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Risk Factors for Enamel Fluorosis in a Nonfluoridated Population

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The purpose of this case-control investigation was to investigate the possible association between mild-to-moderate enamel fluorosis and exposure during early childhood to fluoride supplements, fluoride toothpaste, and/or infant formula use in nonfluoridated communities. Analysis was performed on 460 10- to 13-year-old children, born after 1979, who were residents of six nonfluoridated communities in Massachusetts and Connecticut. The fluorosis status of the subjects was determined on the basis of a clinical dental examination using the Fluorosis Risk Index (FRI). Risk factor exposure was ascertained via a mailed questionnaire with a response rate of 90% and a questionnaire reliability of 87%. Logistic regression analyses revealed a moderate association between mild-to-moderate enamel fluorosis on early forming (FRI classification I) enamel surfaces and both fluoride supplement use (odds ratio (OR) = 2.25, 95% confidence interval (CI) 1.08–4.69) and early toothbrushing habits (OR = 2.56, 95% CI 1.34–4.88). There was a strong association between mild-to-moderate fluorosis on later forming (FRI classification II) enamel surfaces and both supplement use (OR = 7.97, 95% CI 2.98–21.33) and early toothbrushing habits (OR = 4.23, 95% CI 1.72–10.41). Infant formula was not found to be associated with fluorosis on either FRI classification I or II surfaces. *Am J Epidemiol* 1996;143:808–15.

dental enamel; epidemiologic methods; fluorides; mottled enamel; risk

During the past decade, the prevalence of enamel fluorosis in nonfluoridated communities has been reported to be substantially greater than that observed in the classic studies of Dean (1–4). Whereas Dean reported an overall fluorosis prevalence of 2 percent or less in nonfluoridated communities (3–4), recent studies have reported fluorosis prevalence in nonfluoridated communities to range between 3 and 55 percent (1, 2). These findings have led to efforts to identify the causes of this increase in the prevalence of enamel fluorosis in areas with low concentrations of fluoride in the water supply.

Fluoride supplements were developed for use by children living in nonfluoridated areas as a substitute for fluoridated water, with the hope of achieving a similar caries-preventive benefit (5). During the 35 years of supplement use, a variety of dosage schedules have been put forward in an attempt to titrate the appropriate dose with which to achieve this benefit without inducing the unwanted side effect of noticeable enamel fluorosis (5). Although there has recently been considerable discussion as to the true benefit of fluoride supplementation (6, 7), consistent evidence has accumulated to indicate that supplementation, at dosages recommended before 1979, was strongly associated with enamel fluorosis among US children (5, 6). Past risk factor evidence has also suggested that the 1979 revision to the supplement protocol, which reduced the dosage for the first 2 years of life (8, 9), was an inadequate modification, with exposure after the first 2 years found to be strongly associated with the development of fluorosis (10). An assessment of fluorosis risk among children supplemented under the revised 1979 protocol is therefore important.

Nearly all of the toothpaste used today in the United States contains fluoride (11). The toothpaste used by children younger than 6 years is generally swallowed rather than expectorated (12–14), with most of the ingested fluoride being absorbed in the gastrointestinal tract (15–19). Although few quality multivariate studies have been conducted, the epidemiologic evidence indicating an association between early toothpaste use and fluorosis is growing. It has, however, been confined primarily to populations in fluoridated areas or with mixed fluoridation histories. Osuji et al. (20) reported a strong 11-fold association between early toothbrushing and very mild fluorosis in a population of 8- to 10-year-old Canadian children who grew up in a fluoridated community. Riordan (21) reported a

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Abbreviation: FRI, Fluorosis Risk Index.

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moderate association between a history of children swallowing toothpaste and enamel fluorosis in a population of 7-year-old Australian children with a mixed fluoridation history. We (22) previously reported a nearly threefold increase in mild-to-moderate fluorosis associated with frequent toothbrushing during the first 8 years of life in a fluoridated middle school-age population. However, the evidence to date concerning the relation between enamel fluorosis and early toothpaste use within nonfluoridated populations has remained equivocal, with Pendrys and Katz (10) reporting a suggestive but statistically nonsignificant threefold increase in the risk of fluorosis associated with early toothbrushing in a nonfluoridated middle school-age population.

