Kenhardt revisited – a study in a high fluoride area

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SUMMARY

The caries inhibitory effect of optimally fluoridated water is well documented. Communities are often exposed to naturally fluoridated water with F content exceeding the optimal level of 1 ppm. The purpose of this study was to determine the relationship between enamel fluoride concentration, and mass fluoride expressed in picograms (pg) and mass in an endemic fluoride area.

Sixty-one 14 to 17-year-old White children (27 males and 34 females) who were born and had been living continually in Kenhardt were selected for this study. The DMFT and DEGF were determined clinically. Acid etch biopsies were done on both the maxillary central incisors of each pupil. F and Ca analyses were carried out on the biopsy solutions and mass fluoride expressed in picograms (pg) and mass enamel in micrograms (µg). Data transformations to logc mass F (InF), logc mass En (InEn) and \( \sqrt{\text{DMFT}} \) were made. The InF values were adjusted to a standardized depth of 10 µm (enamel equivalent mass of 208.6 µg) by covariance analysis.

In order to determine the association between \( \sqrt{\text{DMFT}} \), InF and DEGF, correlations between the various pairs of variables were calculated for all the pupils, for pupils with DMFT ≤2 and DMFT >2, and for pupils with DEGF ≤1 and DEGF >1.

The following significant associations were established: A negative correlation significant at the 10 per cent level \((p = 0.0902)\) between \( \sqrt{\text{DMFT}} \) and InF for DEGF≤1; A highly significant \((p = 0.0004)\) positive correlation between InF and DEGF for all the pupils and for pupils with DMFT >2.

OPSOMMING

Die kariesbeperkende effek van optimale gefluoreerde water is reeds deeglik beskryf. Gemeenskappe word dikwels blootgestel aan natuurlike gefluoreerde water met 'n F inhoud wat die optimale vlak van 1 dpm oorskry. Die doel van hierdie ondersoek was om die verhouding te bepaal tussen glasuur fluoried konsentrasie, graad van fluoridasie (DEGF) en tandkaries insidensie (DMFT) in 'n endemiese fluoried gebied. Een-en-sestig 14 tot 17-jarige wit kinders (27 manlike en 34 vroulik) wat gebore is en opgegroeie het in Kenhardt, is vir hierdie ondersoek gekies. Die DMFT en DEGF is klinies bepaal. Suurets biopsies is gedoen op beide die maksillêre eerste snytande van elke skolier. F en Ca analyses is uitgevoer op biopsieoplosings en massa fluoried is uitgedruk in pikogramme (pg) en massa glasuur in mikrogramme (µg). Data transformasies na logc massa F (InF), logc massa En (InEn) en \( \sqrt{\text{DMFT}} \) is gedoen. Die InF waardes is aangepas tot 'n gestandaardiseerde diepte van 10 µm (glasuur ekwivalente massa van 208.6 µg) deur kovariante analyse. Ten einde die assosiasie tussen \( \sqrt{\text{DMFT}} \), InF en DEGF te bepaal, is korrelasies tussen die verskillende pare variante vir al die skolieere bereken, vir skolieere met DMFT≤2 en DMFT>2, en vir skolieere met DEGF ≤1 en DEGF >1.

Die volgende betekenisvolle assosiasies is gevind: 'n negatiewe korrelasie betekenisvol op die 10 persent vlak \((P = 0.0902)\) tussen \( \sqrt{\text{DMFT}} \) en InF vir DEGF≤1; 'n hoog betekenisvolle \((P = 0.004)\) positiewe korrelasie tussen InF en DEGF vir al die skolieere en vir skolieere met DMFT >2.

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INTRODUCTION

Endemic dental fluorosis or mottled enamel is widely distributed throughout the world. In the Republic of South Africa it has been observed in the North Western, Western and Karoo regions of the Cape Province, Western and Central Free State and Northern, Eastern and Western areas of the Transvaal (Ockerse, 1946).

Ockerse (1941) examined 6 to 16-year-old White children in the Kenhardt School. Thirty-eight of these children were born and grew up in the village of Kenhardt, and 24 per cent had dental caries while all showed signs of mottled enamel. The fluoride content of the drinking water of Kenhardt at that time was 6.8 ppm F. Of the 142 children born in the Kenhardt district, 9 had questionable mottling and the degree of mottling in the remainder ranged from mild to severe. The fluoride content of four well waters in the Kenhardt district averaged 7.7 ppm.

