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Photographic assessment of fluorosis in children from naturally fluoridated Kungsbacka and non-fluoridated Halmstad, Sweden

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Abstract

Objectives. To assess levels of fluorosis and fluorosis of esthetic concern in children from a naturally fluoridated and a non-fluoridated area of Sweden, and to determine the relative contributions of fluoridated water, parental educational level, and infant oral health-related behaviors. ***Methods.*** A parental questionnaire collected information concerning child F-supplement and F-dentifrice usage histories, and socio-economic status. Photographic examination of 1336 subjects (F = 791; N-F = 545) was undertaken. Fluorosis was assessed (blind to F-exposure) in a random sample ($n = 250$) of 35 mm slides by four dental and two lay "jurors" (with 10% random repeat-viewing for inter-observer and intra-observer agreement). Four outcomes were assessed on each slide: fluorosis at any level, fluorosis of esthetic concern, acceptability of appearance, and treatment needs. Ordinal logistic regression models were used to determine significant determinants. ***Results.*** For presence of fluorosis of esthetic concern, majority jury agreements (>3 of 6) were seen in only 2.3% (N-F) and 13.4% (F) pupils ($p < 0.001$), albeit jurors unanimously scored only 13 F and 2 N-F exposed children as having esthetically unacceptable fluorosed teeth ($p < 0.001$). The over-riding significant factor in terms of fluorosis of esthetic concern was exposure to water fluoridation in infancy in both unadjusted and adjusted models. ***Conclusions.*** The important factor in relation to fluorosis of esthetic concern was explained by exposure to fluoridated water in infancy, and was not explained by age, sex, level of parental education or early childhood oral health behaviors. However, prevalence of this condition was relatively low. These findings should inform policies on appropriate total fluoride exposure levels during infancy.

Key Words: *Dental esthetics, dental fluorosis, dental photography, fluoridation, Sweden*

Introduction

During the past decade there has been much debate concerning the appropriate fluoride dosage exposure for infants to optimize caries prevention and minimize the development of fluorosis of esthetic concern. In many countries, the major contributory vehicles for fluoride delivery are toothpaste and water, with supplements and other community-based routes, e.g. salt and milk, having a more minor role. In 2000, a systematic review [1], commissioned by the UK Government to investigate the efficacy and safety of water fluoridation, concluded that water fluoridation reduced the prevalence of dental caries in children by approximately 15% and reduced the mean number of teeth with caries experience by, on average, approximately 2.2 teeth per child. It stated that the reduction in caries (dmft/DMFT) following fluoridation was greater in those areas with higher levels of caries experience at the outset. With regard to dental fluorosis, the review identified studies from 30 countries and suggested a fluorosis prevalence (all levels of severity) of 48% and 15% in fluoridated and non-fluoridated areas, respectively. For fluorosis of esthetic concern, the suggested prevalence was 12.5% and 6.3% in these same areas. These figures are somewhat higher than those reported in studies conducted across European cities in the late 1990s, where the prevalence of fluorosis of esthetic concern ranged from 0% to 4% [2]. Here, fluoridated water and the prolonged use

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of fluoride tablets were found to be significant contributory factors to fluorosis.

One of the main conclusions of the systematic review, however, was the general low quality of research concerning water fluoridation. It was reported that most fluorosis studies failed to take full account of confounding factors. Subsequent to the publication of the systematic review, the UK Medical Research Council set up a Working Group to determine the research required to strengthen the evidence base in relation to water fluoridation. In addition to supporting the findings of the earlier systematic review that water fluoridation helps to reduce tooth decay, the MRC report concluded that further studies should be undertaken to determine both the prevalence and public's perception of fluorosis, particularly with regard to levels deemed esthetically unacceptable [3].

Fluorosis levels in Halmstad, assessed clinically using the TF Index, were previously reported as 4% at the level of esthetic concern [4]. In addition, data on dental caries in Sweden are collected on an annual basis for every child via the Community Dental Service. Levels of dental caries in children, in both Halmstad and Kungsbacka, are relatively low. In 10-year-olds, there is a higher prevalence and level of dental caries in non-water-fluoridated Halmstad (69% caries-free, mean DMFT 0.62) compared with the naturally water fluoridated community of Kungsbacka (83%, mean DMFT 0.28). The mean level of fluoride in the water supply for the "non-water-fluoride" community of Halmstad is 0.1 ppm and for the naturally water-fluoridated community of Kungsbacka 1.3 ppmF [5].

