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## Fluoride Exposure in Michigan Schoolchildren

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### Abstract

*Recent trends in the prevalence of dental caries in children, as well as a possible increase in the prevalence of dental fluorosis, have prompted some researchers to suggest the reassessment of water fluoride concentration standards. Instead of reducing water fluoride concentrations, an alternative approach would be to limit the use of, or reduce the fluoride concentration of, dentifrices, mouthrinses, and supplements. Information about the use of these other sources of fluoride, however, is scarce. Using data from a 1987 survey of Michigan schoolchildren, exposure to selected fluoride sources as well as toothbrushing habits are described. Responses from questionnaires revealed that, overall, 98.5 percent of the children have used fluoride dentifrices, 27 percent have used topical fluoride rinses, 72.5 percent have had at least one exposure to professionally applied topical fluoride, and 27 percent have used dietary fluoride supplements. Although the use of fluoride dietary supplements was appropriate for most children residing in fluoride-deficient Cadillac, the percentages of children in the other communities who have ingested these supplements suggest that these products are being prescribed improperly. Given the almost universal use of fluoride dentifrices at an early age, it may be time to investigate the use of reduced fluoride dentifrices for children. In addition, continuing efforts to decrease inappropriate dietary fluoride supplementation are required.*

*Key Words: fluoride, dentifrices, mouthrinses, supplements, fluoridation, dental fluorosis, toothbrushing.*

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Recent studies of the prevalence of dental caries and fluorosis in US children (1-4) suggest that the widely recognized decline in caries may be accompanied by an

increase in the very mildest forms of dental fluorosis. These trends have prompted some researchers (5,6) to call for the reassessment of the "optimal" water fluoride (F) concentration standards, in light of the increased availability of multiple forms of fluoride, as well as possible environmental buildup. From a 1987 survey of Michigan schoolchildren, Szpunar and Burt (2) concluded that the value of reexamining water fluoride standards should be balanced against the evidence that caries is still inversely related to water fluoride concentrations. In addition, because water fluoridation requires no individual effort to obtain caries-preventive benefits and is available to individuals of all socioeconomic levels, it remains the most efficient and cost-effective method of caries prevention available in the US today. If the risk of mild dental fluorosis is considered too high, one option might be to limit the use or reduce the fluoride concentrations of other widely available sources of fluoride, such as dentifrices, mouthrinses, professionally applied topical fluorides, and fluoride supplements. Information about who uses these products, as well as the frequency and duration of use, however, is scarce. Until a better understanding of the patterns of childhood fluoride exposure in both fluoridated and nonfluoridated communities is gained, no practical strategies for decreasing the risk of fluorosis can be developed.

This article describes the reported use of selected fluoride products, as well as toothbrushing habits, in a group of 1,103 schoolchildren, aged six to 12 years, from four Michigan communities with varying concentrations of fluoride in the public water supply. In addition, the association between the fluoride status of the community water supply and the reported use of fluoride products is also assessed.

In the US, fluoride dentifrices have been on the market since about 1955. The sale of these dentifrices amounts to about \$700 million annually (7). Fluoride mouthrinsing programs have been reported to serve between 2 and 4 million children (Bedmarsh H, Connolly GN. Presented at APHA meeting, 1984), but the availability of over-the-counter fluoride mouthrinses may have increased the number of children using these products.

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In 1983, for the first time, the National Health Interview Survey (NHIS) included questions on the use of fluoride mouthrinses, dietary fluoride supplements, and dentifrices (8). Results from the survey indicated that about 89 percent of the dentate civilian noninstitutionalized population reportedly used fluoridated dentifrices; approximately 96.8 percent of children between the ages of five and 17 apparently used fluoridated dentifrices.

About 11 percent of dentate Americans reportedly have used fluoride mouthrinses, with the highest percentage of users among those five to 17 years of age (17%). Over 14 percent of children younger than two years of age were reported to have used fluoride supplements, but the proportion decreased in older age groups. Only 3.9 percent of children aged 12 to 13 years have used these supplements.

The increased risk of fluorosis from the use of various combinations of supplements, rinses, dentifrices, and topical applications of high concentration fluoride products remains unknown. From an epidemiologic study of dental fluorosis and fluoride exposure, Forsman (9) determined that in infants, consumption of 0.1 mg F/kg body weight was enough to result in dental fluorosis. This level of consumption could be reached in a variety of ways, depending on the consumption of water, infant formula, food, and the supplemental sources of fluoride (dietary fluoride supplements, rinses, dentifrices).

