

The Prevalence and Severity of Fluorosis in Children Who Received Toothpaste Containing either 440 or 1,450 ppm F from the Age of 12 Months in Deprived and Less Deprived Communities

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Key Words

Deprivation · Digital images · Fluoride toothpaste · Fluorosis · Health promotion · TF index

Abstract

This study compared fluorosis in the upper central incisors of children from socially diverse backgrounds who had received either 440- or 1,450-ppm F toothpaste from 12 months of age. The children were resident in non-fluoridated districts in the north-west of England. They received either 440- or 1,450-ppm F toothpaste and advice regarding its use until the age of 5–6 years. Dental fluorosis (TF index) was assessed on digital images of dried teeth when the children ($n = 1,268$) were 8–10 years old. In the less deprived districts the prevalences of fluorosis ($TF \geq 0$) for the 1,450- and 440-ppm F groups were 34.5 and 23.7% ($p = 0.006$). In the deprived districts the prevalences of fluorosis were 25.2 and 19.5% ($p = 0.2$). Overall the prevalences of $TF \geq 2$ were 7 and 2.1% for the 1,450- and 440-ppm F groups and 2.2 and 0.2% for $TF \geq 3$. These differences were statistically significant ($p < 0.003$). There was a strong association between the deprivation status of wards and fluorosis. Only 1 subject with a TF score of 3 was identified in the two most deprived quintiles of the Townsend score. It is concluded that careful targeting of programmes of this type to chil-

dren living in high caries risk deprived communities carries only a small risk of aesthetically objectionable fluorosis ($TF > 2$) whether low or high fluoride toothpastes are used. High fluoride (1,450 ppm F) toothpastes should not be provided on a community basis to very young children in less deprived communities.

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In an effort to prevent dental caries and reduce the risk of fluorosis the parents of children under 7 years of age are advised to supervise the brushing of their children's teeth twice a day with a fluoride toothpaste, to apply only a small amount of toothpaste (pea or smear) and to encourage the spitting out of excess. Whilst many parents have adopted such practices, children from disadvantaged communities continue to experience high levels of caries [Hinds and Gregory, 1995; Pitts et al., 2003; Pine et al., 2004]. The evidence suggests that children from manual backgrounds are less likely to adopt positive behaviours than those from non-manual backgrounds [Hinds and Gregory, 1995]. In Great Britain, for example, 37% of children, aged 1.5–4.5, from manual backgrounds reported brushing their own teeth compared with 25% from non-manual backgrounds. In addition, 49% of children from manual backgrounds reported brushing more than once a day compared with 61% from

non-manual backgrounds. Although the early adoption of the recommended tooth brushing practices is beneficial in reducing caries risk, there is also evidence that the swallowing of fluoride toothpaste by very young children is associated with an increased risk of fluorosis [Milsom and Mitropoulos, 1990; Wang et al., 1997; Pendrys, 2000].

In the United Kingdom there is considerable interest in community programmes providing free fluoride toothpaste to very young children as a caries-preventive measure. We have demonstrated previously that the provision of free fluoride toothpaste to children from 12 months of age can prevent caries in deprived districts, but the relative impact of low (440 ppm F) and high (1,450 ppm F) fluoride toothpaste depends on the deprivation status of the individuals [Ellwood et al., 2004]. The provision of either low or high fluoride toothpaste provided similar levels of benefit for the most deprived children, but only the high fluoride toothpaste provided a significant benefit in those less deprived. The provision of either 440- or 1,450-ppm F paste in the deprived districts did not have a significant impact on the prevalence of fluorosis [Tavener et al., 2004].

There was some concern that if programmes of this type were initiated in less deprived areas, where better compliance with toothpaste use would be expected, the risk of developing dental fluorosis might be greater. Therefore, in tandem with the main study conducted in deprived districts [Davies et al., 2002] children from less deprived districts were recruited.

The purpose of the present study was to compare the prevalence and severity of fluorosis in children from deprived and less deprived communities who had received either 440- F or 1,450-ppm F toothpaste from 12 months of age.

Method

The study was conducted in 7 health districts in the north-west of England with fluoride in the drinking water at <0.1 ppm. Four of the districts were classified as deprived (Blackburn, Bolton, Burnley and Wigan) and three as less deprived (Warrington, Macclesfield and Stockport). These districts were chosen on the basis of caries and deprivation data that are summarised in table 1. For the deprived districts the mean dmft for 5-year-olds ranged from 3.06 to 3.36 and for the less deprived districts from 1.46 to 1.98 [Pitts and Palmer, 1995].