The aims of this study were photographically to assess levels of fluorosis and fluorosis of esthetic concern in children from a naturally fluoridated and a non-fluoridated area of Sweden, and to determine the relative contributions of fluoridated water, parental educational level, and oral health-related behaviors.

Material and methods

A descriptive epidemiological prevalence study of fluorosis of children from non-fluoridated and naturally fluoridated water areas in Sweden was undertaken.

Identical field epidemiological methods were carried out in both Halmstad (Spring 2002) and Kungsbacka (Spring 2003). Full details of the methodology have been described previously [4]. In summary – a questionnaire was distributed in both areas to a cluster random sample of parents of school children aged 7 to 10 years. This enquired, in detail, into their child's early oral health behaviors, and included a "photographic toothpaste menu" to aid recall. The permanent upper anterior teeth (13–23) were examined clinically (+10% repeats) using a modified Thylstrup-Fejerskov Index. Each child in the study (Halmstad $n = 545$, Kungsbacka $n = 791$) also had two individual anterior labial-view photographs of any upper anterior teeth present, taken by the same photographer (L.M.). Using a Yashica "Dental Eye2" camera, with a 100-mm f4/4 macrolens and ringflash, photographs were taken from approximately 0.5 m on Ektachrome 100 EPN 36 daylight color positive film. The labial surfaces of these teeth were made visible for the photograph using one pair of sterilized cheek and lip retractors per child. This article only reports the results pertaining to the photographic assessment of fluorosis.

Based on an expectation of a difference in the clinical prevalence of fluorosis (at any level) of 70% in (naturally fluoridated) Kungsbacka, and 50% (in non-water fluoridated) Halmstad [4], a power calculation was performed to determine the number of photographic slides to be sampled from the two areas. Thus, single slides from 125 children were randomly selected from both areas, giving 90% power to detect a difference of 20% in fluorosis prevalence.

Subsequently, the 35-mm color slides were inserted randomly into a carousel and projected via a Kodak projector in a lecture theater to give a color projection image measuring approximately 1.5×1.0 m on the viewing screen. Simultaneously, a second separate carousel was used to project the single "fluorosis impact factor" color slide (previously scored as the threshold level of fluorosis of esthetic concern) on to an identical screen adjacent to the study slides [6].

The 35-mm slides were viewed with assessors blind to the source area of each slide and scored under standardized projection conditions by K.W.S. and D.I.C., and by two other dental and two lay staff "jury" members, with a 10% random re-viewing for inter- and intra-observer agreement calculations. This jury fluorosis viewing and scoring methodology was identical to that used in previous studies [6–8]. As before, jurists were given a brief "slide tutorial" to remind them of the photographically visible mottling criteria appropriate to award a diagnosis of fluorosis (Yes/No). They were also shown how to score each positive diagnosis as being of lesser, equal or greater severity than the simultaneously projected comparator image, with the greater severity category representing fluorosis of esthetic concern (TF ≥ 3). Two additional questions were added to this study, the first involved rating the appearance of the teeth as "highly acceptable", "acceptable", "unacceptable", or "highly unacceptable" [9]. In the second question, jurists were asked to indicate whether or not they would request treatment if their teeth had such an appearance.

The jurists' individual assessments for the four variables were dichotomized as: fluorosis presence

Y/N (Yes/No), fluorosis of esthetic concern Y/N, acceptable appearance Y/N, and perceived treatment need Y/N. The number of jurists saying "Yes" was counted to produce a score for each of the four variables on a scale from 0 to 6 for each slide.

The scores for all four variables had generally 'U'-shaped distributions, making them unsuitable for modelling with linear regression techniques. Because of this, each of the four variables was further grouped into three categories 0, 1–3, and 4–6. The justification for this grouping was that 0 represents unanimous agreement that the characteristic was absent from the slide, with 4–6 representing a majority of the jurists agreeing on the characteristic being present. Because of the fairly arbitrary categorization of the response variables, the main analyses were repeated with different groupings: 0, 1–2, 3–4, 5–6, and 0–3, 4–6. Results for these alternative groupings are not presented here since they were all in close agreement with the main analyses.