Before 1979, infant formula contained variable and often high concentrations of fluoride (23–25). Studies (10, 20–22) have suggested an association between ingestion of formula manufactured before 1979 and enamel fluorosis. Although US manufacturers of infant formula voluntarily agreed in 1979 to reduce and control the concentration of fluoride in their products (26), speculation has continued as to whether the reduced concentrations of fluoride still present in formula, taken in addition to other sources, continue to represent an important source of total body intake (27, 28). Only now, as the children who as infants would have used this fluoride-reduced formula are reaching ages 10–13 years, can an association with fluorosis be properly assessed.

The purpose of this case-control study was to investigate, in a *nonfluoridated* population born after 1979, the association between enamel fluorosis and exposure during the first 8 years of life to three nonwaterborne sources of ingested fluoride: infant feeding, fluoride dentifrice, and fluoride supplementation.

MATERIALS AND METHODS

All 10- to 13-year-old children who were enrolled in participating school districts in six nonfluoridated Massachusetts and Connecticut communities at the time of the study (1993–1994) were invited to participate. All contacted school systems agreed to participate, and enrollment was through and with the enthusiastic cooperation of the participating school districts.

Fluorosis examinations were conducted in the subjects' schools by two examiners who used portable dental chairs and headlights. Subjects' teeth were dried with sterile cotton gauze for better visibility before the examination. A plane surface mirror was used when needed for better visualization of tooth surfaces. Trained data recorders entered the data onto computer-ready scoring forms.

Enamel fluorosis was measured using the Fluorosis Risk Index (FRI) (29), which categorizes fluorosis cases and controls based on the presence of mild-to-moderate fluorosis on enamel surfaces forming during defined developmental periods. A complete discussion of the FRI has been presented elsewhere (29), as has its use in other investigations (10, 22) as well as a discussion of its utility in analytical epidemiologic investigations (30–32). Briefly, in the index, the enamel surfaces of the dentition are divided into zones, with each of these zones selectively assigned to one of two classifications based on the age when the formation of these surface zones begins. FRI classification I enamel surface zones begin to form at or shortly after birth, whereas classification II enamel surface zones begin to form after the second year of life. This is a critical consideration in the analytical investigation of fluorosis risk factors, inasmuch as enamel fluorosis observed on different teeth may be related to entirely different routes of exposure at different ages.

Each enamel surface zone was diagnosed for fluorosis, using the traditional clinical diagnostic criteria of Møller (33), Russell (34), and Zimmermman (35). The criteria for a positive diagnosis of mild-to-moderate fluorosis minimally required the presence of noticeable paper white streaking and/or coalescence occurring on more than 50 percent of the enamel surface zone being examined. Surface zones were scored as possessing severe fluorosis if pitting or staining involved more than 50 percent of the zone. A zone was diagnosed negative when no evidence of fluorosis of any severity was present and questionable when some clinical signs of fluorosis were present but the criteria for a positive score were not met. An enamel surface zone was considered unscorable if more than 50 percent of that zone was covered by a restoration, orthodontic appliance, or debris. Inter- and intraexaminer reliability examinations were randomly conducted daily throughout the data collection period. As an examiner would typically examine between 50 and 100 children each day, examiner blindness could occur during these reliability examinations.