Each district comprises a number of wards and, using data from the 1991 census, Townsend scores were used to indicate their level of deprivation. Townsend uses four weighted census variables describing unemployment, household overcrowding, car ownership and numbers in rented accommodation to produce a score in which

higher scores represent increasing levels of deprivation. A score of zero represents the mean score for England with negative values indicating less deprived and positive values more deprived wards. Although the districts included in this study are described as deprived or less deprived each contains both deprived and less deprived wards (table 1).

The study was conducted in two stages. In the first, children in the deprived wards were recruited from birth cohorts born during the period December 1993 to February 1994. In the second, children in the less deprived districts were recruited from the birth cohorts born February to April 1994. All children entered the study when they were approximately 12 months old and were photographed when they were 8–10 years old. The disposition of children recruited into the study is shown in table 2. A total of 4,826 children were recruited into the study and initially received paste. 2,716 (56%) completed the study and were located in schools. Children attended a large number of schools and, for logistic reasons, only schools with 6 or more children in the deprived, and 4 or more children in the less deprived districts, were visited.

For the deprived districts a detailed description of the study method has been reported previously [Davies et al., 2002; Tavener et al., 2004]. Children were randomly allocated from 12 months of age to one of three groups: either a 1,450-ppm F toothpaste, 440-ppm F toothpaste or control (no intervention). In the less deprived districts there was no control group; children received either 1,450- or 440-ppm F toothpaste. The toothpastes, both commercially available, and dental education leaflets were posted to children every 3 months until they were aged 5–6 years. These leaflets advised parents to brush the child's teeth morning and evening with a pea-sized amount of toothpaste and to have them spit the toothpaste out after brushing. Parents were also advised against using fluoride tablets during the course of the study unless advised to do so by their own dentist.

Method of Recording and Scoring the Photographs

Standardised digital photographs of the anterior teeth were taken by a single, experienced examiner (J.A.T.). The photographs were taken from approximately 15 degrees above the perpendicular in order to minimise specular reflection, using a Fuji Finepix S1 Pro with a Micro Nikkor 105-mm lens and Nikon SB 21 ring flash using the top element for illumination. The reproduction was set for 1:1 or lifesize. The upper incisor teeth were wiped with a cotton wool roll and allowed to air-dry for approximately 1 min.

Data relating to subjects included in the deprived wards have been presented previously [Tavener et al., 2004]. For the present study, digital images from the deprived ward data set were randomly mixed with those of the less deprived and re-scored to allow a valid comparison between the two stages of the study. All the images were displayed at a size of 26 by 16 cm on a high-quality computer monitor and scored by 1 examiner (J.A.T.), who was blinded to the district and group of the participants. Scores for the images were entered directly into Microsoft Access using a customised data entry screen.

Recording of Fluorosis

Dental fluorosis was recorded on each of the labial surfaces of the upper central incisors using the TF index [Thylstrup and Fejerskov, 1978]. The criteria for this index are as follows: TF0 = no fluorosis, TF1 = thin white lines running across the tooth surface, TF2 = pronounced white lines, TF3 = merging of white lines and

Table 1. Comparison of districts involved in the study

	BASCD 5-year-olds (1993/94)		Townsend Ward Score 1991 Census			
	% dmft >0	dmft	wards	mean (SD)	max	min
Deprived districts						
Blackburn	60.6	3.06	21	3.1 (4.6)	10.6	-4.6
Bolton	63.8	3.36	20	2.1 (3.7)	10.5	-3.0
Burnley	63.5	3.23	21	1.4 (3.9)	9.5	-5.0
Wigan	65.8	3.17	24	1.5 (2.7)	7.8	-2.8
Less deprived districts						
Warrington	41.5	1.68	26	-0.3 (3.9)	7.14	-4.5
Macclesfield	36.5	1.46	34	-2.7 (2.3)	1.97	-6.3
Stockport	46.7	1.98	21	-0.6 (3.2)	8.61	-5.3
England	42.6	1.74	8,601	0 (3.6)	15.6	-6.8

BASCD = British Association for the Study of Community Dentistry.

Table 2. Disposition of subjects in the study

	4 deprived districts			3 less deprived districts	
	1,450 ppm F	440 ppm F	control	1,450 ppm F	440 ppm F
Randomised to study groups	1,198	1,198	1,193	962	960
Initial non-consent or not able to contact	182	195	NA	149	159
Population initially receiving toothpaste	1,016	1,003	NA	813	801
Available at the end of the study and					
located in schools	6,579	573	681	455	428
Attend schools with 6 or more participants	302	290	355		
Attend schools with 4 or more participants				371	355
Non-consent for photographs	12	11	15	32	22
Left school	38	26	38	38	33
Absent	12	16	13	23	13
Not suitable for analysis (teeth unerupted)	22	11	10	1	2
Used in data analysis	218	226	259	278	287

cloudy areas of opacity and TF4 the entire surface is chalky white. TF scores greater than 4 are associated with pitting and enamel loss.