Each of these ordinal variables was used, in turn, as the response variable in Ordinal Logistic Regression models to examine the unadjusted effect of exposure to fluoridated water in infancy and then adjusting for the effect of age, sex, parental education level and child's early oral health behaviors (detailed in Table I). The oral health behavior variables were added simultaneously to the ordinal logistic regression models. Inter- and intra-observer agreement was assessed by calculating Kappa statistics and percentage agreement. Minitab (version 14) was used for all data analyses.

Results

Full data (questionnaires + photographic assessment) were available for 120/125 in Halmstad and 123/125 in Kungsbacka.

Data were analysed utilizing questionnaire-based information relating to the child's water fluoridation exposure during infancy rather than aggregating to the city of residence. Inter- and intra-observer mean Kappa scores and mean percentage agreements for fluorosis at any level were 0.57, 79%; for fluorosis of esthetic concern, these were 0.59, 93%; for perceived treatment need 0.51, 83%; and for acceptable appearance 0.52, 82%.

Data relating to family socio-demographic characteristics and the parents' behaviors in relation to their children's oral health are given in Table I. There were age and gender differences between water fluoridation exposure groups and this was taken into account in the modeling. Both groups were similar with respect to parents' education attainment. There were no significant differences in early toothbrushing behaviors. As expected, fluoride supplement usage was significantly higher in the group not exposed to water fluoridation in infancy.

Table I. Descriptive analysis of socio-demographic and child's early oral health behaviors

		Fluoridated water supply		
		No ($n=131$)	Yes ($n=112$)	P-value (chi-square test)
Sex	Female	70 (53%)	45 (40%)	0.04
[$n=131$, 112]	Male	61 (47%)	67 (60%)	
Age	7	44 (34%)	2 (2%)	<0.001
[$n=131$, 112]	8	71 (54%)	37 (33%)	
	9	16 (12%)	61 (54%)	
	10	0 (0%)	12 (11%)	
Education	Low	56 (43%)	47 (42%)	0.87
[$n=129$, 111]	High	73 (57%)	64 (58%)	
Age started brushing	6–12 m	86 (66%)	73 (66%)	0.99
[$n=131$, 111]	>12 m	45 (34%)	38 (34%)	
How often brush	≤1/day	25 (19%)	17 (15%)	0.42
[$n=131$, 112]	≥2/day	106 (81%)	95 (85%)	
Toothpaste F	<1000 ppm	7 (6%)	4 (4%)	0.49
[$n=123$, 107]	≥1000 ppm	116 (94%)	103 (96%)	
Amount of toothpaste	≤pea size	88 (76%)	72 (65%)	0.09
[$n=116$, 110]	>pea size	28 (24%)	38 (35%)	
Fluoride tablets previously	No	98 (76%)	101 (94%)	<0.001
[$n=129$, 108]	Yes	31 (24%)	7 (6%)	
Fluoride tablets now	No	79 (60%)	99 (92%)	<0.001
[$n=131$, 108]	Yes	52 (40%)	9 (8%)	
Area of residence	Halmstad	117 (89%)	3 (3%)	<0.001
[$n=131$, 112]	Kungsbacka	14 (11%)	109 (97%)	

Table II. Descriptive analysis of the four outcome variables in relation to exposure to fluoridated water in infancy

Positive response ('Yes') to variable	No. of jurists	Fluoridated water exposure		*P*-value (chi-square test)
		No ($n=131$)	Yes ($n=112$)	
Fluorosis	0	55 (42%)	17 (15%)	<0.001
	1–3	38 (29%)	33 (30%)	
	4–6	38 (29%)	62 (55%)	
Esthetic concern	0	117 (89%)	76 (68%)	<0.001
	1–3	11 (8%)	21 (19%)	
	4–6	3 (2%)	15 (13%)	
Appearance	0	70 (53%)	42 (38%)	0.014
	1–3	49 (37%)	48 (43%)	
	4–6	12 (9%)	22 (20%)	
Treatment	0	74 (56%)	46 (41%)	0.004
	1–3	44 (34%)	38 (34%)	
	4–6	13 (10%)	28 (25%)	

The jurists' assessments of the four key outcome variables are presented in Table II. A significantly higher number of jurists gave a positive response in relation to each of the four variables in the water fluoridation, compared with the non-water fluoridated exposure group.

