Patterns of Dietary Fluoride Supplement Use During Infancy

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Abstract

Objectives: *This paper reports on patterns of dietary fluoride supplement use during infancy.* ***Methods:*** *Data were collected by mail for a birth cohort (n=1,072) studied at 6 weeks and 3, 6, 9, and 12 months of age.* ***Results:*** *Percentages using supplements were 13.7 at 6 weeks, 13.4 at 3 months, 16.5 at 6 months, 13.0 at 9 months, and 12.1 at 12 months. Among those receiving supplements, mean proportions of weeks that supplements were received during the different time periods varied from 0.59 to 0.80. Number of days per week receiving supplements averaged 4.8 to 5.0. Mean fluoride dosages when supplements were received were 0.22 mg to 0.24 mg. Estimated average daily fluoride ingestion per day (among those receiving supplements during that time period and factoring in those days and weeks that supplements were not received) was 0.11 mg at 6 weeks, 0.15 mg at 3 months, 0.12 mg at 6 months, 0.11 mg at 9 months, and 0.14 mg at 12 months. Among the subset of 129 children with complete data at all time points who used supplements sometime during their first year of life, mean annual daily supplement dosage was 0.07 mg fluoride, with 75 percent having less than or equal to 0.10 mg. Those infants with mothers and fathers with more education were more likely to receive supplements.* ***Conclusions:*** *Group average use of fluoride supplements was fairly consistent over the 12 months; however, individual patterns varied substantially. Estimated actual mean daily fluoride intake when including days that supplements were not received was substantially less than the recommended 0.25 mg per day. [J Public Health Dent 1998;58(3):228-33]*

Key Words: dietary fluoride supplements, fluoride, infants, patterns of use.

Dietary fluoride supplements were developed as a primary preventive procedure for those not receiving optimally fluoridated water (1,2). They have been used widely (3-5) and have been identified as one of the major risk factors for dental fluorosis (6-8). Patient compliance has consistently been a problem (9), and a number of studies also have demonstrated that limited provider compliance with recommended protocol frequently results in inappropriate supplementation (10-15).

Largely due to the consistent identification of fluoride supplement use as a risk factor for fluorosis, in combination with difficulties in provider compliance and the dramatic decline in dental caries rates among children in the United States over the past 20 years (16), suggestions were made that the fluoride supplement dosage schedule be reduced (17). In response, the recommended dietary fluoride supplement schedule in the United States was lowered by the American Dental Association (18,19), the American Academy of Pediatrics (20), and the American Academy of Pediatric Dentistry (21).

Despite much study of dietary fluoride supplements, relatively little is known about the actual patterns of supplement use during infancy and early in childhood, when the early-erupting permanent teeth are most at risk for dental fluorosis (4,5,22-24). The purpose of this paper is to describe use of supplements during infancy in a cohort of children studied from birth to age 1 year, including patterns by infant age and parental characteristics.

Methods

As part of a larger study of fluoride exposures and ingestion related to dental fluorosis and caries (the Iowa Fluoride Study), mothers with newborns were recruited from March 1992 to August 1994 from eight Iowa hospital postpartum units prior to their discharge from the hospital. These hospitals were responsible for the large majority of all births in the areas that they served, with a combined total of about 8,000 births per year, or approximately 20 percent of all births in Iowa. Trained part-time recruiters were employed at each hospital, averaging about four hours per week of recruitment per hospital. Within the constraints of the postpartum wards' and recruiters' schedules, as many mothers as possible were invited to participate. Overall, about 50 percent of those invited to participate elected to do so, with most of the others either feeling that the responsibilities and pressures of caring for their newborn would be too great or not expecting to remain living in Iowa for at least four years. Maternal age and education were assessed among those declining to join the study.

The project was approved by the University of Iowa College of Dentistry Institutional Review Board and appropriate informed consent procedures were used. Participants received only small gifts as incentives. At recruitment, detailed information was obtained on items of interest such as family demographics, water sources, and infant feeding plans. Thereafter, pretested questionnaires were mailed to the participants' homes when the infants were 6 weeks and 3, 6, 9, and 12 months of age. Nonrespondents re-

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ceived follow-up mailings after three and six weeks and telephone calls or postcards after nine weeks.