In 1960 Dodd, Levy and Jackson reported that an unknown bone disorder occurred in Coloured children resident in the Rooiblok residential area of Kenhardt. They postulated that the high fluoride content of the drinking water obtained from ghorras (shallow wells observed in children born and reared in this township) was probably the most important factor responsible for the bone deformities observed in children born and reared in this township. They also reported that caries, which occurred at the drinking water of Kenhardt at that time was 6.8 ppm F. Of the 142 children born in the Kenhardt district, 9 had questionable mottling and the degree of mottling in the remainder ranged from mild to severe. The fluoride content of four well waters in the Kenhardt district averaged 7.7 ppm.

Later in 1962 Kenhardt was again visited by Jackson and, amongst others, he determined the extent of dental fluorosis in 7 to 10-year-old White children resident in Kenhardt and Coloured children from "Die Woonbuurt" and Rooiblok residential areas respectively. He reported that 23 of the 25 White children and 29 of the 32 Coloured children from "Die Woonbuurt" had dental fluorosis while none of the 37 children from Rooiblok was fluorosis-free. The drinking water of Kenhardt and "Die Woonbuurt" was from an alternative source and the fluoride content ranged from 2.6 to 3.2 ppm.

In 1975 we revisited Kenhardt to determine the interrelationship between fluoride concentration of surface enamel, degree of fluorosis (DEGF) and caries incidence (DMFT) in 14 to 17-year-old White school children who were born and had been living continually in Kenhardt.

MATERIALS AND METHODS

Kenhardt is a village located in the Northwestern part of the Cape Province in the Republic of South Africa. The average annual rainfall is between 12.5 and 25 cm and the general geologic formation of the district is old granite and gneiss (Ockerse, 1941). The White population of the town is 850 and of the Kenhardt district 2,500. The central water supply of the village is obtained from boreholes situated 8 km from the town and is piped to the village. The drinking water was analyzed by the Department of Health on 23 February, 1978 and part of the analysis is given in Table I. The fluoride content of the drinking water is 3.2 ppm. Analysis of the drinking water collected from several points in the town was done in our laboratory and the fluoride content ranged from 3.16 to 3.22 ppm. Drinking water, mostly obtained from boreholes, was collected from 13 farms in the district and the fluoride content determined (Table II). Several of the children reported that their drinking water was obtained from fountains or "syferwater" but unfortunately none of this water was available for analysis.

Pupils from the Kenhardt High School were selected for this study. The procedures involved in the clinical examination and biopsy procedure were carefully explained to them and their approval to be included in this investigation obtained. Only 14 to 17-year-old children who were born and had been living continually in the village or district of Kenhardt were selected. The 61 pupils consisted of 27 males and 34 females.

| pH | 8.1 |
| Nitrate | 2.4 |
| Chloride | 320 |
| Sulphate | 100 |
| Fluoride | 3.2 ppm |
| Calcium | 98 |
| Magnesium | 42 |
| Potassium | 3 |
| Sodium | 160 |
| Boron | 440 |
| Copper | 21 |
| Iron | 70 |
| Manganese | 6 |

* Department of Health, Republic of South Africa, February 23, 1978

Table I. Composition of the drinking water of Kenhardt*

<table>
<thead>
<tr>
<th>Farm</th>
<th>Source</th>
<th>ppmF</th>
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<tbody>
<tr>
<td>Sanddolk</td>
<td>Borehole</td>
<td>2.44</td>
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<tr>
<td>Witkoppies</td>
<td>Borehole</td>
<td>2.74</td>
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<tr>
<td>Crieff</td>
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<td>Lushof</td>
<td>Borehole</td>
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</tr>
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<td>Nooitgedacht</td>
<td>Cistern</td>
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<td>Arbeidsvreug</td>
<td>Borehole</td>
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<td>Perdevlei</td>
<td>Borehole</td>
<td>2.26</td>
</tr>
<tr>
<td>Reniernrus</td>
<td>Borehole</td>
<td>2.94</td>
</tr>
<tr>
<td>Sonderhus</td>
<td>Borehole</td>
<td>3.02</td>
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<td>Kaapuis</td>
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<td>Geduld</td>
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</tr>
<tr>
<td>Voorspoed</td>
<td>Borehole</td>
<td>1.08</td>
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</table>