Jurists' "fluorosis of esthetic concern" scores related to socio-demographic, behavioral characteristics and exposure to water fluoridation are detailed in Table III. The over-riding significant difference is in relation to water fluoridation exposure – this accounts for the significant differences also seen for area of residence and age.

Table IV gives the jurists' assessment of a perceived need for treatment related to socio-demographic, behavioral characteristics, and exposure to

Table III. Jurors' scores for fluorosis of esthetic concern related to parental questionnaire responses

		No. of jurists			*P*-value (chi-square test)
		0 ($n=193$)	1–3 ($n=32$)	4–6 ($n=18$)	
Sex	Female	91 (47%)	14 (44%)	10 (56%)	0.72
[$n=193,32,18$]	Male	102 (53%)	18 (56%)	8 (44%)	
Age	7	43 (22%)	2 (6%)	1 (6%)	0.007*
[$n=193,32,18$]	8	88 (46%)	15 (47%)	5 (28%)	
	9	55 (29%)	13 (41%)	9 (50%)	
	10	7 (4%)	2 (6%)	3 (17%)	
Education	Low	79 (42%)	15 (47%)	9 (50%)	0.70
[$n=190, 32, 18$]	High	111 (58%)	17 (53%)	9 (50%)	
Age started brushing	6–12 m	124 (65%)	23 (72%)	12 (67%)	0.72
[$n=192, 32, 18$]	>12 m	68 (35%)	9 (28%)	6 (33%)	
How often brush	≤1/day	39 (20%)	3 (9%)	0 (0%)	0.04
[$n=193,32,18$]	≥2/day	154 (80%)	29 (91%)	18 (100%)	
Toothpaste F	<1000 ppm	10 (5%)	1 (3%)	0 (0%)	0.91*
[$n=183, 29, 18$]	≥1000 ppm	173 (95%)	28 (97%)	18 (100%)	
Amount of paste	≤ pea size	126 (70%)	24 (83%)	10 (59%)	0.20
[$n=180, 29, 17$]	>pea size	54 (30%)	5 (17%)	7 (41%)	
Fluoride tablets previously	No	157 (84%)	27 (84%)	15 (88%)	0.88
[$n=188, 32, 17$]	Yes	31 (16%)	5 (16%)	2 (12%)	
Fluoride tablets now	No	138 (73%)	25 (78%)	15 (83%)	0.56
[$n=189, 32, 18$]	Yes	51 (27%)	7 (22%)	3 (17%)	
Area of residence	Halmstad	108 (56%)	9 (28%)	3 (17%)	<0.001
[$n=193,32,18$]	Kungsbacka	85 (44%)	23 (72%)	15 (83%)	
Water F	No	117 (61%)	11 (34%)	3 (17%)	<0.001
[$n=193,32,18$]	Yes	76 (39%)	21 (66%)	15 (83%)	

*After grouping of categories because of small numbers.

Table IV. No. of jurists requesting treatment if their own teeth had this appearance

		No. of jurists			
		0 ($n=120$)	1–3 ($n=82$)	4–6 ($n=41$)	*P*-value (chi-square test)
Sex	Female	54 (45%)	39 (48%)	22 (54%)	0.63
[$n=120,82,41$]	Male	66 (55%)	43 (52%)	19 (46%)	
Age	7	30 (25%)	13 (16%)	3 (7%)	0.07
[$n=120,82,41$]	8	55 (46%)	36 (44%)	17 (42%)	
	9	32 (27%)	28 (34%)	17 (41%)	
	10	3 (3%)	5 (6%)	4 (10%)	
Education	Low	51 (43%)	31 (39%)	21 (51%)	0.42
[$n=119, 80, 41$]	High	68 (57%)	49 (61%)	20 (49%)	
Age started brushing	6–12 m	76 (64%)	57 (70%)	26 (63%)	0.67
[$n=119, 82, 41$]	>12 m	43 (36%)	25 (30%)	15 (37%)	
How often brush	≤1/day	23 (19%)	17 (21%)	2 (5%)	0.07
[$n=120,82,41$]	≥2/day	97 (81%)	65 (79%)	39 (95%)	
Toothpaste F conc.	<1000 ppm	9 (8%)	2 (3%)	0 (0%)	0.03*
[$n=116, 73, 41$]	≥1000 ppm	107 (92%)	71 (97%)	41 (100%)	
Amount of paste	≤pea size	76 (69%)	58 (73%)	26 (70%)	0.81
[$n=110, 79, 37$]	>pea size	34 (31%)	21 (27%)	11 (30%)	
F tablets previously	No	95 (82%)	71 (87%)	33 (85%)	0.67
[$n=116, 82, 39$]	Yes	21 (18%)	11 (13%)	6 (15%)	
Fluoride tablets now	No	85 (73%)	62 (76%)	31 (78%)	0.80
[$n=117, 82, 40$]	Yes	32 (27%)	20 (24%)	9 (22%)	
Area of residence	Halmstad	69 (58%)	39 (48%)	12 (29%)	0.007
[$n=120,82,41$]	Kungsbacka	51 (42%)	43 (52%)	29 (71%)	
Water F	No	74 (62%)	44 (54%)	13 (32%)	0.004
[$n=120,82,41$]	Yes	46 (38%)	38 (46%)	28 (68%)	

