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Dental fluorosis decline after changes to supplement and toothpaste regimens

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Abstract – In 1989/90, in 659 12-year-olds in Perth (F 0.8 mg/L) and the Bunbury region of Western Australia (WA) (F ~0.25 mg/L), dental fluorosis prevalences were 40.2% and 33.0%. Fluoride supplements (OR 4.63) and extended residence in a fluoridated area (OR 4.06) were significant risk factors; toothpaste ingestion variables had ORs greater than unity; in 1990, DMFT for this age group was 0.84. School Dental Service took steps to discourage supplement and toothpaste ingestion and to promote low fluoride toothpaste for children < 6 years of age. *Objectives:* To evaluate the effect of this campaign on fluorosis and caries. *Methods:* Between May–July 2000, 582 10-year-olds were examined for dental fluorosis (TF index) and dental caries (DMFT) in school dental clinics. *Results:* Fluorosis prevalence was 22.2% in Perth and 10.8% in the Bunbury region. Overall prevalence was 18.0% and of this, 80.2% was TF 1, 17.9% was TF 2 and just 1.9% was TF 3. In 1989/90, 79 children had used supplements before the age of 4 year; in 2000 only 40 had done so ($P < 0.001$). Mean DMFT values in Perth and Bunbury were 0.32 and 0.28 ($P > 0.05$). Low F toothpaste, unavailable in 1989/90, had been used by 24.5%. The only significant risk factor was residence, OR 2.0. *Conclusions:* Fluorosis prevalence seems to have fallen in parallel with a reduction in discretionary intake from supplements and toothpaste. No increase in dental caries experience was recorded. Because the teeth examined in this study were at risk of fluorosis in 1992–95, very soon after policies changed, and because people are slow to change health habits, it seems reasonable to expect a further improvement when teeth mineralised in the late 1990s become visible.

Key words: caries, dentifrice, enamel mottling, fluoride, fluorosis, supplement

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In 1989/90 in Western Australia, a survey of dental fluorosis among children (12 year old, $n = 659$) revealed a prevalence of 0.40 in the fluoridated Perth metropolitan area, and 0.33 in the nonfluoridated region around the south-west towns of Bunbury and Busselton (1). The principal risk factors identified in that study were, in descending order of Odds Ratio (OR) magnitude, use of fluoride supplements (OR 4.63, 95% CI 1.97, 10.90), residence in a fluoridated area (OR 4.06, CI 2.55, 6.44) and variables associated with toothpaste use and ingestion at young age (various ORs, range 1.02–1.35, all *n.s*). The use of fluoride supplements in the nonfluoridated areas was in accordance with professional advice at the time.

A subsequent study indicated that dental fluorosis in these children that exceeded TF score 1 was considered unattractive by dentists, parents and other lay people (2) and since that work, other researchers working in different societies have come to essentially the same conclusion, that as fluorotic lesions are more severe, aesthetic concerns increase (3–6). While there is an understandable tendency to play down the importance of aesthetic concerns as a trade-off for improved dental health (7), fluorotic lesions are undesirable. Arguably, they are unaesthetic manifestations of ingestion of mildly toxic quantities of fluoride and their prevalence and severity should be minimised.

As a result of the earlier studies in Western Australia, several options were considered to reduce the aesthetic impact of systemic fluoride ingestion. Reduction of water fluoride concentration was considered. Reduction of water fluoride concentration in Hong Kong led to lower levels of dental fluorosis (8). An interruption to the fluoridation of water supplies in Durham, NC, resulted in reduced fluorosis prevalence and severity in the age cohorts whose teeth were mineralising at the time of the interruption, and these authors concluded that 'dental fluorosis is sensitive to even small changes in fluoride exposure from drinking water' (9). In the WA situation, although fluoridation was a risk factor for fluorosis, it was not the most important and the majority of those exposed to fluoridated water did not display any dental fluorosis (1). It has long been accepted that low levels of mild fluorosis accompany the use of water fluoridation and the issue of concern in Western Australia was the high prevalence of fluorosis rather than the presence of any fluorosis. It thus seemed logical to examine the contribution of discretionary additional sources of fluoride exposure before considering changes to the water fluoridation regimen.

