Dental Fluorosis in an Area of Kenya with 2 ppm Fluoride in the Drinking Water
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We examined 102 children born and reared in an area of rural Kenya with 2 ppm fluoride in the drinking water for dental fluorosis, using the index developed by Thylstrup and Fejerskov (1978). The prevalence of dental fluorosis was 100%, 92% of all teeth exhibited a TF score of 4 or higher, and 50% of the children had pitting or more severe enamel damage in at least half the teeth present. The fluorotic changes showed a high degree of bilateral symmetry. The intra-oral distribution of the changes corresponded to the pattern of fluoride-induced enamel changes reported by other investigators in high-fluoride areas. The high prevalence and severity of dental fluorosis in a 2-ppm-fluoride area is in accordance with recent observations on dental fluorosis being very prevalent in Kenya, even in low-fluoride areas (<1 ppm F). We are presently investigating the possible variables which may explain this unexpected susceptibility of large populations in Eastern Africa to fluorosis from exposure to low levels of fluoride.


Introduction.

In a recently conducted study of the prevalence and severity of enamel changes in populations living in a rural area of Kenya with water fluoride concentrations in the range 0.1–1.0 ppm, we found an unexpectedly high prevalence and severity of dental fluorosis (Manji et al., 1986). In addition, we showed a positive association between increasing prevalence and severity of dental fluorosis and slight increases in the mean fluoride ion concentrations in available supplies of drinking water. It has previously been reported that, with increasing mean annual temperatures, an apparent increase in prevalence and severity of enamel fluorosis occurs (Gallagan and Lamson, 1953; Richards et al., 1967). This relationship has been presumed to result from an increasing human demand for fluids as temperatures increase. From our observations in very-low-fluoride areas of Kenya (Manji et al., 1986), it is evident that such a simple relationship may not fully explain the high prevalence and severity of enamel changes observed.

To obtain further information about various factors which may influence the individual’s susceptibility to develop dental fluorosis, we conducted a study in a rural Kenyan population which had complained about cosmetic dental problems which were assumed to be due to dental fluorosis.

Materials and methods.

The Kenya Medical Research Institute has established a rural study area northwest of Nairobi in Kiambu District (Central Province) for the purpose of studying diarrhoeal diseases. The area is located 2095 metres above sea level, with a mean maximum air temperature of 20.9°C and an annual rainfall of 105-115 cm. The population is predominantly Kikuyu. From one primary school within the study area, all children in standards 4 and 5 (aged between 10 and 15 years) were examined. This particular primary school was selected because most of the children came from families which obtained water from one bore-hole that was established in the mid-1950’s. The only additional source of drinking water was (until recently) rain-water collected during the rainy seasons.

A total of 110 children was examined, but only 102 of these were born and reared in the area. Table 1 shows the distribution of the 102 children according to age and sex. Although there is a variability within the age groups, the total number of boys is equal to that of girls.

The dental examinations were conducted at the school, with natural daylight as the only source of illumination (direct sunlight was avoided). After the buccal surfaces of all permanent teeth were dried with gauze and cotton rolls, the surfaces were classified according to the TF Index developed by Thylstrup and Fejerskov (1978). Only buccal surfaces were coded, since it has previously been shown (Thylstrup and Fejerskov, 1978) that in prevalence studies no extra information may be gained by including other surfaces. Partially erupted teeth (less than half the crown visible) were excluded from the examination. In cases of doubt as to which score should be assigned to a tooth, the lower score was chosen. Examinations were conducted by all three authors. Two of these examiners did not have experience in the use of this index in populations exhibiting severe dental fluorosis, but were experienced in using both the Dean’s Index and the TF Index in low-fluoride areas. Thus, the purpose of the present study was also to calibrate these two examiners with the third examiner (OF), who is one of the original designers of the TF Index.