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An increased prevalence of fluorosis has been associated with the use of dietary fluoride supplements (10-12) and fluoride rinses (2). Houwink and Wagg (13), however, found no increases in the prevalence of fluorosis in a group of children participating in a clinical trial of a fluoridated dentifrice. Compliance in the use of the dentifrices in the test and control groups, however, was not assessed. Larsen (14) also detected no increased prevalence of fluorosis among children receiving periodic topical fluoride gel treatments during tooth formation or prior to the end of mineralization, compared to children receiving the treatments only after tooth formation was complete. Larsen did note, however, that the later a tooth was formed, the more enamel changes were observed, and suggested that such changes may result from the use of dentifrices during childhood.

The information presented here will describe patterns in the reported use of multiple sources of fluoride by children residing in fluoridated and fluoride-deficient areas of Michigan. These data may serve as a starting

point in the assessment of exposure to multiple sources of fluoride in school-aged children today.

## Methods

The four communities surveyed were Cadillac, Hudson, Redford, and Richmond, with community water fluoride levels of approximately 0.0, 0.8, 1.0, and 1.2 ppm, respectively. Overall, 69.2 percent of the children reportedly received water from the public water supply. By community, the percentages were 65.8, 57.8, 99.3, and 47.4 for Cadillac, Hudson, Redford, and Richmond, respectively. Although a question about fluoride assay of private water supplies was not asked, some parents in Richmond indicated that their wells had been assayed for fluoride and found to have levels similar to that of the public water supply (1.2 ppm). Details on the methods of subject recruitment, questionnaire administration, and screening used in this investigation have been described previously (2).

The questionnaire form requested demographic information; residence history; information about the use of dietary fluoride supplements, professionally applied topical fluorides, over-the-counter fluoride rinses, and dentifrices; and information about toothbrushing habits, dental attendance patterns, and the method of feeding and source of nutrition during the child's first year of life. Parents also were asked about the highest level of education of the male and female heads-of-household and an open-ended question about their general opinion of the appearance of their children's teeth.

The data used in these analyses are for the 1,103 children who both returned a questionnaire and participated in the screening examination (Table 1). For the purposes of this analysis, children residing in Hudson (0.8 ppm), Redford (1.0 ppm), and Richmond (1.2 ppm) were classified as living in a fluoridated area, and children living in Cadillac (~0.0 ppm) as living in a fluoride-deficient area. The chi-squared statistic was used to test for associations in contingency table analyses. A *P*-value of .05 or less was considered to indicate statistical significance.

## Results

**Dietary Fluoride Supplements.** Approximately 27 percent of all children were reported to have ever used dietary fluoride supplements. About 50 percent of children in the fluoride-deficient area had reportedly used supplements, compared to 18.1 percent of the children in the fluoridated areas ( $P < .0001$ ). When considering only those children who were lifetime continuous residents of their respective communities, 58.5 percent of Cadillac children reported using supplements, compared to 14.5 percent of children living in fluoridated areas ( $P < .0001$ ).

Using information on the reported ages at start and end of fluoride administration, the time period that a child

**TABLE 1**  
Number of Participants by Age, Sex, and Fluoride (F) Status of the Community Water Supply, Michigan, 1987

F Status/Sex	Age (Years)					Total
	<6	6-8	8-10	10-12	12+	
<b>F-deficient</b>						
Male	13	46	29	37	10	135
Female	12	35	48	62	21	178
<b>Fluoridated</b>						
Male	20	138	119	94	15	386
Female	30	144	121	90	19	404
<b>Total</b>	<b>75</b>	<b>363</b>	<b>317</b>	<b>283</b>	<b>65</b>	<b>1,103</b>

could have received supplementation was computed. For all subjects, over half of the children used supplements from less than one year to two full years. Among continuous residents only, over 50 percent of Cadillac children used supplements for one year or less, compared to over 75 percent of the children residing in fluoridated communities. Cadillac residents reported slightly longer intervals of fluoride supplementation than residents of the fluoridated communities. In all areas, fluoride supplementation for most children did not occur during the entire period of tooth mineralization, but rather for considerably shorter intervals of time.