Of the 1,072 mothers providing one or more responses for this analysis, 966 responded at approximately age 6 weeks, 942 at 3 months, 822 at 6 months, 732 at 9 months, and 616 at 12 months. For 432 participants, responses were received at all 5 time points from 6 weeks to 12 months. Mothers answered a series of questions about their infants' feeding patterns, water sources, food and beverage intake, use of dietary fluoride supplements, and use of fluoride dentifrice (24-26).

Specific to supplements, at each time point concerning the preceding six-week or three-month interval, mothers were asked to report whether their infants received supplements; if so, they reported how many weeks during this interval supplements were received, how many days per week on average, the brand, and dosage or quantity. Mothers' responses were not validated; however, they were contacted by mail or telephone when necessary to clarify responses.

Reliability of responses concerning supplementation was assessed for a sample of the infants. Mothers were contacted by telephone approximately seven to 10 days after completion of a study questionnaire and several questions were repeated, including whether supplements were received at all during the preceding time period. Supplement reliability data were collected on 42 infant time periods.

Infants' home water sources were assayed for fluoride content whenever individual well water sources, filtration, and/or bottled water were used. For those receiving water from public water systems without home filtration, monthly mean fluoride level results were obtained from the state health department.

Data were reviewed for consistency and completeness by two staff members and then were double entered and verified. Descriptive statistics were generated using SAS (27). For each period, the individual average daily dosage of supplement ingested was calculated by multiplying: (the proportion of weeks supplements were used) x (the proportion of days supplemented during those weeks) x (the dosage per day when supplements were used). Descriptive results are summarized both for the total number of respondents at each age and separately for the subset for whom data were obtained for all of the five periods. Weighted least squares (WLS), using ratio estimation for incomplete categorical data, and generalized estimating equations (GEE) (28,29) were used in the SAS statistical package to do the analyses. The WLS modeled how the prevalence of supplement use changed over the child's age and the GEE approach developed regression models to assess the relationship between the outcome variable and the covariates of interest. Both of the analyses account for data with correlated outcomes within an individual and different numbers of measured outcomes among individuals. The SAS macro of Karim and Zeger (30) was used for GEE computations and the CATMOD procedure (27) was used for the WLS computations.

In the modeling, the covariates of interest were child's age, mother's age, father's age, family income, whether it was the mother's first child, plans to breastfeed, mother's education level, and father's education level. The outcomes of interest were supplement use, proportion of weeks supplements were used, and average daily fluoride intake. All dependent variables were assessed concerning when the children were 1.5, 3, 6, 9, and 12 months of age. The modeling approach for these outcomes first looked at the crude effect of child's age and then the joint effect of the other covariates without the child's age effect. This was done due to a significant fourth degree polynomial term for child's age, which makes its effect difficult to interpret and too complex to model further. Thus, the remaining covariates were modeled jointly without the child's age effect to find the most parsimonious model. *P*-values less than .05 were considered statistically significant.

Results

Table 1 summarizes the demo-

TABLE 1
Demographic Characteristics of Respondents (*n*=1,072*)

Variable	Categories	Percent
Mother's age (years)	<20	8.2
	20–24	20.7
	25–29	30.1
	30–34	27.8
	≥35	13.2
Father's age (years)	<20	1.3
	20–24	11.8
	25–29	30.0
	30–34	32.4
	≥35	24.6
Mother's education	Up to high school	31.6
	Some college	32.6
	College graduate or more	35.9
Father's education	Up to high school	35.8
	Some college	27.8
	College graduate or more	36.4
Family income	<$20,000	25.9
	$20,00–$39,999	35.5
	≥$40,000	38.6
Race	White	95.1
	Other	4.9
First child	Yes	42.5
	No	57.5

*Among the 1,072 recruited who provided at least one response other than at baseline recruitment.