*After grouping of categories because of small numbers.

water fluoridation. While there is a marginally significant difference with regard to concentration of fluoridated toothpaste, the actual number in this study who were exposed to <1000 ppm F toothpaste in infancy was very small ($n=11$). Again the exposure to fluoridated water is the key significant determinant of the perceived need for treatment.

Separate models for each of the outcome variables are given in Table V. Each variable is modelled and presented as: unadjusted, adjusted for age and ("fully") adjusted for age, gender, parental education, and simultaneously for all the early childhood oral health behaviors.

The presence of fluorosis at any level is significantly higher in those exposed to water fluoridation during infancy. Compared to the unadjusted and fully adjusted models, adjustment for age gives a slightly less significant difference between the two groups.

A similar pattern is seen in the fluorosis of esthetic concern model.

The model examining acceptability of appearance shows a more significant effect of exposure to water fluoridation when unadjusted, compared with the adjusted models, which are only marginally significant.

The significant effect of exposure to water fluoridation on perceived treatment need seen in the unadjusted model is lost when adjusted.

Table V. Ordinal logistic regression modeling of the effect of water fluoridation on four outcome variables scored as 0; 1–3; 4–6

Model	OR and 95%CI (Water F/non-water F)
Presence of fluorosis at any level	
Unadjusted	3.37 (2.07 – 5.50) $p<0.001$
Adjusted for age	1.99 (1.11 – 3.58) $p=0.021$
Adjusted for age+sex+education+behaviors	2.94 (1.44 – 5.98) $p=0.003$
Fluorosis of esthetic concern	
Unadjusted	4.08 (2.07 – 8.06) $p<0.001$
Adjusted for age	2.92 (1.30 – 6.56) $p=0.01$
Adjusted for age+sex+education+behaviors	4.36 (1.49 – 12.75) $p=0.007$
Unacceptable appearance	
Unadjusted	3.37 (2.07 – 5.50) $p<0.001$
Adjusted for age	1.99 (1.11 – 3.58) $p=0.021$
Adjusted for age+sex+education+behaviors	2.12 (1.03 – 4.36) $p=0.041$
Perceived need for treatment	
Unadjusted	2.10 (1.30 – 3.42) $p=0.003$
Adjusted for age	1.48 (0.82 – 2.68) $p=0.19$
Adjusted for age+sex+education+behaviors	1.70 (0.83 – 3.51) $p=0.15$

Discussion

The method of photographic assessment of fluorosis slides by a jury comprising both lay and dental professional assessors, and incorporating repeat examinations for validation, was first developed in 1991 [7], and since then has been used on several occasions [6,8]. However, the data in this investigation were analysed in a slightly different manner, with the jurists' scoring categories grouped into three levels (i.e. 0, 1–3, or 4–6), with 0 being complete agreement of absence of the variable under study. The four categories previously used (0, 1–2, 3–4, 5–6) were not applied in this study because of small numbers in some of the groupings (especially 3–4) which would have caused problems with the ordinal logistic model. Furthermore, the new categories also helped clarify the level of jurists' "majority agreement".