*Department of Health, Republic of South Africa, February 23, 1978
### Table III. DMFT distribution in male and female pupils

<table>
<thead>
<tr>
<th>DMFT</th>
<th>Frequency</th>
<th>Cumulative frequency</th>
<th>Per cent</th>
<th>Cumulative per cent</th>
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<td>M</td>
<td>F</td>
<td>M</td>
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<td>4</td>
<td>32</td>
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</tr>
<tr>
<td>12</td>
<td>-</td>
<td>1</td>
<td>34</td>
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</table>

### Table IV. DEGF distribution in male and female pupils

<table>
<thead>
<tr>
<th>DEGF</th>
<th>Frequency</th>
<th>Cumulative frequency</th>
<th>Per cent</th>
<th>Cumulative per cent</th>
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<td>6</td>
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<td>9</td>
<td>9</td>
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<td>33.3</td>
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### Table V. Various parameters for the male, female and combined pupils

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Male</th>
<th>Female</th>
<th>T</th>
<th>P</th>
<th>Combined pupils</th>
</tr>
</thead>
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<tr>
<td>n</td>
<td>27</td>
<td>34</td>
<td></td>
<td></td>
<td>61</td>
</tr>
<tr>
<td>Unadjusted InF</td>
<td>13.08 ± 0.08*</td>
<td>12.94 ± 0.06</td>
<td>-1.43</td>
<td>0.1571</td>
<td>13.00 ± 0.05</td>
</tr>
<tr>
<td>Enamel F (ppm)</td>
<td>2410 ± 220</td>
<td>2011 ± 129</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Adjusted InF</td>
<td>13.08 ± 0.07</td>
<td>12.94 ± 0.03</td>
<td>-1.43</td>
<td>0.1557</td>
<td></td>
</tr>
<tr>
<td>Unadjusted InTi</td>
<td>5.59 ± 0.03</td>
<td>5.41 ± 0.03</td>
<td>0.4464</td>
<td>0.6569</td>
<td>5.40 ± 0.02</td>
</tr>
<tr>
<td>Biopsy depth (μm)</td>
<td>10.46 ± 0.34</td>
<td>10.66 ± 0.30</td>
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<td></td>
</tr>
<tr>
<td>DMFT</td>
<td>2.30 ± 0.41</td>
<td>3.44 ± 0.57</td>
<td></td>
<td></td>
<td>2.93 ± 0.37</td>
</tr>
<tr>
<td>DKGF</td>
<td>1.85 ± 0.18</td>
<td>1.79 ± 0.16</td>
<td>-0.2364</td>
<td>0.8140</td>
<td>1.82 ± 0.12</td>
</tr>
<tr>
<td>Age</td>
<td>15.22 ± 0.22</td>
<td>15.35 ± 0.21</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Mean ± SE

The caries incidence (DMFT) of each participant was determined in good natural light with the use of mouth mirrors and sharp dental probes by a dental surgeon (DHR). Teeth lost as a result of trauma or those congenitally missing were not included in determining the DMFT index. The DMFT distribution in the male and female pupils is given in Table III and the mean DMFT ± S.E. in Table V. The degree of fluorosis was assessed by a dental surgeon (FHB) using Dean's (1934) classification as a guide.

Class I: Normal teeth with no evidence of fluorosis. Score 0.

Class II: Mild fluorosis characterized by localized white streaks or areas. Score 1.

Class III: Moderate fluorosis characterized by extensive white opaque mottling and isolated pitting of enamel. Score 2.

Class IV: Severe fluorosis characterized by marked pitting and often accompanied by brown staining. Score 3.
The DEGF distribution in male and female pupils is given in Table IV and the mean DEGF ± S.E. in Table V.