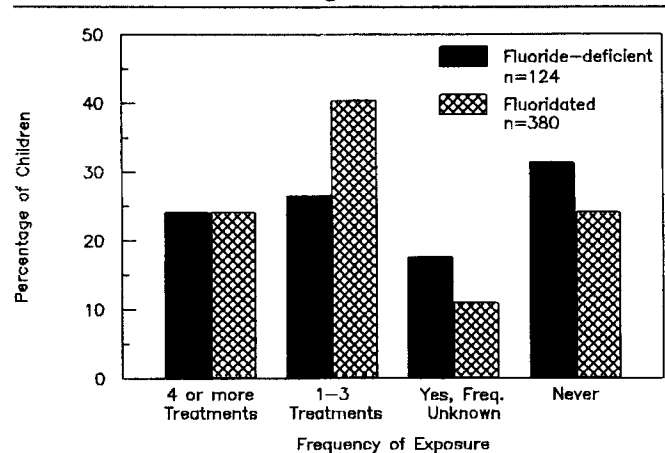
About 62 percent of all subjects and 69 percent of continuous residents reported that dietary fluoride supplements were given on a daily basis during the period of administration. Among the continuous resident subgroup, 83.3 percent of Cadillac children reported daily use, compared to 57.6 percent of children in the fluoridated areas ( $P=.0037$ ).

**Professionally Applied Topical Fluorides.** Almost one-quarter of all children reportedly had never received a professional topical fluoride application. Children continuously residing in fluoridated areas were more likely to have had any exposure to topical fluoride. However, about one-quarter of the children in both fluoridated and fluoride-deficient areas reported frequent exposure (Figure 1).

**Toothpaste Use.** Over 97 percent of all parents reported that they used a fluoride toothpaste when brushing their child's teeth; 98.5 percent of all children were reported to use a fluoridated paste when brushing their own teeth. Overall, children in the fluoridated areas were more likely to use a fluoridated paste than children from Cadillac ( $P=.0141$ ). However, no statistically significant difference was found among the continuous-resident subgroups.

**Topical Fluoride Rinse Use.** Overall, 73 percent of the children reportedly had never used a fluoride rinse. There were no significant differences in the use of fluoride rinses by fluoridation status of the community

**FIGURE 1**  
Percent Distribution of Continuous Resident Children by Fluoride Status of the Community Water and Exposure to Professionally Applied Topical Fluoride Treatments, Michigan, 1987



for either the full study group or the subset of continuous-resident children. Approximately 42 percent of all fluoride rinsers reported that they started using the rinse between the ages of four and five years, and 43 percent reported starting use at age six or older. Overall, children in the fluoridated areas tended to begin using these rinses at an earlier age than children in the fluoride-deficient area ( $P=.0207$ ), but no significant differences were found for the subset of continuous resident children. From these data, it appears that the use of fluoride rinses generally began when the child was nearing school age, after some permanent teeth may have erupted and several had completed mineralization.

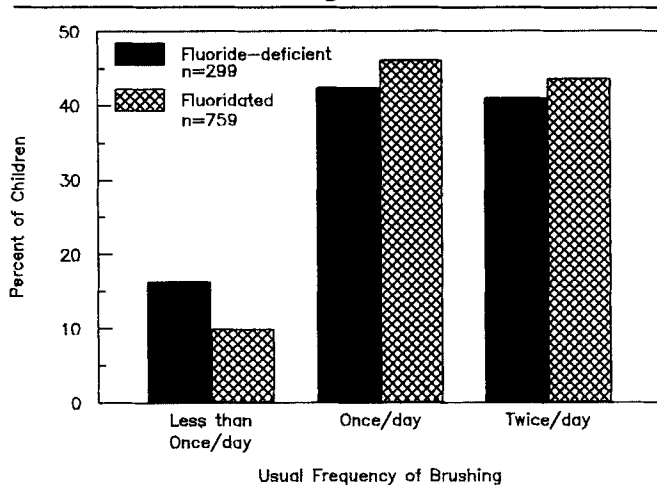
**Toothbrushing Habits.** Over 50 percent of all children reportedly had their teeth brushed by a parent or guardian before the age of two years; there were no significant differences by fluoridation status of the community of residence.

Figure 2 shows that about 45 percent of all children reportedly brushed once a day and about 43 percent brushed twice per day or more. Children in the fluoride-deficient area tended to brush less frequently than children in the fluoridated areas ( $P=.015$ ), but the differences among the groups were small.

**Associations with Age and Gender.** Age in years was significantly associated with exposure to professionally applied topical fluorides ( $P<.0001$ ) and with the use of topical fluoride rinses ( $P=.0244$ ). As expected, the proportion of children with exposure to those sources of fluoride was greater among older age groups.