The power calculation used was based on the clinical fluorosis findings from the two areas. The study had ample power, particularly if related to the York Review fluorosis findings in which the differences between fluoridated and non-fluoridated areas were greater [1]. To address the York Review's concerns around the lack of inclusion of confounding factors, this study incorporated relevant socioeconomic, demographic and other fluoride exposure behavioral factors into the modeling, to ensure that fluoridated water exposure was not examined in isolation.

One of the difficulties in this study was that the children from Kungsbacka (who were generally those exposed to fluoridated water in early childhood) were approximately a year older than the children from Halmstad (who were generally those not exposed to fluoridated water during infancy). Although children from the two areas had different ages, they were actually from the same birth cohort. Therefore the inclusion criteria for the field studies sought to find children with similar dates of birth and, while it would have been ideal to have carried out the fieldwork in the two areas at the same time, for logistical reasons this had to be undertaken a year apart. The age difference was therefore unavoidable, but was taken into account, and adjusted for in the modeling.

The proportion of children for whom the majority of jurists (4–6) agreed on a positive finding of fluorosis of esthetic concern was 13% for those exposed to water fluoridation during infancy compared with 2% of those not exposed. This compares with prevalence data for fluorosis of esthetic concern reported in the York Review of 12% and 6% from fluoridated and non-fluoridated areas, respectively [1]. In terms of fluorosis at any level, the proportion of children where the majority of jurists (4–6) agreed on a positive finding was 55% and 29% of children exposed to/not exposed to fluoridated water in infancy, respectively. Comparative data from the York Review were 48% and 15%, respectively [1]. However, it is appreciated that individual studies included in the York Review were not necessarily comparable with the present investigation in terms of age of study subjects, teeth scored, and total fluoride exposure.

The findings in the present study relating to the higher prevalence of fluorosis of low esthetic impact may be due to a number of factors, including the almost universal use of toothpaste with a fluoride concentration of at least 1000 ppm from a young age, as well as the fluorosis' assessment method used. These methodological factors include the use of projected, magnified images of anterior teeth, the potential drying of the teeth during the photographic process and the composition of the jury panel.

The assessment of the clinical photographs took place in an area of Scotland where the water fluoride concentration is extremely low. The jury members were also substantially older than the study population. Hence, it is possible that jurists of different ages and from the local Swedish populations may have rated the acceptability of appearance and perceived treatment need variables in slightly different ways. Thus further work is required in the fluorosis assessment field to determine the effect of different population groups and different background levels of water fluoridation on the way in which fluorosis is perceived.

Recent work has suggested that the manner in which teeth with fluorosis are shown to an assessor can affect the perceptions of its severity and acceptability. Here lay photographically based scoring has been shown to be influenced by the size of the tooth images and by the inclusion/exclusion of whole/part-facial features [10].

The higher number of jurists agreeing a positive finding of fluorosis (at any level) and fluorosis of esthetic concern in the children exposed to fluoridated water during infancy was explained by this exposure. This remained when controlling for socioeconomic, demographic and other fluoride exposure behaviors. These differences also extended to the findings related to "unacceptable appearance" with greater numbers of jurists finding the teeth from children exposed to fluoridated water in infancy being "unacceptable".

While the effect of exposure to water fluoridation was initially significant with regard to the perceived need for treatment, the effect was lost when taking account of other factors in the adjusted analysis. This agrees with anecdotal evidence of Community Dental staff in Kungsbacka, who report extremely low numbers of requests for esthetic treatment of fluorosis among young adults from the area.

It is accepted that, when assessing the risk of fluorosis, all fluoride exposures must be taken into account and the dental health status of the area must

also be considered [11]. Furthermore, it is interesting to note the variations in policy among European countries with regard to fluoride exposure for young children. The present guidelines from the European Academy of Paediatric Dentistry [12] recommend, for those under 2 years of age, the use of a smear of toothpaste with a fluoride concentration of less than 500 ppm, even in non-water fluoridated areas. In 2002, the Irish Forum on Fluoridation [13] recommended reducing the concentration of fluoride in water to a mean of 0.7 ppmF, and advised that parents should not use toothpaste when brushing the teeth of children under 2 years of age. These recommendations were made as a result of an increase in the prevalence of fluorosis (at any level) and the low levels of childhood caries seen in Ireland.