Blinded duplicate examinations of a random selection of 127 subjects were performed 2 weeks after the initial assessment. The original and duplicate scores were compared using a kappa statistic [Fleiss, 1981].

Statistical Analysis

Using the participant's postcode at entry into the study to locate the subject, the Townsend score for the electoral ward of residence was added to the study database. Of the 1,009 subjects using either the 440- or 1,450-ppm F pastes postcodes were matched to Electoral Wards for 97% of subjects. The participants were divided into

quintiles using the frequency distribution of the Townsend area. For the quintiles the mean (SD) Townsend scores were -3.7 (0.87), -1.4 (0.55), 0.3 (0.47), 2.4 (0.65) and 6.6 (2.1) for the least through to the most deprived quintiles, respectively.

The highest TF score on either of the upper central incisors for each subject was included for analysis. χ^2 tests were used to compare differences in prevalence between the groups and between the less deprived and deprived districts. Two logistic regression models, considering disease cut-offs of TF >0 and TF >2, toothpaste group and ward Townsend score for each subject were used in overall analyses. The overall level of significance was set at 0.05 for all tests.

Ethical approval for the study was obtained from the Local Research Ethics Committees for the selected districts. Passive consent

Table 3. Number (%) of subjects with different TF scores for the dried upper central incisors scored from photographic digital images taken in deprived (study 1) and less deprived (study 2) communities

	Study 1: deprived				Study 2: less deprived				
	TF0	TF1	TF2	TF3	TF0	TF1	TF2	TF3	TF4
1,450 ppm F	163 (74.8)	42 (19.3)	9 (4.1)	4 (1.8)	182 (65.5)	74 (26.6)	15 (5.4)	6 (2.2)	1 (0.4)
440 ppm F	182 (80.5)	40 (17.7)	4 (1.8)		219 (76.3)	61 (21.3)	6 (2.1)	1 (0.3)	
Control	208 (80.3)	42 (16.2)	9 (3.5)						

Table 4. Logistic regression model for cut-offs of fluorosis TF >0 and TF >2 for toothpaste group and Townsend residence score

	Fluorosis cut-off TF >0			Fluorosis cut-off TF >2		
	odds ratio	95% CI	p	odds ratio	95% CI	p
Toothpaste group (reference 440 ppm F)	1.7	1.25–2.23	0.001	11.0	1.4–86.0	0.02
Townsend score (range –5.3 to 10.6)	0.94	0.91–0.98	0.006	0.80	0.64–1.0	0.04

for participation in the study was sought using prepaid post cards at the start of the study and again for participants to have their upper anterior teeth photographed in school.

Results

For the deprived districts 703 subjects were photographed and included in the data analysis. Of these, 218 received the 1,450-ppm F paste, 226 the 440-ppm F paste, while 259 subjects were in the control group and did not receive an intervention. For the less deprived districts data from 565 subjects were analysed, 278 of whom received the 1,450- and 287 the 440-ppm F paste. Blinded duplicate examinations on 127 subjects resulted in a weighted kappa score of 0.73 (95% CI: 0.59–0.87) for the subject level comparison.

For the 4 deprived districts the prevalences of any fluorosis (TF >0) for the 1,450-ppm F, 440-ppm F and control groups were 25.2, 19.5 and 19.7%, respectively. The difference between the three groups and the comparison between subjects using the 1,450- and 440-ppm F pastes did not attain statistical significance ($p > 0.2$). In the 3 less deprived districts, the prevalence of fluorosis for subjects using the 1,450-ppm F paste was 34.5% compared to 23.7% for those using the 440-ppm F paste ($p = 0.006$).

The prevalence of fluorosis (TF >0) for those using the 1,450-ppm F paste was less in the deprived districts than in less deprived districts ($p = 0.03$). For those using the 440-ppm F paste the prevalence of fluorosis was less in the deprived districts than in the less deprived districts, but the difference did not attain statistical significance ($p = 0.3$).

When the data from the two study sites (table 3) were combined the prevalences of subjects with TF scores of ≥ 1 were 30.4 and 21.8% and TF scores ≥ 2 were 7 and 2.1% for the 1,450- and 440-ppm F group, respectively. The prevalences of TF ≥ 3 were 2.2% for the 1,450-ppm F and 0.2% for the 440-ppm F group. These differences were statistically significant ($p < 0.003$).