TABLE 2
Patterns of Supplement Use by Age*

Variable	Categories	Age				
		6 Weeks (*n*=132)	3 Months (*n*=126)	6 Months (*n*=136)	9 Months (*n*=95)	12 Months (*n*=74)
		Percent Distribution of Subjects				
Proportion of weeks	<0.25	22.1	8.0	15.6	17.9	11.0
	0.25–0.50	28.2	17.6	20.0	10.5	9.5
	0.51–0.75	16.0	7.2	10.3	9.5	12.4
	0.76–1.00	33.6	67.2	54.1	62.1	67.1
		Mean Proportion (SE)				
		0.59 (0.03)	0.80 (0.03)	0.69 (0.03)	0.73 (0.03)	0.78 (0.04)
		Percent Distribution of Subjects				
Number of days per week†	<1	3.0	5.6	5.2	1.0	8.2
	1–2	18.9	15.1	18.5	21.9	12.3
	3–4	19.7	22.2	20.0	24.0	23.3
	5–6	6.1	7.1	12.6	9.4	6.8
	7	52.3	50.0	43.7	43.8	49.3
		Mean Number (SE)				
		5.0 (0.20)	5.0 (0.20)	4.8 (0.20)	4.8 (0.21)	5.0 (0.27)
		Percent Distribution of Subjects				
Dosage per day when supplements received (mgF)	0.063	5.7	1.7	1.6	7.9	2.9
	0.125	12.3	14.2	16.7	15.7	12.9
	0.188	2.5	2.5	0.8	—	—
	0.250	77.0	80.0	79.4	75.3	81.4
	0.375	0.8	—	0.8	1.1	—
	0.500	0.8	—	0.8	—	—
	1.000	0.8	—	—	—	2.9
		Mean Dosage (SE)				
		0.23 (0.01)	0.24 (0.01)	0.23 (0.01)	0.22 (0.01)	0.25 (0.02)
		Percent Distribution of Subjects				
Average daily supplement dosage over whole time interval (mgF)‡	<0.01	4.1	3.4	7.9	6.7	4.3
	0.01–0.050	29.5	18.4	24.6	19.1	18.6
	0 051–0.100	24.6	16.0	15.1	31.5	18.5
	0.101–0.150	13.9	18.5	19.9	13.5	14.3
	0.151–0.200	9.9	10.9	8.7	7.9	12.9
	0.201–0.250	17.2	31.1	23.8	26.2	28.5
	0.375	0.8	—	0.8	1.1	1.4
	0.500	—	0.8	—	—	1.4
	0.833	—	0.8	—	—	—
		Mean daily dosage (SE)				
		0.11 (0.01)	0.15 (0.01)	0.12 (0.01)	0.11 (0.01)	0.14 (0.01)

*Includes only those receiving supplements during the time period.
†Only for those weeks supplements were received.
‡Factoring in the number of weeks and days that supplements were received and dosage per day when received.

graphic characteristics of the full study sample at recruitment. Most mothers were younger than 30 year of age, with fathers being slightly older. The majority of mothers and fathers had at least some college education. Ninety-five percent of the children were white and almost half were first children.

Those mothers who joined the Iowa Fluoride Study were significantly ($P<.001$) more likely to be of higher socioeconomic status than those who declined, as assessed by maternal education (57% of nonrespondents had some college vs 68% of respondents). Respondents also were significantly older than those who declined to participate (33% of nonrespondents were aged 30+ years vs 41% of respondents).

The fluoride levels of infants' home drinking water sources (including bottled and filtered) ranged from <0.05 to 7.22 ppm. Approximately 20 to 24 percent of infants at the various ages had drinking water with less than 0.3 ppm fluoride, 6 to 8 percent with 0.3–0.6 ppm, and 69 to 73 percent with greater than 0.6 ppm. Those receiving supplements were significantly more likely to have lower water fluoride levels at each age. However, consistent with results of other studies (11-15), substantial percentages receiving supplements had water fluoride levels above 0.3 ppm, suggesting inappropriate supplementation.

Test and retest agreement for mothers' responses about the presence or absence of supplementation for the 42 infant assessments was 100 percent (35 agreed on absence and 7 agreed on presence). Total percentages reporting supplement use during the preceding time interval were 13.7 percent at 6 weeks of age, 13.4 percent at 3 months, 16.5 percent at 6 months, 13.0 percent at 9 months, and 12.1 percent at 12 months. Approximately 60 to 65 percent were prescribed by pediatricians, 35 percent by family physicians, 1 percent by pediatric dentists, and 1 percent by general dentists.