A review of the literature on fluoride supplements suggested that the scientific basis for fluoride supplements as a community caries preventive strategy was weak; randomised controlled clinical trials of fluoride supplements were few and frequently methodologically deficient (10). Referring in part to generally poor compliance with fluoride supplement regimens, Ismail (11) stated: 'The scientific evidence supports the efficacy of fluoride supplements in caries prevention but there is weaker support for their effectiveness' and they are generally accepted not to be a useful public health strategy (12, 13). In many countries, recommendations to use fluoride supplements have recently been modified either to discontinue their use altogether, or to reduce the quantity of fluoride children ingest (14–19).

All fluoride dentifrices available in Western Australia in 1990 had a fluoride concentration of 1000 mg/L, except for one Colgate® product introduced about that time with fluoride concentration 400 mg/L. Ingestion of toothpaste by small children has been reported (20–23) and such fluoride is virtually totally bio-available (24). The caries preventive effect of low fluoride toothpastes may be slightly less than that of adult strength alternatives (25) but the generally good caries status of the child population (26) made the use of low-fluoride toothpaste by children under 6 years of age seem warranted. To encourage such products to be marketed, a conference was held in Perth in 1993 at which all the larger toothpaste manufacturers, as well as some 25 Australian and international experts were present. Subsequently, in the early 1990s, all the major manufacturers introduced low fluoride toothpastes to the Australian market with fluoride concentrations in the range 400–550 mg/L.

The School Dental Services in Western Australia chose therefore to discourage the use of fluoride supplements by any children regardless of the local water fluoride concentration, and a new dosage schedule for fluoride supplements, entailing ingestion of much lower quantities of fluoride by children younger than 8 years, was published for the benefit of any dentists who felt that the continued use of fluoride supplements was warranted. Advice on toothpaste use, designed to reduce the quantity of fluoride ingested by children under 6 years, was offered; low fluoride toothpaste was recommended, alternatively parents were advised to ensure minimal toothpaste ingestion by using a very small quantity of regular toothpaste, and by encouraging children under 6 years not to swallow toothpaste. Toothpaste manufacturers assisted by printing good advice on quantities of toothpaste to use on the packaging. Because the service reaches about 90% of the schoolchildren in the state (pop. 1.8 m) and because all clinicians employed in the service were made aware of the strategy, and various printed brochures were prepared in support of these policies, it is likely that most parents would have come across the messages at some time.

The purpose of the present study was therefore to evaluate the effect of the changed regimen on discretionary fluoride use by conducting a new survey to measure dental fluorosis and dental caries.

Participants and methods

The study followed, as far as possible, the same protocol as had been used in 1989/90 (1), but participants in the present study were aged 10 years rather than 12 years as in the 1989/90 study. All participants were enrolled patients in the School Dental Service whose parents had agreed to provide background information for the purpose of this survey. All examinations were conducted between May and July 2000.

Participants

In the Perth metropolitan area (water fluoride concentration 0.85 mg/L), a sample of 14 schools was drawn at random from a list of schools that had on-site Dental Therapy Centres (DTCs), the clinics in which school dental care is provided. Because one DTC was undergoing building maintenance, a mobile clinic was being used temporarily.

In and around the city of Bunbury, 200 km south of Perth, there is no water fluoridation. Natural fluoride levels vary depending on which bore is used to supply water, but they average around 0.2–0.3 mg/L (communications from Bunbury and Busselton water boards). Because the population in this area is much smaller than in Perth, the same DTCs as were used in 1990 were chosen, except that one clinic had been closed so another was chosen. One mobile clinic was used; it was fortunately located in the same town (Donnybrook) as it had been in 1990. Mobile clinics are slightly cramped but are otherwise equipped to the same standard as fixed clinics.