Sex was significantly associated with only one of the factors studied: a child's usual frequency of toothbrushing ( $P=.0256$ ). A larger proportion of girls than boys reportedly brushed twice a day or more, and a smaller

**FIGURE 2**  
**Percent Distribution of All Children by Fluoride Status of Community Water and Usual Frequency of Toothbrushing, Michigan, 1987**



proportion of girls than boys reportedly brushed less than once a day.

**Associations with Socioeconomic Status.** Factors that were significantly associated with the highest level of education of the male head of household included the use of dietary fluoride supplements ( $P=.0238$ ), the exposure to professionally applied topical fluorides ( $P=.0034$ ), the age at which parents began brushing their children's teeth ( $P=.0064$ ), the age a child began brushing his or her own teeth ( $P=.0369$ ), and the usual frequency of the child's toothbrushing ( $P=.0009$ ).

As expected, the frequency of exposure to dietary fluoride supplements and professionally applied topical fluorides was greater in homes where the male parent had a college degree or some college than in homes where the male parent had fewer years of formal education.

The majority of individuals with a high school education or more began to brush their children's teeth before the children were two years old, but in homes where the male adult had only a grade school education, parents were most likely to begin brushing their children's teeth when they were a bit older. Similarly, the majority of children from households where the male adult had a high school education or more began to brush their own teeth between the ages of two and three years. In households where the male adult had only a grade school education, the largest proportion of children began brushing between the ages of four and five years. In addition, the majority of children from households where the male adult had a grade school education reportedly brushed once a day. However, in households where the male adult had a college degree or some college, the majority of children reportedly brushed twice a day or more.

**Bivariate Associations.** A series of analyses was completed to assess the association of one variable—for example, the use of dietary supplements—with another variable, such as fluoride mouthrinses. In brief, the results from these analyses suggested that children who received one exposure on a frequent basis tended to receive other exposures on a frequent basis also. For example, the reported use of over-the-counter fluoride rinses was significantly related to the reported exposure to professionally applied topical fluorides. Over 38 percent of children who had received four or more professionally applied topical fluoride treatments were frequent users of fluoride mouthrinses, compared to 28.7 percent of children who had received one to four professional fluoride treatments, and 18.8 percent of children who had never received a professional fluoride treatment ( $P<.0001$ ).

## Discussion

In this study, subjects were neither selected randomly nor were the study communities selected to be specifically representative of the state of Michigan. The four communities were selected purposely to have a range of water fluoride concentrations in the investigation.

The information collected on the questionnaire forms relied on parents' recall. With several children or a long interval of time, it is reasonable to assume that a parent's recall of an event, such as the age a child began toothbrushing, may have been inexact. Additionally, parents of younger children probably had more accurate recall of early events than parents of teenagers. In addition to possible recall bias, some parents may have answered a question in the way they thought the question should be answered, rather than what really occurred. For example, it is a widespread belief that people should brush after every meal. Some parents, then, may have indicated that their child brushed more than once a day because it is the "correct" answer, not the true frequency. Because only information about children who both returned a questionnaire and participated in the survey was used, there was also opportunity for selection bias. Few differences were noted among children who returned the questionnaire and agreed to be examined, and children who only returned the questionnaire. However, it was impossible to assess the differences between children who returned a questionnaire and those who did not participate in any way (2).

Another potential confounding factor is that some children in each community were not using the public water supply. Based on anecdotal reports from these areas, however, it is unlikely that water from private wells in Cadillac, Hudson, or Richmond had fluoride concentrations significantly greater than that found in the public water supply.

As discussed in the review, Ismail et al. (8) found that 96.8 percent of children aged five to 17 years used

fluoridated dentifrices. Similarly, in this data set, 98.5 percent of children aged six to 12 used fluoride dentifrices when brushing their own teeth. About 27 percent of children in the Michigan investigation reportedly had used a topical fluoride rinse, compared to 17 percent of children aged five to 17 in the NHIS data (8). The larger proportion of children using these rinses in the Michigan study may have been a result of the difference in age groups and the increased amount of advertising of these products since 1983.

One reason to examine the differences in the exposure to fluoride sources by community is to see if children in the fluoride-deficient area were more likely to use other methods of fluoride exposure than children in the fluoridated areas. The data showed that the use of fluoride supplements was greater in the fluoride-deficient area than the fluoridated areas, as is appropriate. For the other factors that were examined, however, the small but statistically significant differences among the communities were probably a result of socioeconomic and urban/rural differences, not of an awareness of the fluoride concentration of the water supply.