After the fluorosis examinations, which took place within a 1-month period, the data were analyzed to identify cases and controls. For each of the two FRI classifications, a subject was categorized as a fluorosis case if the subject possessed a fluorosis-positive score on two or more enamel surface zones assigned to that classification. A subject was categorized as a control if the subject possessed no fluorosis-positive or questionable scores on any of the surface zones assigned to that classification. Subjects who might otherwise be classified as a control under an FRI classification were

classified as masked if the fluorosis status of more than one surface zone *under that classification* were unscorable. Furthermore, a subject who met the criteria for a control under one FRI classification but was categorized as a case based on any other surface zones would not be accepted as a control (e.g., a classification I control cannot be a classification II case). This rule serves to increase the confidence that controls are indeed fluorosis free. Subjects who failed to meet either the case or control definition were categorized as questionable. Thus, case-control status was determined for each of the two FRI classifications based solely on the clinical findings on enamel surface zones assigned to that particular FRI classification, with the exception of the control rule cited above. Subjects who were identified as questionable or masked under both FRI classifications were not included in any analyses.

A 41-item, self-administered, closed-ended fluoride exposure questionnaire was mailed to the parents of the identified case and control subjects. This questionnaire had been pretested and used in two prior investigations (10, 22). For each quarter of the first year of life, and globally for the second year, the parent was asked to check 1) breast-fed, 2) formula-fed (ready to feed, liquid, or powdered concentrate), or 3) cow's milk or solid food to indicate the respondent's judgment as to the subject's main source of food. Parents were also asked to indicate the brand of formula that was usually used. For each of the first 8 years, the parent was asked the subject's residence history for each year and whether either fluoride supplement drops or tablets were used during each year. Parents were also asked to indicate at what age their child began to brush, at what ages they helped the child brush, and the usual frequency of brushing throughout the first 8 years (i.e., did not brush, brushed once daily, brushed twice daily). They were also asked to circle a drawing to indicate, for the entire period, whether the child usually placed a pea-sized amount, covered half, or covered all of the toothbrush when brushing. Last, the questionnaire asked for the informant's relationship to the child, whether the informant had lived with the child during each of the 8 years surveyed, and the race of the subject using National Institutes of Health-described categories.

Parents were offered 20 dollars for return of the completed questionnaire. Two mailings followed the initial mailing. Incomplete questionnaires were returned to the parent with a letter identifying the specific areas requiring completion. Only responses from parents/guardians who had lived with their child during the first 8 years of the subject's life were accepted for analysis.

A randomly drawn reliability sample, blocked on the mailing round on which the questionnaire was returned, was mailed a second questionnaire 1 month after the completion of the third mailing round. None of the parents or subjects were informed of the subjects' case or control status until after the return of the reliability sample.

The fluoridation status of subjects who had lived any of the first 8 years in other than their current town of residence was determined by the 1992 Fluoridation Census (36). All analyses were limited to subjects who had lived only in *nonfluoridated* communities during this period.

All data were entered into an IBM-compatible computer and analyzed using SPSS for Windows (37) and Epidemiological Graphics, Estimate, and Testing (EGRET) (38) statistical packages. All descriptive and inferential analyses were conducted separately on the basis of FRI classification I or classification II enamel surface zones, respectively. Basic descriptive and univariate statistics, as well as Mantel-Haenszel (39) odds ratios to the extent allowed by cell size, were used to initially categorize the data and help construct the multivariate analyses. Unconditional logistic regression analyses were used to develop a model of exposures associated with mild-to-moderate enamel fluorosis. The regression coefficient-generated odds ratio was used to estimate the relative risk for each factor, adjusted for all other factors in the model (38, 40, 41). Tests for trend and departure from linearity were performed where appropriate (42). Infant formula ingestion, amount and frequency of fluoride toothpaste use, and fluoride supplement use during the first 8 years of life were the independent variables of principal interest. Additional covariates included in the model were sex, race, and dental examiner. Socioeconomic status was measured, as in two previous studies, by the median household income of subjects' census tract, as determined by 1990 US Census tract data (43). Ninety-five percent confidence intervals were generated for all adjusted odds ratios.

RESULTS

Table 1 is an outline of the process of fluorosis identification and fluoride history ascertainment. It can be seen from the table that 1,091 subjects (94 percent of those enrolled and 15 percent of those eligible by grade level) were examined for fluorosis. Intra- and interexaminer agreement on case versus control status was 98.9 percent and 93.8 percent, respectively (Cohen's kappa = 0.93 and 0.73, respectively (44)).