Twenty-seven children were examined by all three examiners independently, so that interexaminer consistency could be assessed. A total of 749 teeth was thus classified by each examiner. The scores assigned by each were compared, and the degree of agreement between them was calculated. The results are shown in Table 2. The Spearman rank correlation coefficients of the TFI scores assigned by each of the examiners with the scores assigned by the others show that the between-examiner agreement was high and significantly greater than 0 (the chance expectation).

At the time of the examination, water samples were collected from the bore-hole supplying water to the population. The examiners had no knowledge of the fluoride ion concentration, which, on later analysis, was found to be 2.14 ppm.

Results.

All the children examined exhibited dental fluorosis, i.e., the prevalence was 100%. The prevalence in the

<table>
<thead>
<tr>
<th>Age</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>19</td>
<td>31</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>51</td>
<td>102</td>
</tr>
</tbody>
</table>

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From this Fig., it is apparent that in 95% of the children, more than 50% of their teeth had TFI scores of 4 or higher. Moreover, 50% of the children had pitting in at least one tooth exhibiting a score of 7 or higher. Only about 5% of the children had more than half of their teeth with TFI scores from 7 to 9.

Bilateral symmetry of the enamel changes, according to the homologous pairs of buccal surfaces, is evident from Fig. 3. In 65% of the tooth pairs, the same degree of fluorosis was recorded. The observed probability of obtaining an homologous pair of buccal surfaces where one surface deviates one score or less from the other was 93%.

In Fig. 4, the observed probability of obtaining the same score, or having deviations of one score or more, is presented for each tooth type. The lower 2nd molar and the upper first molar were those having the lowest probability of exhibiting the same score on homologous buccal surfaces (about 50% of the tooth pairs). In contrast, the central incisors showed bilateral symmetry on about 80% of the surfaces.

The frequency distribution of the TFI scores assigned to each tooth type shows a characteristic pattern within the dentition (Fig. 5). Except for the incisors, where from 15 to 20% had TFI scores of 3 or lower, most of the teeth exhibited TFI scores of 4 or higher. The first molars were the most severely affected, with from 70 to 80% having enamel destruction, whereas the lower incisors were the least affected, with about 30% having enamel destruction. However, about 50% of the upper central incisors showed loss of surface enamel to a varying extent (TFI scores, 5-9).

**Discussion.**

In this population of children from an area of Kenya with 2 ppm F in the water, there was an unexpectedly high prevalence
and severity of dental fluorosis. This finding is consistent, however, with our recent findings of higher prevalence and severity of dental fluorosis than would be expected in very low-fluoride areas of Kenya in the Eastern Province (Manji et al., 1986). The children examined in the two studies originate from very different provinces of Kenya with respect to ecology, mean annual maximum air temperatures, and annual rainfall. Moreover, the children were from different ethnic groups. Nevertheless, we observed the same tendency for higher prevalence and severity of dental fluorosis in relation to water fluoride concentration in both populations.

The enamel changes within the dentition exhibited the expected bilateral symmetry characteristic of dental fluorosis. However, not all tooth types exhibited the same degree of symmetry, with the lower 2nd molars and upper 1st molars showing the largest variation. A number of factors may have contributed to this finding, such as difficulties in having a sufficiently good field of view of the buccal surfaces of the posterior teeth, combined with rather intensive masticatory attrition which, in this population, affected buccal and other surfaces, leading to varying degrees of damage to the enamel (Baelum et al., 1986). The relatively high degree of bilateral symmetry of the TFI scores of the incisors may, to some extent, have been influenced by examiner bias, since the proximity of these teeth makes it difficult to examine them independently.

