

SEVERE FLUOROSIS IN CHILDREN CONSUMING FLUORIDE CONTAINING MAGADI

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SUMMARY: The Prevalence and severity of dental fluorosis among children in East Africa has in several areas been reported higher than would be expected from the fluoride content in the water supplies. This study aimed to measure dental fluorosis in 50 randomly selected 12 to 15-year-old children who were born and raised in an endemic fluorosis area in the northern Tanzania, and aimed to relate the prevalence and severity of their dental fluorosis to fluoride exposure. Buccal surfaces of all permanent teeth were scored for fluorosis according to the Thylstrup Fejerskov Index (TFI). Children and their mothers were interviewed with aid of a questionnaire about dietary habits and methods of food preparation. 96% of the examined children exhibited dental fluorosis of TFI 4 on more than 2 teeth. The water sources used since birth had a fluoride content of less than 0.4 mg-F/l. results of the interviews revealed a frequent use of "magadi", a potash (trona) salt, which is added to food as a tenderizer. The magadi samples collected from 25 different households showed a fluoride concentration of 760 - 6800 µg-F/g (mean 2776 µg-F/g). It was calculated that adults in this community consumed approximately 34 mg-F per week through magadi containing meals. Infants started to ingest fluoride through magadi in the first year after birth. However, an accurate estimate of fluoride consumption during period of tooth formation was not possible on the basis of the present data. The lack of an association between dental fluorosis and fluoride exposure through drinking water in some of the previous reports from African communities may be explained by inadequate identification of available fluoride sources. It is suggested that in many areas in Tanzania endemic fluorosis may occur as a result of fluoride supplementation to food through magadi rather than exposure to fluoride in drinking water. This urges further research.

Key words: Fluorosis, fluoride exposure, Thylstrup Fejerskov Index, magadi.

INTRODUCTION

Dental fluorosis is a disorder of tooth mineralization caused by excessive intake of fluoride during tooth development. The severity of dental fluorosis increases with the amount of fluoride ingested during the period of tooth formation¹. The mild form is characterized by opaque white lines along the perikymate which may fuse to form opaque white patches, mottled enamel. It may be stained yellow to dark brown by uptake of pigments from food and drinks after the teeth have erupted. In more severe cases discrete pits and larger areas of hypoplasia of enamel may occur to the extent that the normal morphology of the tooth is lost. Endemic dental fluorosis is most prevalent in areas where the drinking water contains elevated levels of fluoride. The dental fluorosis prevalence in some regions in East Africa is believed to be caused by fluoride in drinking water²⁻⁵. However an increasing number of reports have appeared from East African countries indicating a high prevalence and severity of dental fluorosis that can not be explained by the fluoride content of the drinking water⁶⁻¹⁰.

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Recently, a low fluoride community which used drinking water with 0.4 mg-F/l but still was affected with severe dental fluorosis was identified in the central region of Tanzania. An additional fluoride source was discovered in the form of "magadi" $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot \text{H}_2\text{O}$. Magadi are used as a tenderiser to speed up the cooking time of certain foods. Magadi is found in numerous places in Tanzania. Not all magadi contains high levels of fluoride but the type used in this community appeared to be heavily contaminated with soluble fluoride salts. The exposure to magadi with a high fluoride content was considered to explain the severity of dental fluorosis in the observed community¹¹.

The present study aimed to determine the prevalence and severity of dental fluorosis in association with fluoride levels in drinking water and magadi in a community in the northern region of Tanzania. This region has for decades been known for endemic fluorosis¹² and for numerous places with high fluoride in water supplies³.

MATERIALS AND METHODS

The study was carried out in Kibosho at 1,300 m altitude near Moshi in the Kilimanjaro region. School-children aged between 13 and 15 year, who were born and brought up in that community, were identified. All children who met the selection criteria in classes 3 and 4 and some children according to the alphabetical order of their surname in class 5 were selected to form a sample of 50 (mean age 13.9 years).

The children had used several water sources in that area since birth. Water samples from these sources (n = 9) were collected in August 1991 in a period of long rains, in January 1992 during a long dry period and again in October 1992 in a period with occasional rains. The water samples were collected in plastic containers. Analysis of the fluoride ion concentration was done using the fluoride ion specific electrode.