Based on these examinations, 767 cases and controls for mild-to-moderate fluorosis were identified, with a

TABLE 1. Ascertainment of cases and controls for mild-to-moderate enamel fluorosis and fluoride exposure questionnaire data among Massachusetts and Connecticut children born between 1980 and 1983

Subject category	No.
Case/control ascertainment	
Total number of subjects examined for enamel fluorosis*	1,091
Diagnosed as other than a definite case or control†	324
Diagnosed as a fluorosis case or control‡	767
Fluoride exposure history ascertainment	
Unable to contact with questionnaire	13
Parents of cases/controls sent questionnaires	754
Questionnaires returned complete	677
Excluded on the basis of mixed or fluoridated residence history or excluded informant§	185
Subjects born before 1980	32
Total cases and controls in analysis	460

* Study was open to all middle school-aged children enrolled in participating school districts.

† Includes subjects diagnosed as questionable for mild-to-moderate enamel fluorosis or whose enamel surfaces were masked by the presence of orthodontic appliances, restorations, or debris under both Fluorosis Risk Index classifications.

‡ Subjects who were either a case or control for enamel fluorosis under at least one of the two Fluorosis Risk Index classifications.

§ Only parents/guardians who lived with their child during the first 8 years of the child's life were considered acceptable informants.

90 percent (n = 677) return rate for the fluoride history questionnaires after three mailing rounds. Response rates were similar for both cases and controls (i.e., 92 and 88 percent, respectively). A 12 percent (n = 85) reliability sample showed an average agreement between the second and first questionnaire responses of 87.5 percent, which was similar regardless of case/control subject status.

A total of 460 cases and controls, ages 10–13 years (mean = 12.5 years), were available for subsequent analyses after exclusions due to residence history, informant status, and year of birth. Fifty-seven percent of the subjects were male. Ninety-four percent of the subjects were Caucasian, reflective of the town populations. All of the children in this analysis were born after 1979 (i.e., 1980–1983), and all lived in nonfluoridated areas throughout the entire first 8 years of life. Eighty-six percent of the subjects had lived in their current town of residence for their entire lives. Analysis of water samples from the enrolled towns indicated fluoride concentrations less than 0.1 ppm. The cross-classification of FRI classifications I and II case-control status is given in table 2.

In table 3, descriptive information for the variables included in the logistic regression models is shown. The age at which the child began toothbrushing was determined as either the reported age when brushing began or when the parent first began to help the child to brush. All but one of the respondents indicated that they had helped their child brush during at least part of the first 8 years, therefore parental help with toothbrushing was not found to be useful as a covariate. Infant formula use was not found to be associated with mild-to-moderate fluorosis on either the FRI classification I or II enamel surfaces. This was true regardless of the time and duration of exposure during the first or second year and regardless of whether the formula was milk based, soy based, ready to feed, or in the form of

TABLE 2. Fluorosis Risk Index (FRI) classification I status stratified by FRI classification II subject status for nonfluoridated Massachusetts and Connecticut children born between 1980 and 1983*

FRI classification I subject status	FRI classification II subject status				
	Fluorosis case	Fluorosis control	Questionable	Masked†	Total
Fluorosis case	145	‡	34	7	186
Fluorosis control	‡	67	30	108	205
Questionable	56	5	II	II	61
Masked§	3	5	II	II	8
Total	204	77	64	115	460

* Only subjects who were either a case or a control under at least one FRI classification are included in the table and in the analyses.

† FRI classification I cases or controls whose status for FRI classification II could not be determined because of the masking of classification II enamel surfaces, for example, by the presence of orthodontic bands or dental restorations.

‡ Subjects who were fluorosis free under one FRI classification but a fluorosis case under the other FRI classification were categorized as questionable, not as a control.