Background information

DTC staff were asked to distribute study information and questionnaires to all children born in 1990 (i.e. about 10 years old) who attended the school to which the DTC was attached and who already were enrolled in the school dental service. The information and questionnaire were to be brought home to a parent. The information explained the purpose of the study and invited the parent to complete the questionnaire which requested information about residence from birth, drinking water sources, fluoride supplement use, use of infant formula, toothpaste use and toothpaste preferences. The questions were identical to those used for the 1989/90 study. Two weeks after the first questionnaire was distributed, DTC staff contacted children from whom no response had been received and if necessary provided a second questionnaire. In a few cases, the background information was collected by telephone directly from a parent.

Fluoride exposure

For each participant, residence in the period from birth to five years of age was categorised as 'F' if more than half the period had been spent in a fluoridated area and 'Non-F' if not. In the case of children who had migrated from other parts of Australia and New Zealand, the child's fluoride exposure could be determined without difficulty. Migrants from other parts of the world were excluded because their fluoride exposure from water, toothpaste and supplements could not be determined with accuracy.

Fluorosis and caries examinations

The standard of clinical equipment was similar in the fixed and mobile clinics. Routine clinical hygiene measures (disposable gloves, autoclaved instruments) to avoid cross-infection were employed. Children were brought from their classroom to the DTC in groups of 3–6. They were provided with a new toothbrush* and toothpaste, and supervised while they cleaned the upper anterior teeth. Each child rinsed with water and was helped to place a cotton roll under the upper lip in an attempt to keep moisture away while waiting to be examined. For examination, each child sat in a normal dental chair, and the maxillary anterior teeth were dried using an air blower. Using the normal clinical light, the upper right central incisor (tooth 11) was examined and fluorosis scored using the TF index (27). In one clinic, a short power cut led to the light failing and about 20 children were examined outdoors under winter sunlight. Caries examinations were conducted according to WHO criteria (28) and generally without probing except to remove debris. Fissure sealants were not scored as restorations. Children not at school were lost to the survey, except that there was an opportunity to revisit one school in Bunbury a few days after the initial visit, and three additional children were examined. All clinical examinations were conducted by one experienced examiner, with one or two clinic assistants.

Reliability of examinations

Since an important part of the present survey was to compare its fluorosis findings with data from the 1989/90 survey, an estimate of examiner variation was necessary. In 1989/90, colour slides were made in a standard way for almost all participants. In 2000, no photographs were taken but a randomly selected set of 80 colour slides (selected independently by an assistant to cover TF scores in the range 0–3) from the 1989/90 survey were re-examined and re-scored by the same examiner. The weighted Kappa value for this re-examination was 0.75 indicating 'substantial' agreement on the scale of Landis and Koch (29).

Analyses

For each child, the clinical findings were called by the examiner and noted by an assistant on a list of participants derived from the school class lists.

* Toothbrushes, which the children kept, were very kindly provided by Colgate Oral Care Pty, Sydney New South Wales.

Later, the same assistant transferred the findings to computer and combined them with data from the questionnaires. They were analysed using the StatView program (SAS Institute Inc, Cary, NC). Fluorosis and caries prevalence were defined as the proportion of participants who had, respectively, TF score > 0 or DMFT > 0. ANOVA and nonparametric methods were used to estimate differences between subgroups and to identify variables possibly associated with the presence of fluorosis. Such variables were entered into a logistic regression analysis as independent predictors and the outcomes expressed in terms of odds ratios and confidence intervals. The methods were analogous to those used previously (1).

Results

Participation

Altogether 672 children, chosen on the basis of class lists, were invited to participate in the survey. Of these, 58 were excluded for reasons such as not born in 1990, consent refused ($n=24$), absence from school on the day of the examinations or having left the school by the time the examinations were conducted. A further 31 children who had been examined were not included in the study because they had not lived their first four years of life in any part of Australia or New Zealand. This report is thus based on information from the remaining 582 children, 283 girls and 299 boys.

Fluoride exposure

Three hundred and seventy-five children (64.4%) had lived the major part (≥2.5 year) of their first 4 years of life in areas with fluoridated water supplies.