The children were examined in natural daylight in a shaded area by one examiner. Buccal surfaces of erupted permanent teeth were wiped with a gauze and were left to dry before they were scored for fluorosis according to the TFI. Colour photographs of teeth with different TFI scores were available as an aid to reliability¹⁴. The examiner was not aware of the prevailing fluoride content in the water sources.

The children were interviewed about their dietary habits with the aid of a 24-hour-recall questionnaire. In addition they were asked how frequently they consumed tea, fish and magadi on a weekly basis at the time of the interview. Every second mother (n = 25) was interviewed about the frequency of magadi use for food preparation. They were also asked how long they were using magadi and at which age their children were introduced to foods which contained magadi. Each interviewed mother provided the interviewer with a sample of magadi equal to the amount they normally used for cooking meals. Magadi in this community has been supplied through local market traders who, bring it from salt lakes in the northern part of Tanzania, implying that there are several sources of magadi. The samples of magadi were weighed and subsequently 5 grams were dissolved in 20 ml of distilled water prior to the analysis with the fluoride ion specific electrode.

RESULTS

The fluoride content in the water sources in Kibosho varied over time but the variation was very low (Table 1). These sources have been used by the studied community for the at least 15 years.

The prevalence and severity of fluorosis among the 50 children is illustrated in Figure 1. Forty six percent of the children exhibited TFI higher than 3 on all their teeth whereas 96% of the children exhibited TFI higher than 4 in more than 2 teeth and 63% showed at least 50% of their teeth with TFI higher than 4. A TFI score higher than 4 represents severe fluorosis as it manifests hypoplasia and deformations of the normal morphology of the teeth. Due to the porosity of the enamel, dark discoloration may occur.

TABLE 1. Average and range of fluoride concentrations in 9 water sources at different times of the year.

Sampling time	Average (mg-F/l)	Range (mg-F/l)
August 1991	0.04	<0.05 - 0.12
January 1992	0.35	0.26 - 0.43
October 1992	0.28	0.21 - 0.56

Information from the children revealed that tea was not drunk excessively (average 5.7 times per week), neither was fish consumed frequently (average 0.7 times per week). Mothers reported that "magadi" was added to the boiling pot for taste and to reduce the cooking time particularly for beans. Mothers reported that they cooked beans with magadi in average 4.1 times per week (the children reported nearly the same frequency of 4.3 meals per week). The amount of magadi addition for preparation of beans for 6 - 8 persons were on average 21 grams. The usual meal containing beans and cooked bananas were served as a juicy dish. No water was discarded after the cooking process. Consequently all fluoride added through magadi was consumed. Only when the cooking pot did not contain bananas some remaining water was discarded before the meal was served.

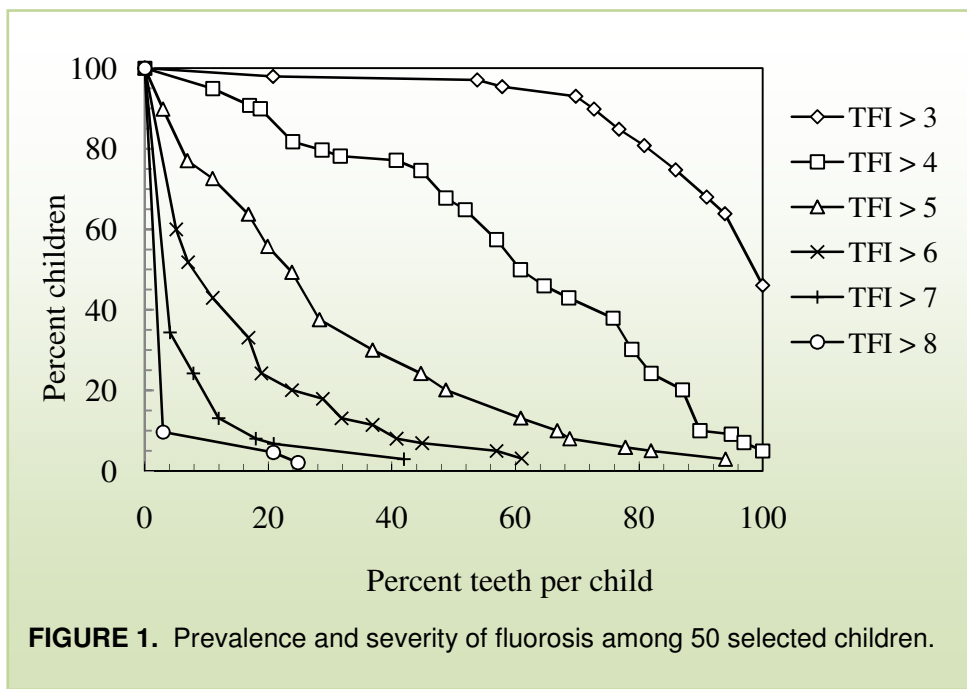
The average fluoride concentration in the magadi samples was 2776 $\mu\text{g-F/g}$ with a range of 760 - 6800 $\mu\text{g-F/g}$.