§ FRI classification II cases or controls whose status for FRI classification I could not be determined because of the masking of classification I enamel surfaces, for example, by the presence of orthodontic bands or dental restorations.

II This table includes only subjects who were defined as a case or control under at least one of the FRI classifications and were thus included in subsequent risk factor analyses.

TABLE 3. Cases and controls for mild-to-moderate enamel fluorosis, stratified by Fluorosis Risk Index (FRI) classification and history of breastfeeding, toothbrushing, fluoride supplementation, and ethnicity for nonfluoridated Massachusetts and Connecticut children born between 1980 and 1983

	FRI classification I				FRI classification II			
	Cases (n = 186)		Controls (n = 205)		Cases (n = 204)		Controls (n = 77)	
	No.	%	No.	%	No.	%	No.	%
Supplemented year 1								
No	44	24	67	33	40	20	26	34
Yes	142	76	138	67	164	80	51	66
Supplemented during years 2–8								
No	17	9	41	20	10	5	20	26
Yes	169	91	164	80	194	95	57	74
Toothbrushing history*								
Began after year 2, 1/day	22	12	48	23	19	9	18	23
Began after year 2, >1/day	29	15	36	18	34	16	16	21
Began during year 1–2, 1/day	37	20	44	21	37	18	16	21
Began during year 1–2, >1/day	98	53	77	38	114	56	27	35
Amount of toothpaste used								
Pea size	22	12	19	9	20	10	6	8
>Pea size	164	88	186	91	184	90	71	92
Breast fed								
No	66	35	103	50	80	39	40	52
Yes	120	65	102	50	124	61	37	48
Ethnicity								
Non-Caucasian	4	2	17	8	8	3	11	14
Causasian	182	98	188	92	197	97	66	86

* Year toothbrushing began and usual daily frequency of toothbrushing during the first 8 years. The mean age at which toothbrushing began among subjects who started toothbrushing after year 2 was 3.5 ± 0.9 years. The mean age at which toothbrushing began among subjects who started brushing during the first 2 years was 1.5 ± 0.5 years.

a concentrate. The findings related to infant formula use are reflected in findings related to breastfeeding (the alternate exposure to infant formula), which appears as a variable in the models.

In table 4 are crude odds ratio estimates and the logistic regression-derived adjusted odds ratio estimates with 95 percent confidence intervals for mild-to-moderate enamel fluorosis for both FRI classifications. The logistic regression-derived odds ratio estimates are adjusted for the other variables in the table as well as sex, median household income, and dental examiner. The analyses revealed no significant interactions between any of the variables.

As shown in the table, the use of fluoride supplements during years two through eight conveyed statistically significant odds ratios of 2.25 and 7.97, for mild-to-moderate enamel fluorosis on FRI classification I and II enamel surfaces, respectively, as compared with subjects who had no history of supplement use during that period. As is also shown in table 4, a history of beginning to brush during the first 2 years while usually brushing more than once per day with fluoride toothpaste conveyed statistically significant adjusted odds ratios of 2.56 and 4.23 for mild-to-moderate fluorosis on FRI classification I and II enamel surfaces, respectively, as compared with subjects who did not begin to brush until after the second year and who usually brushed only once per day. Tests for trend indicate a significant linear trend across the four exposure categories.

A history of having been breast fed conveyed a borderline significant 60–80 percent increase in the risk of fluorosis, as compared with subjects who had never been breast fed. It is also evident from the table that Caucasians were three to four times more likely to develop fluorosis than minorities.