Table 2 displays, for those using supplements, information on the proportions of weeks that supplements were used, days per week (when supplements were used), dosage, and average daily dose ingested by study time interval. About half of the infants receiving supplements from birth to age 6 weeks received them during more than half of the weeks (4–6 weeks) while about half received them 1 to 3 weeks. The majority of those receiving supplements from 3 to 12 months received them more than 75 percent of the weeks. Approximately half (44–53%) of those receiving supplements at each time point reportedly received them 7 days per week, while 35–47 percent received them 1 to 4 days per week. Approximately 80 percent of those receiving supplements reportedly received a dosage of 0.25 mg fluoride per day when used, 15 percent received 0.125 mg, and 2 percent received 0.375 mg to 1.0 mg.

The last section of Table 2 summarizes the overall distribution of estimated average daily fluoride supplement dosage, factoring in the weeks supplements were received, number of days per week received, and dosage per day when received. The resulting distributions are more dispersed than are the earlier elements of the table. Approximately one-fourth (18–30%) received 0.01–0.05 mg daily over the complete interval, 15–32 percent received 0.051–0.100 mg, 14–20 percent received 0.101–0.150 mg, 8–13 percent received 0.151–0.200 mg, 17–31 percent received 0.201–0.250 mg, and up to 2 percent received 0.375–0.833 mg daily. The daily effective means for successively older age groups beginning with 6-week-old infants were 0.11, 0.15, 0.12, 0.11, and 0.14 mg, respectively.

Among the 243 infants who received supplements during a total of 563 time periods, five infants with a total of seven observations had daily effective average intake per time period (averaged over both days receiving and not receiving supplements) that exceeded 0.25 mg fluoride. Four individuals exceeded 0.25 mg in one time period and one individual did so three times. On the other hand, 26 of the infants receiving supplements averaged less than 0.01 mg fluoride during one time period and one infant did during two.

Among the 432 children for whom responses were received at each of the five time periods, the proportions receiving fluoride supplements at 6 weeks and at 3, 6, 9, and 12 months were slightly higher than the corresponding proportions in the entire population at 15.7 percent, 16.9 percent, 19.2 percent, 15.0 percent, and 12.5 percent, respectively. Among these infants, the mean effective daily fluoride dosages over each specific time period when receiving supplements were 0.11 mg (SE=0.01), 0.15 mg (SE=0.01), 0.13 mg (SE=0.01), 0.11 mg (SE=0.01), and 0.14 mg (SE=0.01), respectively (results not shown). These results were quite similar to those found in the entire population (see Table 2).

Table 3 summarizes the year-long patterns of fluoride supplement use among these 432 children. Seventy percent received no supplements while 4 percent received supplements during four time periods and 4 percent received them during all five time periods. Among the 129 (30%) receiving supplements in 1 or more time periods, the total annual number of weeks with supplements ranged from 1 to 52 (mean=19.9), and the total annual number of days ranged from 1 to 365 (mean=102). The average dosage per day on days when supplements were received ranged from 0.0625 mg to 0.625 mg (mean=0.23 mg). The average daily fluoride supplement intake only during the periods receiving supplements among these 129 (including both days within the period receiving supplements and not receiving them) ranged from <0.01 mg to 0.34 mg (mean=0.12 mg). The average daily supplement intake over the whole year among supplement users varied from <0.01 mg to 0.26 mg (mean=0.07 mg).

Weighted least squares regression analyses using PROC CATMOD found a modest but statistically significant change in the proportion of infants using supplements over time. However, the trend is not easily interpretable due to the presence of higher order polynomial terms in the model. In separate analyses, both increasing maternal and paternal education, but no other SES variables, were significantly associated with increased supplement use. For example, at the lowest level of father's education, prevalence of supplement use went from 6 percent to 9 percent to 14 percent with increasing level of mother's education; at the highest level of father's education, it went from 10 percent to 15 percent to 23 percent.

Regression analyses were conducted relating proportion of weeks supplements were received to age (time period), using GEE among the total of 243 infants receiving supplements during at least one time period.

