to area.

Table 2). Magadi had no significant effect on the prevalence of dental fluorosis (χ^2 = 2.7, df = 1, Table 3). According to the mothers, the average consumption of magadi was 2 g twice a week. ´

DISCUSSION

The prevalence and severity of dental fluorosis showed a direct relationship with the concentration of fluoride in the drinking waters and with altitude, cf. Figure 2. The differences in the fluoride exposure explained more of the variations in the prevalence of dental fluorosis in the 2.5 mg F/L area than in the low fluoride area. Children in the high fluoride area consumed more liquid than in low fluoride area. However, the high fluoride level in the water rather than the difference in water intake may account for the greater explanatory power of the fluoride exposure in the high fluoride area.

TABLE 2. Variables related to the prevalence of dental fluorosis according to district.

District	Variable	Regression Coefficient	Prediction (%)	P-value
Kisoro	[1]F exp. from water	0.83	67.7	0.001
2.5 mg F/L	Altitude	0.13	1.5	0.01
Kasese	[1]F exp. from water	0.55	30.6	0.001
0.5 mg F/L	Altitude	0.19	3.3	0.005

[1]The fluoride exposure (mg) from water is the product of volume of water (L) taken per (a 3 years old) child per day and the concentration of F (mg/L) in drinking water.

TABLE 3. Use of Magadi according to children with and without dental fluorosis.

Use of magadi	Children with fluorosis	Children without fluorosis
Yes	130	124
No	26	14
(χ^2=2.7, df=1)		

When simple analyses were only carried out, the prevalence of dental fluorosis was significantly related to altitude. Regression analyses, however, showed only a limited, but significant effect of altitude. This finding strengthened results from Tanzania. They claim that the effect of altitude, first reported from Kenya,[18] could rather be explained by the use of magadi in food preparation.[9] In our study about 2.0 g magadi is consumed per child twice a week, according to the mothers' estimates. Provided, a mean concentration of 8.5 mg F/kg magadi, compared to 36 - 6800 mg F/kg in Tanzania, a child will only consume about 0.03 mg F/week from the magadi. This is about 1/10 of the amount ingested daily from the drinking water in a 0.5 mg F/L area and thus the magadi probably contributes little to the severity of dental fluorosis in our material. The prevalence of dental fluorosis in our study was relatively low as compared to results from other African studies with similar range of fluoride concentration in the drinking water.[2,6,9,11,12,31] The different prevalences may partly be explained on the basis of factors such as temperature, altitude, differences in life styles and dietary habits such as the use of magadi. Moreover, other possible explanations are the criteria used for recording fluorosis, conditions under which the examinations were done inter-examiner variations, and analyses of the data.

REFERENCES

1. Dean HT. Chronic endemic dental fluorosis (mottled enamel). In: *Dental Science and Dental Art* Henry Kimpton, London 1938.
2. Møller IJ, Pindborg JJ, Gedalia I, Roed-Petersen B. Prevalence of dental fluorosis in the people of Uganda. *Archives of Oral Biology 15* 213-225 1970.
3. Thylstrup A, Fejerskov O. Clinical appearance of dental fluorosis in permanent teeth in relation to histological changes. *Community Dentistry and Oral Epidemiology 6* 315-328 1978.
4. Olsson B. Dental findings in high-fluoride areas in Ethiopia. *Community Dentistry and Oral Epidemiology 7* 51-6 1979.
5. Manji F, Bælum V, Fejerskov O. Dental fluorosis in an area with 2 ppm fluoride in drinking water. *Journal of Dental Research 65(5)* 659-662 1986.