DISCUSSION

Previous evidence (10) has suggested that the 1979 US fluoride supplement revision, which reduced supplement fluoride dosage only for the first 2 years, would be inadequate to reduce the fluorosis risk associated with supplement ingestion. The findings reported in this paper represent the first direct data on fluorosis risk for children supplemented under that revised 1979 fluoride supplement protocol. The findings of this study of a strong association between

TABLE 4. Crude and adjusted* odds ratios (ORs) with 95% confidence intervals (CIs) for mild-to-moderate enamel fluorosis, stratified by the Fluorosis Risk Index (FRI) classifications, for nonfluoridated Massachusetts and Connecticut children born between 1980 and 1983

	FRI classification I			FRI classification II		
	Crude OR	Adjusted OR	95% CI	Crude OR	Adjusted OR	95% CI
Supplemented year 1						
No	1.00†	1.00†		1.00†	1.00†	
Yes	1.57	1.30	0.75–2.23	2.09	1.63	0.79–3.37
Supplemented during years 2–8						
No	1.00†	1.00†		1.00†	1.00†	
Yes	2.49	2.25	1.08–4.69	6.81	7.97	2.98–21.33
Toothbrushing history*						
Began after year 2, 1/day	1.00†	1.00†		1.00†	1.00†	
Began after year 2, >1/day	1.75	1.33	0.60–2.97	2.00	1.54	0.55–4.34
Began during year 1–2, 1/day	1.83	1.61	0.77–3.38	2.17	2.10	0.76–5.78
Began during year 1–2, >1/day	2.77	2.56	1.34–4.88	3.96	4.23	1.72–10.41
Amount of toothpaste used						
Pea size	1.00†	1.00†		1.00†	1.00†	
>Pea size	0.76	1.21	0.56–2.59	0.78	0.73	0.23–2.29
Breast fed						
No	1.00†	1.00†		1.00†	1.00†	
Yes	1.84	1.62	1.03–2.55	1.68	1.86	1.00–3.48
Ethnicity						
Non-Caucasian	1.00†	1.00†		1.00†	1.00†	
Causasian	4.11	3.31	0.92–11.96	4.69	4.28	1.34–13.72

* Each variable was adjusted for all of the other variables in the table, sex, median household income, and dental examiner.

† Reference category.

‡ Year toothbrushing began and usual daily frequency of toothbrushing during the first 8 years. Test for trend, $p < 0.001$; test for departure from linearity, $p = 0.11$.

fluoride supplementation during years two through eight and fluorosis strongly support the recent joint decision of the American Dental Association, the American Academy of Pediatric Dentistry, and the American Academy of Pediatrics to reduce the fluoride supplement dosage schedule, particularly for the *third through sixth* years (45, 46). By contrast, the observed weak association between supplement use during the first year and fluorosis suggests that the 1979 supplement dosage reduction for the *first* year of life may have been sufficient to eliminate that exposure as an important fluorosis risk factor.

Our finding that a history of brushing more than once per day beginning during the first 2 years was strongly associated with mild-to-moderate enamel fluorosis represents the first epidemiologic evidence that early toothbrushing habits are strongly and statistically significantly associated with mild-to-moderate enamel fluorosis in children growing up in *nonfluoridated* areas. These findings are consistent with our previous findings (22) in a pre-1980 birth cohort of children who grew up in *fluoridated* communities, where frequent brushing throughout the first 8 years was found to be strongly associated with mild-to-moderate fluorosis on both early and later forming enamel surfaces. They are also consistent with those of Osuji et al. (20), who reported an odds ratio of 11 for early brushing and very mild fluorosis in a *fluoridated* Canadian population, and with the findings of Riordan (21), who reported an association between early toothbrushing habits and enamel fluorosis in Australian children with a *mixed fluoridation* history. The findings of this study support the need to reduce the ingestion of fluoride via toothpaste by pre-school age children.

Although there was a suggestive though nonsignificant association (odds ratio = 3) observed between amount of toothpaste used and fluorosis in our previous investigation in fluoridated communities (22), there was no association suggested in this current investigation. However, a judgment of usual amount of toothpaste used may be an overly crude dose measure across an 8-year span, especially given that only 10 percent of the subjects were reported to have usually used a pea-sized amount of toothpaste, which has only recently become the recommended amount for use by preschool children (5). The role of this variable merits further study as the proportion of children who use a pea-sized amount increases in the years ahead.