By contrast, in the Kungsbacka area, the mean level of fluoride (1.3 ppm) in water is relatively high and most children are having their teeth brushed with toothpaste containing at least 1000 ppmF before the age of 2 years. While the caries prevalence and mean DMFT levels are relatively low in both the Swedish study areas compared with some European countries [14], clear differences in caries data could be seen between the fluoridated and non-fluoridated areas as described earlier.

Some variation in recommendations concerning total fluoride exposure during infancy is expected due to differing levels of dental health in different populations. It is therefore appropriate that regimes will vary at community and individual levels, based on caries risk. However, the major lack of consensus in Europe regarding fluoride regimes for young children suggests a need for further research into both the profession's and public's perceptions of the caries reduction benefits and fluorosis risks of the combination of fluoridated water and toothpaste use. In particular, more work is required among population groups in Europe concerning the public's views of dental fluorosis rather than via professional-only assessment [2].

Although this study demonstrated that exposure to fluoridated water during infancy resulted in increased prevalence of both fluorosis and fluorosis of esthetic concern, the proportions in the latter category were low, even among the water fluoride-exposed group. Furthermore, the increased prevalence of fluorosis did not translate into a significant increase in perceived treatment need when the analysis was adjusted for confounding variables. These findings should help inform much needed further debate into appropriate total fluoride exposure levels during infancy.

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References

[1] McDonagh MS, Whiting PF, Wilson PM, Sutton AJ, Chestnutt I, Cooper J, et al. Systematic review of water fluoridation. Br Med J 2000;321:855–9.

[2] Cochran JA, Ketley CE, Arnadottir IB, Fernandes B, Koletsi-Kounari H, Oila AM, et al. A comparison of the prevalence of fluorosis in 8-year-old children from seven European study sites using a standardized methodology. Community Dent Oral Epidemiol 2004;32(Suppl 1):28–33.

[3] MRC Working Group. Water Fluoridation and Health. London: Medical Research Council; 2002.

[4] Conway DI, Macpherson LMD, Stephen KW, Gilmour WH, Petersson LG. Prevalence of dental fluorosis in children from non-water-fluoridated Halmstad, Sweden: fluoride toothpaste use in infancy. Acta Odont Scand 2005;63: 56–63.

[5] Hedenberg G. Swedish communities with significant levels of fluoride in the drinking water. Liljeholmen: Svenskt Vatten AB; 2002.

[6] Stephen KW, Macpherson LM, Gilmour WH, Stuart RA, Merrett MC. A blind caries and fluorosis prevalence study of school-children in naturally fluoridated and nonfluoridated townships of Morayshire, Scotland. Community Dent Oral Epidemiol 2002;30:70–9.

[7] Stephen KW, McCall DR, Gilmour WH. Incisor enamel mottling prevalence in child cohorts which had or had not taken fluoride supplements from 0 to 12 years of age. Proc Finn Dent Soc 1991;87:595–605.

[8] Stephen KW, Macpherson LMD, Gorzo I, Gilmour WH. Effect of fluoridated salt intake in infancy: a blind caries and fluorosis study in 8th grade Hungarian pupils. Community Dent Oral Epidemiol 1999;27:210–15.

[9] Hawley GM, Ellwood RP, Davies RM. Dental caries, fluorosis and the cosmetic implications of different TF scores in 14-year-old adolescents. Community Dent Health 1996;13:189–92.

[10] Edwards M, Macpherson LMD, Simmons DR, Gilmour WH, Stephen KW. An assessment of teenagers' perceptions of dental fluorosis using digital simulation and web-based testing. Community Dent Oral Epidemiol 2005;33: 298–306.

[11] Pendrys DG, Stamm JW. Relationship of total fluoride intake to beneficial effects and enamel fluorosis. J Dent Res 1990; 69:529–38.

[12] Oulis CJ, Raadal I, Martens L. Guidelines on the use of fluoride in children: an EAPD policy document. Eur J Paediatr Dentistry 2000;1:7–12.

[13] Government of Ireland. Forum on Fluoridation. Dublin: Stationery Office; 2002.

[14] World Health Organization Oral Health Programme. Oral Health Country/Area Profile Programme. WHO Collaborating Centre, Malmö University, Sweden. Available at: http://www.whocollab.od.mah.se/index.html (accessed 30 June 2006).