TABLE 3
Patterns of Supplement Use Among Those Who Responded for All Five Time Periods (n=432)

	Categories	% Distribution of Subjects	Mean (SE)
Number of time periods receiving supplements	0	70	0.79 (0.07)
	1	8	
	2	7	
	3	7	
	4	4	
	5	4	
Total annual weeks receiving supplements*	1–13	45	19.9 (1.40)
	14–26	26	
	27–39	18	
	40–52	12	
Total annual days receiving supplements*	1–91	57	102.4 (8.3)
	92–182	24	
	183–273	14	
	274–365	5	
Mean supplement dosage per day in mg (on days receiving supplements)*	0.01–0.10	2	0.23 (0.01)
	0.101–0.20	23	
	0.201–0.25	73	
	≥0.251	2	
Mean supplement dosage received in mg (only during periods receiving supplements)*	0.01–0.10	50	0.12 (0.01)
	0.101–0.20	32	
	0.201–0.25	16	
	≥0.251	2	
Mean annual supplement dosage received in mg (averaged for all days)*	0.01–0.10	75	0.07 (0.01)
	0.101–0.20	19	
	0.201–0.25	5	
	≥0.251	1	

*Among the 129 infants receiving supplements during one or more periods.

A statistically significant relationship was identified between the proportion of weeks receiving supplements and increasing child's age, thus showing that the proportion of weeks of supplement use changes over time. However, with higher order terms in the model, this change in proportion of supplement use over time is complex.

Similarly, a statistically significant relationship was found between estimated average daily fluoride supplement dose ingested (considering the numbers of weeks and days supplements were received and the actual dosage) and age. Again, linear through quadratic age effects were statistically significant, which made interpretation difficult. In separate analyses, none of the other SES covariates were statistically significant.

Discussion

Several limitations should be noted concerning these study results (25). Respondents are not a fully defined, random sample, despite the large size of the cohort and large numbers of respondents at each time point. Those who joined the study were more educated and older than those who declined, although both groups had relatively high levels. Direct validation of parent self-report was not done. Ages of the infants varied by a few days to a few weeks at each time point, with most children slightly older than the stated ages by time period. And although the present study is not an intervention, the parents' behaviors concerning supplement use could have been affected by their participation in the study, a form of the Hawthorne effect (31).

However, because there are no previously published reports of longitudinal patterns of supplement use during infancy other than our earlier, smaller studies (22,24), these results are important ones. The results suggest that the proportion of infants receiving dietary fluoride supplements was fairly steady overall at 13.7 percent, 13.4 percent, 16.5 percent, 13.0 percent, and 12.1 percent from 6 weeks to 12 months, respectively (15.7%, 16.9%, 19.2%, 15.0%, and 12.5% among those with all 5 responses). However, the proportions increased slightly from 6 weeks to 3 and 6 months, and then declined at 9 and 12 months. The results (Tables 2 and 3) also emphasize the substantial individual variation in actual patterns of supplement use. Most infants who received supplements got them fewer than half the weeks and fewer than 100 days during their first year of life. For most infants receiving supplements, the effective average daily fluoride ingestion from supplements (considering all days and not just those when supplements were

received) was much less than 0.25 mg, the currently recommended daily dosage for children 6 months to 3 years of age who are without fluoridated water (19). Only 25 percent of children averaged greater than 0.10 mg per day for the year. Even among the 432 children for whom responses were received at each time point, thus demonstrating high parent compliance, most supplement users received much less than 0.25 mg, with an average of 0.07 mg for the year.

The regression analyses showed complex effects of age on the use of supplements, proportion of weeks supplements were used, and actual average daily supplement dose, involving linear to fourth-order terms, with interpretation of such results being difficult. Higher maternal and paternal education were associated with increased supplement use.

Our analyses provide valuable insight into infant supplement use patterns and can provide a baseline for comparison of results of both future new studies and continued study of this birth cohort at later ages.

Individuals from families with higher socioeconomic status were more likely to receive dietary fluoride supplements and to receive them more regularly. This finding should be considered in dental public health policy discussions because these infants of higher socioeconomic status would have, on average, lower caries risk and greater risk of dental fluorosis as a result of greater exposure to other fluoride sources such as fluoride dentifrice. Additional investigation is necessary at later ages and of different study populations to help understand patterns of fluoride supplement use.

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