Infant formula had been used from birth by 160 (27.5%) children, and a further 90 commenced formula use between 3 and 6 months of age. By the age of 12 months, 336 children (57.7%) had used formula but the duration of use was not recorded.

Toothpaste use commenced below the age of 1.5 years for 287 children (49.5%) and after that age for 244 children (41.9%). Information was not provided for 51 children (8.8%). Low fluoride toothpaste was reported to have been used by 127 children (21.8%) and regular toothpaste by 66.8% of the children while aged under 6 years. Fluoride supplements had been used by 40 (6.9%) of participants, not used at all by 539 participants (92.6%) and no information was available for 3 persons (0.05%). Almost all supplement users were residents of the nonfluoridated areas (Table 1).

Table 1. Use of fluoride supplements by children ($n=582$) resident in Perth (fluoridated) and Bunbury (nonfluoridated) areas

	All		Perth Metro		Bunbury region	
Supplement use	*n*	%	*n*	%	*n*	%
Yes	40	7.0	2	0.5	38	18.4
No	539	92.6	370	98.7	169	81.6
No information	3	0.5	3	0.8		
	582	100.1	375	100.0	207	100.0

Table 2. Distribution of TF scores among children ($n=582$) currently resident in Perth (fluoridated) and Bunbury (nonfluoridated) areas

	All		Perth Metro		Bunbury region	
TF score	*n*	%	*n*	%	*n*	%
0	476	81.8	293	78.1	183	88.4
1	85	14.6	66	17.6	19	9.2
2	19	3.3	15	4.0	4	1.9
3	2	0.3	1	0.3	1	0.5
Totals	582	100.0	375	100.0	207	100.0

Table 3 Distribution of DMFT scores among children ($n=582$) currently resident in Perth (fluoridated) and Bunbury (nonfluoridated) areas

	All		Perth Metro		Bunbury region	
DMFT	*n*	%	*n*	%	*n*	%
0	480	82.5	309	82.4	171	82.6
1	57	9.8	39	10.4	18	8.7
2	28	4.8	19	5.1	9	4.3
3	8	1.4	4	1.1	4	1.9
4	9	1.5	4	1.1	5	2.4
Totals	582	100.0	375	100.1	207	99.9

Fluorosis and caries

The distribution of TF fluorosis scores for boys and girls was almost identical and the two sexes were combined for analysis. Overall, 18.2% of participants had some degree of dental fluorosis. Prevalence among persons currently resident in the fluoridated area was 20.68% and among persons resident in the nonfluoridated areas it was 15.1%. People resident in the Perth region as a child (birth – 4 years) were more likely to have some fluorosis than persons then resident in nonfluoridated areas and this difference was statistically significant (21.9% versus 11.6%, $P<0.05$ ANOVA) but almost all those recorded as having fluorosis had TF score 1 (Table 2).

The overall prevalence of permanent tooth caries was 17.5%. Mean caries experience was 0.3 DMFT. Caries experience in girls was marginally higher than in boys (0.318 versus 0.278 DMFT) but the difference was not statistically significant. Caries differences between the fluoridated and nonfluoridated areas were very slight (Table 3) and not statistically significant (e.g. DMFT $P > 0.4$, ANOVA). The range of DMFT scores was 0–4.

Analyses

In bivariate analysis, no relationships were found between the presence of fluorosis and the age of commencement of toothpaste use, reported swallowing of toothpaste, reported liking of toothpaste, the duration of breast feeding and the duration of formula use (in all cases, $0.2 < P < 0.8$). Fluoride supplement use was not associated with the presence of fluorosis in bivariate analysis ($\chi^2 = 0.111$, d.f. = 1, $P > 0.7$) but residence in a fluoridated area from birth to 4 years of age showed a strong bivariate association ($\chi^2 = 9.45$, d.f. = 1, $P < 0.0025$).