All mothers reported to have introduced magadi to their infants meal in the weaning period between 4 - 9 months (mean 6.9) after birth. The mothers stated that they had always used magadi and that small children shared the meal with adults.

DISCUSSION

The fluoride content of the water sources in the examined community varied with time but was always found low. This finding corroborates previous reports on the fluctuating fluoride concentrations in drinking water in several countries¹⁵. The low fluoride content on the drinking water of the present community (on average < 0.4 mg-F/l) could not explain the high prevalence (96%) of the children with TFI higher than 4 which is severe according to Dean's score¹⁶. The severity of dental fluorosis in the present community, if caused solely by fluoride in drinking water, would be accounted for by a fluoride concentration of at least 7 mg-F/l in the water¹.

Other usual sources of fluoride prevailing in developed countries e.g. infant formulae, fluoride in toothpaste, fluoride tablets fluoride rinsing and other fluoride applications do not exist. However, an additional source of fluoride was identified in the form of magadi. The magadi used in this community contained on an average 2800 $\mu\text{g-F/g}$ magadi. The average amount of fluoride ingested from this source in the Kibosho community for adults was approximately 34 mg-F per person per week. It is precarious on the basis of the present data to calculate the amount of fluoride ingested by infants and young children in this community. According to the information of mothers, their infants ingested magadi in the first year of their life through weaning foods but the quantity is not known. Fifty percent of the children in Tanzania are breast-fed up till age of 23 months¹⁷ and although they share their meals with other members of the family, the amount of fluoride consumed through magadi during weaning and later up till the age of 12 years is unknown.



Besides the fluoride exposure during the period of tooth formation up till the age of 12 years, other factors have been suggested to exert effects on the severity of dental fluorosis¹⁸. Several reports from Tanzania, South Africa, Kenya, and Senegal have shown a higher severity of dental fluorosis than would be expected from the fluoride content in their drinking water supplies^{6-10,13,19}. In an attempt to explain the high prevalence and severity of dental fluorosis in those communities, climate⁸⁻¹⁰, altitude¹⁹, diet and malnutrition²⁰ have been suggested as possible factors.

The present community did not exhibit malnutrition among its infants and young children. The climate in Kibosho is not very hot and dry, since Kibosho is located at the foothills of the Kilimanjaro at 1300 meters altitude.

The prevalence and severity of dental fluorosis found in this study were in agreement with a report from another Tanzania community in the central region on the country at

a comparable altitude, but in disagreement with data from a community in the coastal region at sea level which exhibited low levels of dental fluorosis¹¹. Both these communities consumed drinking water with a low fluoride content of 0.4 - 0.6 mg-F/l. The main difference in fluoride exposure between the two communities appeared to be the use of magadi in the community at high altitude¹¹. This correlation to magadi consumption raise doubts about the explanation given for a Kenyan community, that altitude related hypobaric conditions may have modified the susceptibility of individuals of fluoride¹⁸. It seems more likely that unidentified dietary fluoride source in those people may have caused the observed severe dental fluorosis. It is suggested that in studies on dental fluorosis careful attention should be paid to dietary habits and local customs in the preparation of food in order to identify possible additional fluoride sources.

Tanzania has several endemic dental fluorosis areas and the possibility is suggested that many of these areas may exist as a results of high fluoride supplements to food rather than the fluoride content of water supplies. This urges further investigation.

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