Infant formula used by subjects in this study would have been produced after the 1979 voluntary decision by formula manufacturers to maintain low fluoride concentrations in their products (26, 47). In contrast to previous reports of a strong association between formula consumption and fluorosis (10, 20–22), the findings of this study suggest that this voluntary reduction in formula fluoride concentration has had the desired effect of eliminating infant formula as a risk factor for enamel fluorosis, at least within nonfluoridated populations, and support the importance of continuing this action.

The related finding of a suggested moderate association between fluorosis and breastfeeding is intriguing, given that breast milk has been consistently demonstrated to contain little fluoride regardless of the amount of fluoride ingested by the mother (48, 49). Therefore, it is likely that breastfeeding is serving as a surrogate for some other variable or variables related to increased fluoride exposure during early childhood.

This investigation did not attempt to retrospectively obtain a detailed dietary history across the 8 years surveyed. Although it has been demonstrated that the fluoride content of food per se has not meaningfully changed during the past 40 years (1), the ingestion of beverages produced in fluoridated communities has become a likely and highly variable source of additional fluoride among many nonfluoridated populations (28), especially those that are served by fluoridated manufacturing centers. Indirect evidence of this is the observed trend of decreasing, within-region differences in caries prevalence between fluoridated and nonfluoridated populations, as the total proportion of people within that region served by fluoridated water increases (11). Because an accurate, continual assessment of a young child's total fluoride intake is not practicable in the medical or dental practice setting, the impact of this increase in fluoride exposure in nonfluoridated areas on individual patient management will likely need to be based on a population, rather than an individual basis.

The finding that exposure to fluoride supplementation during years two through eight was strongly associated with mild-to-moderate fluorosis on FRI classification I enamel surface zones adds additional evidence indicating vulnerability during the maturation phase of enamel formation, when most of the mineralization occurs, as contrasted to the earlier secretory phase. This finding is consistent with the findings from other animal model and epidemiologic studies (10, 22, 50–52). At the same time, the finding of an association between toothbrushing during the first 2 years and fluorosis on FRI classification I enamel surface zones suggests that a possible susceptibility to fluorosis during the secretory phase of enamel development cannot be discounted.

The findings, adjusted for socioeconomic status, suggest that there may be important racial differences in fluorosis risk. This finding illustrates the important need to extend fluorosis risk factor investigations to include substantial minority representation.

The question arises as to whether parental awareness of mottling on their child's teeth or awareness of the purpose of the study could have led to either a selection or a recall bias. In accordance with institutional review board guidelines, parents and subjects were informed in general terms of the purpose of the study. However, specific suspected risk factors were not mentioned. The analyses were adjusted for socioeconomic status, thereby reducing the risk that an association between socioeconomic status, fluorosis, and enrollment, if present, would bias the results. A subgroup analyses of FRI classification II fluorosis cases and controls (fluorosis on the less visible posterior teeth) revealed no differences in observed associations, regardless of whether maxillary anterior fluorosis was also present, suggesting that awareness of the presence of fluorosis did not influence enrollment or exposure history responses. Nonfluorotic opacities, which to the nontrained observer appear similar to fluorosis, were also diagnosed. There was no association between the presence of these opacities and either fluoride supplementation or toothbrushing habits. These findings suggest the absence of significant biases related to parental knowledge of their child's fluorosis status and study purpose.

All of the cases reported in this study of children living in nonfluoridated communities possessed fluorosis of mild-to moderate severity, with the exception of one subject who showed evidence of more severe fluorosis. The classic investigations of Dean (4) demonstrated that virtually maximal caries prevention could be achieved without producing fluorosis of any clinical relevance. The task today must be to make adjustments as necessary in fluoride exposure patterns to maintain the maximum benefits of fluoride use, while at the same time minimizing the risk of noticeable fluorosis. The findings of this study provide further evidence as to the underlying causes of mild-to-moderate fluorosis in nonfluoridated areas and suggest potential strategies to help reduce the risk of fluorosis among future generations.

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