The facial surfaces of the maxillary central incisors of each pupil were cleaned with a water slurry of flour of pumice and a slowly rotating rubber cup. The teeth were washed and dried well. Areas, 3 mm in diameter, were demarcated on the middle third of the crowns of the incisors by means of annular adhesive discs (No. 471; 3 M Co., St. Paul, MI). The discs were burnished well to ensure good marginal adaptation to the underlying enamel. Enamel specimens were obtained from the demarcated surface areas by means of an acid etch biopsy procedure (Van der Merwe et al., 1974). The etching solutions were transferred to plastic tubes containing 1 ml of Total Ionic Strength Adjustment Buffer 1 diluted with an equal amount of deionized water. The test solutions were analyzed for fluoride and calcium. The fluoride content was determined with a Model 96-09 Orion combination fluoride electrode coupled to an Orion Model 801A pH/mv meter. The mass of fluoride in the etching solutions was expressed in picograms (pg). The calcium content was determined in aliquots of etching solutions diluted 25 times with 1 per cent lanthanum chloride to prevent interference from phosphorus and aluminium (Willis, 1961). Duplicate calcium determinations were carried out with a Zeiss Model PMQ11 with flame attachment FA2 atomic absorption spectrophotometer. The mass of enamel in each etching solution was calculated by assuming that human enamel contains 37 per cent calcium (Relief et al., 1971) and expressed in micrograms (µg). The fluoride concentrations in the enamel of the central incisors were calculated as follows:

\[ \text{Unadjusted fluoride concentration (ppm)} = \frac{\text{Mass F (pg)}}{\text{Mass Enamel (µg)}} \]

The mean and S.E. of the average values for left and right maxillary central incisors of each individual were determined for the male and female pupils (Table V). The biopsy depth for each tooth was calculated from the following formula:

\[ \text{Biopsy depth (µm)} = \frac{\text{Mass enamel (µg)}}{\text{Density of enamel (µg/mm²)} \times \text{Biopsy area (mm²)}} = \frac{\text{Mass enamel (µg)}}{20.86} \]

1 (TISAB, Orion Research Inc., Cambridge, MA)
2 (Carl Zeiss. Oberkochen/Württ, West Germany)
Density of enamel is 2.95 (Manly and Hodge, 1939). The mean and S.E. of the average biopsy depths for left and right maxillary central incisors were determined for the male and female children (Table V).

Because of the steep fluoride gradient in the outermost enamel (Brudevold et al., 1956), the mass of fluoride in a given biopsy obtained from a standardized area depends on the biopsy depth or equivalently, on the mass of enamel in the biopsy solution. The biopsy depth is an uncontrollable variable and ranged from 6.8 μm to 14.8 μm. In order to make valid comparisons between the fluoride content of the central incisor teeth, the fluoride concentrations were corrected to a uniform depth of 10 μm (equivalent enamel mass of 208.6 μg).

Statistical analysis
The following data transformations were made:
- Mass F in picograms to log10 mass F (lnF)
- Mass enamel in micrograms to log10 mass En (lnEn)
- DMFT to √DMFT

The data were transformed in order to stabilize variance and to make the data more nearly follow a Gaussian distribution. Preliminary t-tests were carried out to determine the significance level of the differences between lnF and lnEn respectively for the left and right incisors of the pupils involved in this study. The differences between lnF (t = 1.40, p = 0.167) and lnEn (t = 1.70, p = 0.0947) were not significant. The means of lnF (unadjusted) and lnEn (unadjusted) for the sexes were determined from the average values of lnF (left) and lnF (right) and lnEn (left) and lnEn (right) for each individual. Two sample t-tests were used to determine the significance level of the differences between lnF (unadjusted), lnEn (unadjusted), √DMFT and DEGF between the sexes.

A covariance analysis (Steel and Torrie, 1960) was run to test the differences between sexes for lnF (adjusted) using lnEn as the covariate. The adjusted lnF values were obtained by correcting the unadjusted lnF values to a standardized depth of 10 μm (equivalent enamel mass of 208.6 μg).

In order to determine the association between √DMFT, lnF and DEGF, correlations (Steel and Torrie, 1960) between the various pairs of variables were calculated for all the pupils, for pupils with DMFT ≤2 and DMFT >2, and for pupils with DEGF ≤1 and DEGF >1.

All computations were performed utilizing the Statistical Analysis System (Barr et al., 1976).