There were 169 participants who had not lived in a fluoridated area between birth and 4 years of age, and who had not reported using fluoride supplements. Nineteen (11.2%) of these were scored as having dental fluorosis (15 had TF 1, 3 had TF 2 and 1 had TF 3). No fluoride-related variable was statistically significantly associated with this finding.

The only statistically significant risk factor identified using multiple logistic regression analysis was residence in a fluoridated area from birth to 4 years of age (Table 4).

Discussion

When measurements are made over time, good examiner reliability is the key to a valid comparison of prior and current findings. In the original 1989/90 fluorosis study (1), clinical re-examination of 50 participants yielded a kappa score of 0.78 which is characterised as 'substantial' agreement (29). Good quality colour slides of almost all the 1989/90 cases were available and it has been documented that the use of photographs is a valid method for assessing dental fluorosis (30, 31). Re-examination of 80 of these photographs in 2000 and comparison of the recording with the results of the 1989/90 clinical examinations yielded a kappa score of 0.75, categorised as 'substantial' agreement. On this basis, it seems warranted to compare the current findings with the 1989/90 findings. Nevertheless, the possibility of examiner bias is present and it would be desirable to have different examiners corroborate the current findings.

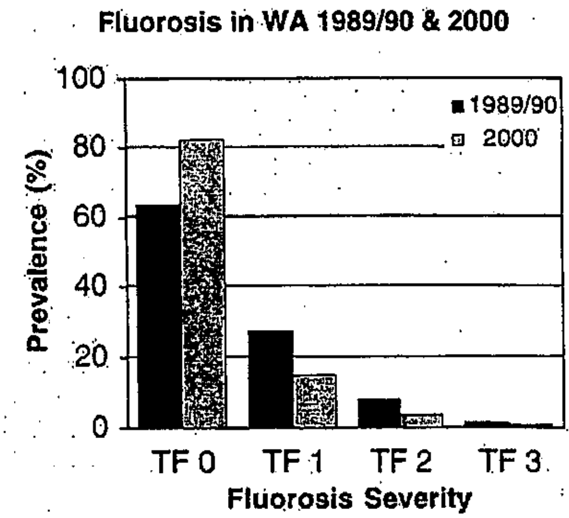

Fig. 1. Comparison of distribution of fluorosis severity (TF) scores between children examined in 1989/90 (n = 659) and children examined in 2000 (n = 582).

The principal finding of interest in this study is the substantial reduction in the prevalence of dental fluorosis compared with the situation in 12-year-old-children 10 years previously. The overall preva-

Table 4 Logistic regression coefficients, odds ratios and 95% confidence intervals for predicting the presence of dental fluorosis

			95% Confidence Interval	
Exposure term	Coefficient	Odds Ratio	Lower	Upper
Constant	−2.60			
Residence F Area[a]	0.72	2.06	1.21	3.50
Other F Exposure[b]	0.58	1.79	0.21	14.80
F Supplement[c]	0.03	1.03	0.37	2.88

Reference exposures were: [a] No residence in a fluoridated area birth-4 years of age; [b] No other early fluoride exposure; and, [c] No use of fluoride supplements before 4 years of age.

lence then was 0.37 against 0.18 in the current study. The magnitude of the reduction was unexpected but it is supported by information on the use of fluoride supplements: in 1989/90, 12% of children were reported to have used supplements between birth and the age of 4 years (1), whereas in the present study only 6.9% had done so ($P<0.001$). In 1989/90, low fluoride toothpaste had just arrived on the Australian market but it could not have affected the teeth then examined. In 2000, the teeth of interest in the study would have mineralised approximately in the period 1992–95, a period during which one low fluoride toothpaste was well established on the market and others were being introduced. Recalled information on early toothpaste use by children is known not to be reliable (32) and this may explain why the use of low-fluoride toothpaste did not figure as a protective factor in the quantitative analysis. Direct observation in the local supermarkets confirms that children's low-fluoride toothpastes are prominently promoted today.