For cut-offs at both TF >0 and TF >2, the association with deprivation, study site and toothpaste group was considered in binary logistic models (table 4). At TF >0, there was a significant difference in the prevalence of fluorosis between the 1,450- and 440-ppm F toothpastes ($p = 0.001$) with the subjects using the 1,450-ppm F paste having 1.7 (95% CI: 1.3–2.2) times the odds of having fluorosis than those using the 440-ppm F paste. The model also demonstrated a significant correlation between fluorosis and Townsend deprivation scores ($p = 0.006$) with subjects in the least deprived wards having more fluorosis than those from the most deprived.

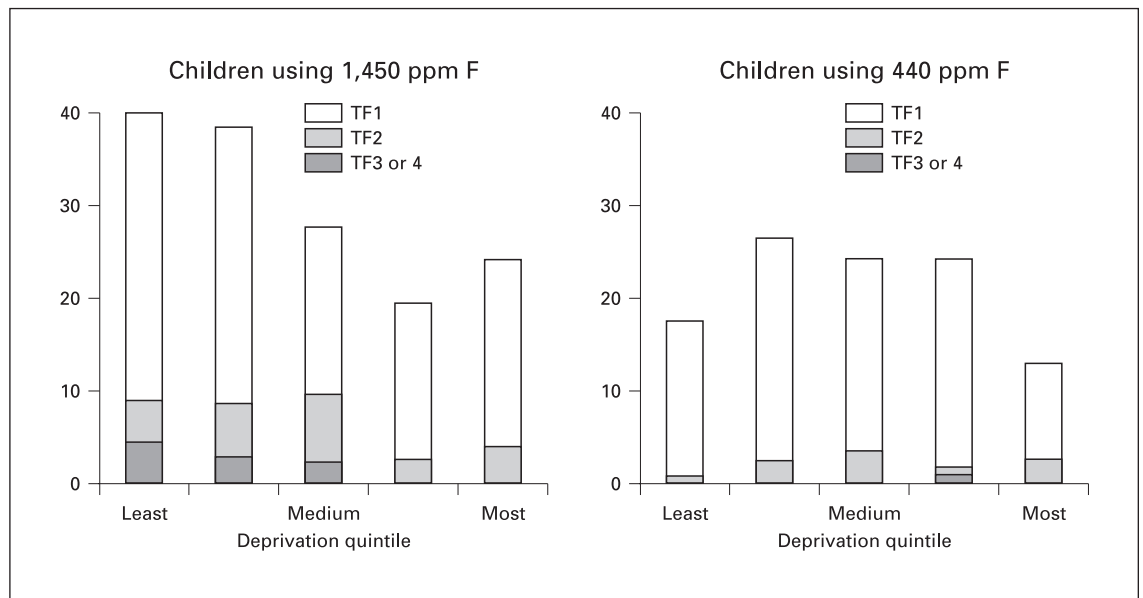


Fig. 1. Percentages of subjects with fluorosis for quintiles of the Townsend Ward Score for children using the 1,450- and 440-ppm F toothpastes.

At $TF > 2$ the odds of having fluorosis were 11 (95% CI: 1.4–86.0) times greater in the 1,450-ppm F group than the 440-ppm F group ($p = 0.02$) and the association between the Townsend score and fluorosis was also statistically significant ($p = 0.04$). In both models, when controlling for deprivation scores the apparent difference in prevalence of fluorosis between the 4 deprived districts and the 3 less deprived was not statistically significant ($p > 0.2$) and this variable was therefore excluded from the final model. An interaction term was used in both models to test the difference in association (slope) between fluorosis and deprivation in the two toothpaste groups and found not to be statistically significant ($p = 0.24$). This means that the relationship between deprivation and fluorosis was similar for the two levels of fluoride in the toothpaste.

The combined data are illustrated in figure 1 for the quintiles of the distribution of the Townsend scores. For the 1,450-ppm F group there was a trend for the prevalence of fluorosis to decrease with increasing deprivation. In the least deprived quintile the prevalence of fluorosis was 40% compared to 24% in the most deprived quintile. For the children using the 440-ppm F paste this trend was less clear, with a prevalence of 18% in the least deprived and 13% in the most deprived quintile. With the exception of 1 subject all subjects with TF scores of ≥ 3 were in the 3 least deprived quintiles using the 1,450-ppm F paste.