In the present population, the TFI scores for all teeth combined showed an unimodal distribution (Fig. 1). However, in the study by Thylstrup and Fejerskov (1978), in which the index was developed, a bimodal distribution of TFI scores was reported in three high-fluoride areas, with modes around TFI scores 4-5 and at score 7. The pattern obtained in the present study may have been influenced by the following: The enamel along the buccal-occlusal border tends to be affected by occlusal attrition, often resulting in the hypomineralized enamel on the buccal surface being partially damaged. Consequently, there is a tendency, where buccal surfaces alone are being scored, for the surface to be scored as TFI score 7. In the course of the calibration exercises, we decided that where less than 1 mm of the buccal surfaces was so involved, we would include this as being score 6. It is likely, therefore, that this practice resulted, on subsequent analysis, in a more unimodal distribution being obtained in contrast to the bimodal distribution apparent in studies in populations exhibiting severe dental fluorosis. This modification of the classification system is
one which we would recommend for use in future studies, especially in communities exhibiting severe dental fluorosis.

The intra-oral distribution of the enamel changes was characteristic of the distribution associated with dental fluorosis (Dean, 1934; 1942; Thylstrup and Fejerskov, 1978). However, in contrast to our findings in low-fluoride areas of Kenya (Manji et al., 1986), the first molars appeared to be the most severely affected tooth type. It is probable that this is a reflection of a greater severity of dental fluorosis in these teeth at the time of eruption: Dental fluorosis is characterized by varying degrees of sub-surface porosity of the enamel (Thylstrup and Fejerskov, 1978), and the pitting of the enamel is known to occur post-eruptively (Thylstrup and Fejerskov, 1979; Thylstrup, 1983); thus, the degree of pitting of the enamel may be a function of both the degree of porosity at the time of eruption and the masticatory forces around the teeth post-eruptively. From the available evidence, there appears to be little reason to believe that the diets of these two populations may be sufficiently different to attribute a greater proportion of pitting in the present study population to masticatory forces alone (van Ginneken and Muller, 1984). Further studies on post-eruptive changes in fluorotic enamel are, however, needed in order to elucidate the mechanisms of post-eruptive changes.

In the present population, a larger proportion of the upper incisors exhibited post-eruptive changes than would be anticipated from other studies (Larsen et al., 1985a, b, 1986). This may be explained by the fact that the fluorotic changes in the anterior teeth are cosmetically unacceptable to the present population: It was common to find subjects who had ground the buccal surfaces of their teeth to varying extents. This made an exact and accurate classification of the actual changes very difficult and often tended to increase the scoring of severity. Therefore, we would recommend that the scoring of incisors should be considered with caution in any population where attempts have been made to carry out cosmetic grading of incisors. Because such practices are usually undertaken among children approaching the age of puberty, it may be of value to score the incisors only in younger age groups.

The most common way to describe fluorosis in a population is to use mean values (for example, the Fci values calculated from Dean's index). The limitations of this method of presenting data have been discussed elsewhere (Thylstrup and Fejerskov, 1978). In the present study, using a classification system which is sensitive enough to characterize both very slight and severe degrees of fluorosis, we have presented our findings (Fig. 2) in a manner which enables us to characterize the features of dental fluorosis in a population such that both prevalence rates and the differences in severity between and among individuals can be interrelated. This method of characterizing the population seems to us to have the advantage that it is possible, within one graph, to present prevalence of disease within a population and at the same time immediately visualize the relative severity of disease within the population described. To substantiate further the usefulness of this way of describing the features of dental fluorosis in different populations, we will, in future papers, demonstrate how various populations may be characterized and compared by means of such analytical methods.

Taking into account that two of the examiners here had not previously used the TF Index in populations exhibiting severe dental fluorosis, it was remarkable that there was a very close consistency in scoring by each of the examiners, following a short calibration exercise before the survey. This indicates that the TF Index is easy to use and can provide consistent results — a concept recently supported by Granath et al. (1985).

In conclusion, our present findings lend further support to previous findings from Kenya that the relationship between exposure to fluoride from drinking water and the prevalence and severity of dental fluorosis may be more complex than has previously been thought. Although it may be argued that the present observations may be particular to Kenya, it seems important to consider the relevance of our data in the light of claims of an increasing prevalence and severity of dental fluorosis in other parts of the world. We are in the process of further investigating the possible variables which may explain the unexpected susceptibility of various populations to the effects of low levels of fluoride.

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