6. Manji F, Bælum V, Fejerskov O, Gemert W. Enamel changes in two low-fluoride areas of Kenya. *Caries Research 20* 371-380 1986.
7. Grobber SR, van Wyk CW, Kotze D. Relationship between enamel fluoride levels, degree of fluorosis and caries experience in communities with a nearly optimal and high fluoride level in the drinking water. *Caries Research 20* 284-288 1986.
8. Brouwer ID, de Bruin A, Backer Dirks O, Haustvast JGA. Unsuitability of the World Health Organisation guidelines for fluoride concentrations in the drinking water in Senagal. *The Lancet 1* 223-225 1988.
9. Mabelya L, König KG, van Palenstein Helderman WH. Dental fluorosis, altitude and associated dietary factors. *Caries Research 26* 65-67 1992.
10. Lewis HA, Chickte U, Butchart A. Fluorosis and dental caries in school children from rural areas with about 9 and 1 ppm in the water supplies. *Community Dentistry and Oral Epidemiology 20* 53-54 1992.
11. N'ganga PM, Valderhaug J. Prevalence and severity of dental fluorosis in primary school children in Nairobi, Kenya. *Community Dentistry and Oral Epidemiology 21* 15-18 1993.
12. Ibrahim YE, Affan AA, Bjorvatn K. Prevalence of dental fluorosis in Sudanese children from two villages with 0.25 and 2.56 ppm fluoride in drinking water. *International Journal of Paediatric Dentistry 5* 223-229 1995.
13. Mabelya L, van Palenstein Helderman HW, van't Hof MA, König KG. Dental fluorosis and the use of high fluoride-containing trona tenderiser (magadi). *Community Dentistry and Oral Epidemiology 25* 170-176 1997.
14. Galagan DJ, Lamson GG. Climate and endemic dental fluorosis. *Public Health Report 68* 497-508 1953. Washington.
15. Galagan DJ, Vermillion JR. Determining optimum fluoride concentrations. *Public Health Report 72* 491-493 1957. Washington.
16. Richards LF, Westmoreland WW, Tashiro M, McKay CH, Morrison JT. Determining optimum fluoride levels for community water supplies in relation to temperature. *Journal of American Dental Association 74* 389-397 1967.
17. Warnakulasuriya KAAS, Balasiriya S, Perera PAJ, Peiris LCL. Determining optimal levels of fluoride in drinking water for hot, dry climates - a case study in Sri Lanka. *Community Dentistry and Oral Epidemiology 20* 364-367 1992.
18. Manji F, Bælum V, Fejerskov O. Fluoride, altitude and dental fluorosis. *Caries Research 20* 473-480 1986.
19. Han YZ, Zhang JQ, Liu XY, Zhang LZ, Yu XH, Dai JA. High fluoride content of food and endemic fluorosis. *Fluoride 28*(4) 201-202 1995.
20. Murray MM, Dagmar CW. Fluorosis and nutrition in Morocco: Dental studies in relation to environment. *British Dental Journal* 97-100 1948.
21. Massler M, Schour I. Relation of endemic dental fluorosis to malnutrition. *Journal of American Dental Association 44* 156-165 1952.
22. Forsman B, Ericsson Y. Fluoride absorption from swallowed fluoride toothpaste. *Community Dentistry and Oral Epidemiology 1* 115-120 1973.
23. Ekstrand J, Ehrneb M. Absorption of fluoride from fluoride dentifrice. *Caries Research 14* 96-102 1980.
24. Ekstrand J, Koch, Petersen LG. Plasma fluoride concentrations in preschool children after ingestion of fluoride tablets and toothpaste. *Caries Research 17* 379-384 1983.

25. Osuji OO, Leake JL, Chipman ML, Nikiforuk G, Locker D, Levine N. Risk factors for dental fluorosis in a flouridated community. *Journal of Dental Research 67* 1488-1492 1988.
26. Pendrys DG, Katz RV. Risk of enamel fluorosis associated with fluoride supplementation, infant formula, and fluoride dentifrice use. *American Journal of Epidemiology 130*(1) 199-208 1989.
27. Pearce E. Fluoride intake: Fluorosis risk from swallowing toothpaste. *New Zealand Dental Journal 87* 60 1991.
28. Riordan PJ. Dental fluorosis, dental caries and fluoride exposure among 7-year-olds. *Caries Research 27* 71-77 1993.
29. WHO. *Oral health surveys.* Basic methods. Geneva. 3rd ed. 1987.
30. Rozier RG. Epidemiological indices for measuring the clinical manifestations of dental fluorosis: Overview and critique. *Advanced Dental Research 8*(1) 39-55 1994.
31. Awadia AK, Bjorvatn K, Birkeland JM, Haugejorden O. Dental fluorosis in incisors and molars: A study in Tanzanian schoolchildren in two communities with 3.8 mg/l. respectively 0.4 mg/l. in the drinking water. 1997. (Unpublished).