As a result of the 1989/90 study findings, consideration was given to advising that the water fluoride concentration in the southern part of Western Australia (where the present study was undertaken) be lowered. For the period in which the teeth of interest in these studies were mineralising, the target water fluoride concentration remained about 0.85 mg/L although there probably have been fluctuations (33). A similar problem of high fluorosis prevalence in Hong Kong was tackled by reducing water fluoride concentration from 1.0 to 0.7 mg/L, which brought about a reduction in fluorosis prevalence from 0.64 to 0.47 (8). The lower initial water fluoride concentration in Western Australia, coupled with the fact that despite the relatively high fluorosis prevalence recorded, most children had no dental fluorosis even though the recording tool, the TF index, identifies fluorosis at a very early stage on dried teeth, argued for not changing the water fluoride concentration initially. The identified risk factors for fluorosis in 1989/90 listed supplement use as a more important risk factor for fluorosis than area of residence, and at that time a number of authors were querying the usefulness of fluoride supplements as public health measures, querying the then current dosage schedules, and attempting to balance their caries preventive effect against the risk of dental fluorosis (10, 11, 13, 34–37). It was therefore decided in Western Australia to attempt to discourage the ingestion of discretionary fluorides such as supplements and toothpastes. In the case of toothpaste, ingestion could not be totally eliminated in children under six years of age (38) because the use of toothpaste was considered desirable; therefore the use of products with lower fluoride concentrations was encouraged. This decision has recently been corroborated by Pendrys (39), who estimates that up to two-thirds of fluorosis prevalence in US fluoridated areas, and one-third in nonfluoridated areas, can be attributed to inappropriate use of discretionary fluorides.

The teeth examined in the present study would have mineralised fairly soon after several of these decisions on fluoride exposure were made, approximately 1992–95. This may account for the fact that the present study reports some continued use of supplements by participants, and some continued use of full strength fluoride toothpaste. New advice given by the staff of the dental services and private dental practitioners probably did not reach all parents by these dates. It seems therefore likely that in five years time the modified recommendations will have reached a greater proportion of parents and if so, fluorosis prevalence should be even lower.

Insofar as fluoride supplements contribute to caries prevention, a contentious question, their reduced use should entail a greater risk of dental caries. The 12-year-old children examined in 1989/90 had caries experience levels of 0.89 DMFT in the Perth region and 1.57 DMFT in the Bunbury (nonfluoridated) region (26). In the present study, the corresponding caries experience scores were 0.31 (SD 0.75) DMFT in the fluoridated area and 0.28 (SD 0.77) DMFT in the nonfluoridated area, but since the current data are derived from 10-year-olds in 2000 against 12-year-olds in 1989/90, these figures are not directly comparable. Australian Child Dental Health Survey (40) data for 10-year-olds in all of Western Australia in 1990 reported a DMFT value of 0.84 for 10-year-olds, substantially greater than reported in this study for 2000. The major part of the Western Australia population lives in the Perth and Bunbury regions, so these data suggest that caries levels have continued to decline despite the reduced use of fluoride supplements. The very small difference between caries levels in the two regions (0.31 versus 0.28 DMFT) should not be ascribed great importance: the teeth at greatest caries risk in 10-year olds, the first permanent molars, would have been exposed in the mouth about 2 1/2 years, a period during which few carious cavities would have become established under today's conditions.

The prevalence of dental fluorosis has been reported to be unexpectedly high in many countries since the late 1980s. This has largely been ascribed to water fluoridation because generally the highest prevalences have been reported from fluoridated regions, and community fluorosis prevalence even has been considered to be irreversible (41). However, fluoride intake comes from many sources which cumulate to produce fluorosis if ingestion occurs when teeth are mineralizing. The findings of this study suggest that dental fluorosis can be brought under control at a population level by eliminating discretionary fluoride intake from supplements and by reducing the possibility of intake from toothpaste, without apparent adverse changes in the impact of dental caries. The study should encourage other communities to consider limiting discretionary fluoride intake to levels that prevent disease but 'produce only sporadic instances of the mildest forms of dental fluorosis of no practical esthetic significance' (42).

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