RESULTS
Of the male pupils 25.9 per cent were caries-free and 3.7 per cent showed no signs of fluorosis. The corresponding percentages for the females were 29.4 and 8.8. The mean (± S.E.) values for DMFT, DEGF, enamel fluoride concentration (ppm) and biopsy depth for the male and female pupils are given in Table V. Two sample t-tests of the transformed data √DMFT, lnF (unadjusted), lnEn (unadjusted) and DEGF showed that the differences between sexes for these parameters were not significant (Table V). The covariance analysis revealed that the covariate (lnEn) was not significant (t = 0.21, p = 0.83) and that the difference in lnF (adjusted) between sexes was also not significant (t = 1.43, p = 0.1577). The correlations between the parameters √DMFT, lnF and DEGF are given in Table VI. The following significant associations were established:
- A negative correlation significant at the 10 per cent level (p = 0.0902) between √DMFT and lnF for DEGF ≤1; A highly significant (p = 0.0004) positive correlation between lnF and DEGF for all the pupils and for pupils with DMFT >2 (Table VI).

DISCUSSION
Sixty-one of the 70 odd children in the Kenhardt High School who were born and had been living continually in the Kenhardt village and district were selected for this study. Sixteen of these children were resident in the village and the remainder were from the district. Approximately one-half of the children from the district were boarding in the school hostels during the school term. They were approximately 7 years old when first admitted to the hostels. The children examined were representative of the area as only 10 per cent of the Kenhardt children attended other schools.

The drinking water of the district was mainly obtained from boreholes with a fluoride content ranging from 0.49 to 3.02 ppm F. Rainwater collected from the roofs of dwellings in cisterns is used on some of the farms, but this supply of drinking water is sporadic as it is dependent on the rainfall in a semi-arid region. The school hostels and the high school are supplied with the same drinking water as the village which contains 3.2 ppm F.

The adjustment of lnF to a standardized depth of 10 μm was made because the biopsy depths ranged from

<table>
<thead>
<tr>
<th>Table VI. Correlations between DMFT, lnF and DEGF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>√DMFT and lnF</td>
</tr>
<tr>
<td>DMFT and DEGF</td>
</tr>
<tr>
<td>lnF and DEGF</td>
</tr>
<tr>
<td>n</td>
</tr>
</tbody>
</table>

*Significant correlations
was confirmed by Richards 
studies on the effect of water fluoridation, conclusions 
content of all the other maxillary teeth from the same 

The present investigation is based on the premise that 
within a given community differed from those of their 
caries incidence and fluoride content of enamel. As 
based on the F levels of only one tooth type were 
obtained for the male and female pupils respectively. 

No significant differences between InF (t = 1,40, 
P = 0,167) and InEn or equivalent biopsy depth (t = 1,70 
P = 0,0947) respectively for the left and right maxillary 
incisors of the pupils involved in this study were 
obserbed. This is in accordance with previous findings by 
Keene et al. (1973) and Bischoff et al. (1976). Aasenden 
(1974) reported that the mean fluoride concentration 
of biopsies taken to comparable depths was generally 
about 10 per cent higher in males than in females. He 
suggested that this observed difference in F concentra-
tion could be related to the longer pre-eruptive matura-
tion time of the enamel in boys than in girls. In the pre-
sent study the difference in the InF values adjusted to a 
standardized depth of 10 \( \mu \text{m} \) between sexes was not sig-
nificant (t = 1,43, p = 0,1577).

The present investigation is based on the premise that 
the average F concentration of the biopsied left and 
right maxillary central incisors of an individual is an 
index of the fluoride status of the entire dentition of 
that individual. This premise is supported by the expe-
riental work of Aasenden et al. (1973) and Richards et 
al. (1977). Aasenden et al. (1973) determined the fluo-
ride concentration in surface enamel of maxillary cen-
tral and lateral incisors and canines of children from 
three communities living in areas supplied with differ-
ent F levels in the drinking water. Their study showed 
that there were differences between the F concentra-
tions in the surface enamel of various tooth types but 
that the F concentrations of the three tooth types 
within a given community differed from those of their 
ho\( \text{mologous teeth in another community by a relativ-
ly constant factor. They concluded that in compara-
tive studies on the effect of water fluoridation, conclu-
sions based on the F levels of only one tooth type were 
applicable to the general F status of a community. This 
was confirmed by Richards et al. (1977) who reported that 
the fluoride content of the maxillary central inci-
sors was closely correlated to the grand mean fluoride 
content of all the other maxillary teeth from the same 
individual.