Discussion

The results demonstrate that children who received the 1,450-ppm F toothpaste had significantly more fluorosis ($TF > 0$) than those receiving 440 ppm F. The majority of fluorosis was mild (TF 1–2) and of no aesthetic concern. However, some children had TF scores of 3 or 4 and this might be considered aesthetically objectionable [Riordan, 1993; Ellwood and O'Mullane, 1995; Hawley et al., 1996; Lalumandier and Rozier, 1995]. A recent survey in the United Kingdom [Alkhatib et al., 2004] reported that 63% of adults found TF scores of 3 and 4 as unattractive. In this study, although the odds of having fluorosis for the 1,450-ppm F group were high compared to the 440-ppm F group, the prevalence and hence attributable risk were low. This was particularly true in the case of the least deprived children.

The link between levels of deprivation and the prevalence and severity of dental fluorosis is not unexpected. Practices such as the early use of fluoride toothpaste, that occur more frequently in non-manual than manual families, are associated with decreased caries risk [Hinds and Gregory, 1995] and an increased risk of fluorosis [Lalumandier and Rozier, 1995; Pendrys et al., 1996; Wang et al., 1997]. The available evidence suggests that parental supervision, applying a pea-sized amount of toothpaste

and spitting out excess rather than rinsing, maximise the benefits of tooth brushing and minimise the risk of fluorosis [Ellwood and Fejerskov, 2003].

Table 1 illustrates one of the problems of targeting programs of this type when large geographical areas are employed. Districts contain populations with a range of deprivation and there is considerable overlap in deprivation levels of wards even between the most deprived and least deprived districts. More sensitive targeting methods may be needed to ensure that resources are used for the greatest benefit and to minimise risk.

It can be seen in figure 1 that there were no cases of TF3 or TF4 for the 1,450-ppm F group in the two most deprived quintiles. Only 1 subject using the 440-ppm F toothpaste had a TF score of 3, but this child was resident in a ward in one of the two most deprived quintiles. These data suggest that children in the most deprived communities could be provided with either 1,450- or 440-ppm F paste without a significant risk of increasing the prevalence of aesthetically objectionable fluorosis (TF score >2). In contrast, a total of 11 children using the 1,450-ppm F paste were resident in wards in the three least deprived quintiles and none in the 440-ppm F group had TF scores of 3 or 4. Careful targeting of provision of 1,450-ppm F paste to exclude children from less deprived communities is required to minimise the risk of aesthetically objectionable fluorosis.

A significant weakness of this study is the high rate of attrition. This was not unexpected as families with young children, particularly in the types of communities included in this study, are highly mobile. By selecting subjects who had toothpaste deliveries throughout the study the ability to detect the difference between the two groups was maximised for the materials available.

This study was of an ecological design and might have been strengthened by individual measures of fluoride exposure. However, long-term follow-up of fluoride exposures for children in this study would have been impossible within the resources available for the study. Use of fluoride tablets is rare and instructions provided to parents asked them not to use them. Fluoride rinses are not recommended for children under the age of 6. With the randomised design of this study, it is unlikely that these sources of fluoride could explain the differences identified.

The two stages of the study were conducted using identical methods and this has allowed a combined analysis of the two data sets. The strength of using photographic methods of recording developmental enamel defects is further emphasised in this study. The examinations con-

ducted in the less deprived districts were conducted after those in the deprived districts. By using photographs both sets of data could be scored together so that a valid comparison between the two data sets could be made. Photographs from the deprived districts were assessed previously [Tavener et al., 2004] and the reported prevalences of fluorosis for the 1,450-ppm F, 440-ppm F and control groups were 26, 24 and 25%, respectively. The same photographs when re-scored in the present study yielded prevalences of fluorosis of 25, 20 and 20%, respectively. This demonstrated the difficulty of scoring consistently at different time points with the TF index. It should be noted that even though differences in prevalences for groups were noted they did not change the conclusion of the previous study. The photographs will now form a historical archive, which can be rescored using different methods, or in combination with other data sets recorded using the same methods.

The teeth were dried prior to photography as recommended when using the TF index. This is likely to have made the fluorosis more apparent and increased the prevalence of fluorosis seen. The largest difference is likely to have been for the mildest forms of fluorosis (TF 1–2), but for TF scores of 3 or 4 the impact is likely to have been less significant [Tavener et al., 2004]. It is important that when the public health implications of this study are considered the effect of drying the teeth on the prevalence of fluorosis is considered.

It is concluded that careful targeting of programmes providing free toothpaste to deprived, high caries risk communities is not associated with an increased risk of aesthetically objectionable fluorosis whether low or high fluoride toothpastes are used. High fluoride (1,450-ppm F) toothpastes are not indicated for community programmes in less deprived, low caries risk communities.

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