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*"In optimally fluoridated areas ... any additional caries protection afforded from an increased fluoride toothpaste could be small compared to a potential increase in the risk of fluorosis."*

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The proportions of continuous-resident children in the fluoridated areas who had ingested dietary fluoride supplements suggest that there were some physicians and dentists who were prescribing these products improperly. In this study, only children living in Cadillac (using the public water supply or fluoride-deficient water from a private well) and children in the other three areas who were totally breast-fed should have received dietary supplements. For those children using the community water supply, over 55 percent of children living in the fluoridated areas who received fluoride supplements were bottle-fed. According to the ADA fluoride prescription schedule, none of these children should have been receiving fluoride supplements. In fluoridated communities, the inappropriate prescription of dietary fluoride supplements may increase a child's risk of developing dental fluorosis. Other investigators (15-17) also have reported inappropriate fluoride prescription practices in fluoridated and nonfluoridated communities. Levy et al. (18) found that in both fluoridated and nonfluoridated communities, most dentists prescribed systemic fluoride supplements, but only a small number of practitioners assayed water supplies before doing so.

As demonstrated in this investigation and the 1983 NHIS data, over 95 percent of the individuals studied reportedly used fluoridated toothpastes. A portion of the decline in the prevalence of dental caries among children in the United States and other developed countries since the 1970s may be attributed to the use of such dentifrices. Beltran and Szpunar (19) concluded, from a review of the literature, that small children may swallow large enough amounts of dentifrice to produce levels of fluoride consumption associated with an increased risk of developing fluorosis. Bruun and Thylstrup (20) found that 55 percent of three-year-olds and 35 percent of seven-year-olds were ingesting fluoride from 1,000 and 1,500 ppm dentifrices in quantities exceeding recommended daily doses for their respective age groups. In the Michigan investigation, about half of the continuous resident children from the fluoridated areas had experienced dental fluorosis in the permanent dentition (2).

Recently the manufacturers of dentifrices in the US have begun to market two new types of products: dentifrices with an increased concentration of fluoride (1,500 ppm F) and dentifrices designed especially for children. The children's dentifrices are promoted as being less abrasive on tooth enamel than standard dentifrices, as having an appealing taste for children, and as supplying the usual caries-protective benefits. One dentifrice even incorporates "sparkles" in a blue gel. These good-tasting and appealing dentifrices may promote excessive ingestion by children.

Clinical trials comparing the anticaries effects of increased fluoride toothpastes with the standard 1,000 ppm concentration suggest relatively small increments of additional caries protection (21-23). In optimally fluoridated areas, therefore, any additional caries protection afforded from an increased fluoride toothpaste could be small compared to a potential increase in the risk of fluorosis. With "kiddy" toothpastes already on the supermarket shelves, this may be the right time to investigate the use of lower concentrations of fluoride for children under the age of six years, in order to decrease the risk of dental fluorosis.

The questionnaire information collected in this investigation demonstrates the widespread use of fluoridated toothpastes at an early age by children in four Michigan communities. Other sources of fluoride, such as professionally applied topical fluorides and over-the-counter mouthrinses, are also used by a substantial number of individuals. However, these sources are used less frequently than dentifrices, and are more likely to be used by children from higher socioeconomic backgrounds.

Along with the decline in dental caries that is being experienced by many American children today, data suggest that the prevalence of the mildest forms of dental fluorosis may be increasing in optimally and suboptimally fluoridated communities (1-4). To assess the role of various sources of fluoride in the etiology of dental

fluorosis, more sensitive and reliable information on fluoride exposure will need to be collected. Future investigators should consider the use of personal or telephone interview of parents instead of the self-administered questionnaire that was used in this study. Personal interviews, although costly and time consuming, would allow the researcher to ask more specific questions, to estimate quantity using models (for example, estimating the amount of dentifrice used per brushing), and to verify that the parents understand the meaning of the questions.

Given current trends in the prevalence of caries and fluorosis, as well as the introduction of new dentifrices to the consumer market, it may be time to investigate the use of dentifrices with a decreased concentration of fluoride for children under the age of six years to reduce the possibility of future dental fluorosis. The use of professionally applied topical fluoride products and topical fluoride rinses should perhaps be restricted to those children who appear to be at high risk of decay—for example, children with recent caries activity, orthodontic bands, or poor oral hygiene. In addition, increased efforts to decrease the inappropriate prescription of dietary fluoride supplements should be directed at dentists and physicians, perhaps through continuing education courses, journal articles and newsletters, and at professional association meetings.

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