Several attempts have been made to determine the re-
lationship between parameters such as dental fluorosi-
caries incidence and fluoride content of enamel. As 
early as 1936, Bowes and Murray reported that the flu-
oride content of pooled bulk enamel from mildly 
mottled teeth was higher than that of non-mottled 
teeth. Armstrong and Brekhus (1938) found that the 
mean fluoride concentration in bulk enamel of sound 
teeth was higher than that of carious teeth. McClure 
(1948), however, reported that he could not relate dif-
fences in the fluoride content of sound and carious 
teeth from the same individuals to their caries status.

McClure and Likins (1951) found that an increase in the 
fluoride content of the drinking water resulted in an 
increased fluoride uptake by bulk enamel and that this 
was associated with a marked reduction in dental caries 
experience. 

A study was undertaken by Forrest (1956) to correlate the 
incidence of caries and mottling with different 
levels of fluoride in the drinking water. She reported 
that the caries incidence was markedly lower in the flu-
oride than in the non-fluoride areas and that the inci-
dence and severity of fluoride mottling was directly 
related to the amount of fluoride in the water. Examini-
ation of her results showed that the caries incidence in 
children resident in an area containing 5.8 ppm F was 
twice as high as the caries incidence in children living in 
an area containing 3.5 ppm F (2.8 vs 1.4). The caries 
experience of both groups of children was, however, 
considerably lower than that of children living in low 
fluoride (0.1 - 0.2 ppm F) areas.

Binder (1973) carried out a survey to determine the ef-
effects of natural fluoride in the drinking water on dental 
caries and fluorosis. He found that the DMFT values of 
children resident in high fluoride areas decreased while 
the incidence of fluorosis increased. The interrelation-
ship between fluoride exposure, dental fluorosis, concen-
trations of fluoride in surface enamel obtained by an 
abrasive biopsy procedure and caries experience 
was examined in young Naval recruits (Keene et al. 
1973). Enamel from the caries-free group contained sig-
ificantly higher levels of fluoride than the enamel 
from the groups with caries experience. Dental fluoro-
sis and years of exposure to fluoride in drinking water 
were significantly higher in the caries-free group. To 
obtain further information on the interrelationships of 
the same parameters, the study was extended to indi-
viduals with obvious manifestations of dental fluorosis 
(Keene et al. 1975). They found that the mean enamel 
fluoride concentrations were significantly higher in the 
fluorosis group than in the control group but that the 
difference in the mean DMFT scores was not statisti-
cally significant.

DePaola et al. (1975) determined the caries experience 
(DMFS index) and surface enamel fluoride concentra-
tions in a large number of 12-16-year-old pupils living in 
selected fluoridated and non-fluoridated areas. Fluo-
ride was expressed as \( \log_{10} \) mass F corrected to a stan-
dardized depth and a square root transformation of 
DMFS was carried out. An analysis of the data re-
vealed a highly significant inverse relationship between 
\( \log_{10} \) mass F and \( \sqrt{\text{DMFS}} \). Bischoff et al. (1976), ho-
\( \text{ever}, could find no correlation between caries experi-
ence (DMFT) and fluoride concentration in surface 
enamel in a population group living in an endemic fluo-
rosis area.

In the present study the following significant correla-
tions between the parameters DMFT, InF and DEGF 
were established: A weak negative correlation 
(\( p = 0.0902 \)) between \( \sqrt{\text{DMFT}} \) and InF for pupils with 
DEGF < 1.

A strong positive correlation (\( p = 0.0004 \)) between InF 
and DEGF for all the pupils involved and for children 
with DMFT >2. There was a tendency for the caries in-
cidence to decrease with increased enamel fluoride
concentration in pupils with no or mild fluorosis. This could not be demonstrated for pupils with DEGF > 1. Retief et al. (1979) had previously reported that there was a significant positive (p < 0.02) correlation between DMFT and DEGF in Coloured children resident in Kenhardt. The DEGF of the Coloured pupils was much more severe than in the White children studied in the present investigation, but it may explain why no significant correlation could be established between DMFT and InF in pupils with moderate and severe fluorosis.

The highly significant positive correlation (p = 0.0004) between InF and DEGF for all the pupils was also observed for Coloured children resident in Kenhardt (Retief et al. 1979)

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REFERENCES


Forrest, J. R. (1956) Caries incidence and enamel defects in areas with different levels of fluoride in the drinking water. British Dental Journal, 100, 193-200.


