HHS Public Access

Author manuscript

*J Public Health Dent*. Author manuscript; available in PMC 2017 August 03.

Published in final edited form as:

*J Public Health Dent*. 2012 ; 72(2): 128–134. doi:10.1111/j.1752-7325.2011.00292.x.

# Fluoride content of solid foods impacts daily intake

**Scott J. Rankin, DDS, MS**[1], **Steven M. Levy**[2], **John J. Warren, DDS, MS**[2], **Julie Eichenberger Gilmore**[3], and **Barbara Broffitt, MS**[2]

[1]US Army, Fort Sam Houston, San Antonio, TX

[2]College of Dentistry, University of Iowa, Iowa City, IA

[3]Institute for Clinical & Translational Science, University of Iowa, Iowa City, IA

## Abstract

**Objective—**To determine the amount of fluoride received from solid foods for a cohort of children.

**Methods—**Parents were asked to complete questionnaires for the preceding week and dietary diaries for 3 days for their children. Data collected at 6, 9, 12, 16, 20, 24, 36, 48, and 60 months were analyzed cross-sectionally.

**Results—**At 6 months of age, children ingested an estimated mean of 8 percent of dietary fluoride from solid foods. At 12 months of age, children ingested an estimated 39 percent of dietary fluoride from solid foods. Although the percentage of fluoride intake from solid foods stabilized from 24 to 60 months (means of 36–39 percent), some children received as much as 85–88 percent of their dietary fluoride from solid foods.

**Conclusions—**Some children receive a substantial portion of dietary fluoride from solid foods.

### Keywords

fluoride content; solid foods; daily intake

Despite the advances in oral health care, dental caries remains one of the most common chronic diseases (1). Fluoride has been established as one of the most important preventive tools against dental caries. Public water fluoridation and the availability of fluoridated water have been associated with a great decline in the prevalence of dental decay for many populations and have been credited with being one of the greatest disease prevention methods of all time (2). The US Centers for Disease Control and Prevention has listed water fluoridation as one of the 10 great public health achievements of the 20th century (3).

Current evidence suggests that fluoride prevents caries primarily through its presence in the oral cavity and that its primary mechanism of action occurs posteruptively (1). Fluoride helps to prevent demineralization and to promote remineralization of early carious lesions.

**Correspondence**, Dr. Scott J. Rankin, US Army, 2050 Worth RD, MCDS, Fort Sam Houston, TX 78249. Tel.: 210-221-7839; Fax: 210-221-8810; scott.rankin@us.army.mil.
Steven M. Levy, John J. Warren, Barbara Broffitt are with the College of Dentistry, University of Iowa. Julie Eichenberger Gilmore is with the Institute for Clinical & Translational Science, University of Iowa.

Due to fluoride's posteruptive effects, exposure to low levels of fluoride provides dental benefits to people of all ages.

Exposure to high levels of fluoride can lead to the development of dental fluorosis. Dental fluorosis is the result of excessive systemic intake of fluoride during enamel formation. Due to the fact that fluorosis can only occur during enamel formation, it is important to better understand the fluoride intake of young children (1). Excessive intake of fluoride can come from dietary sources (water, foods, and other beverages) and non-dietary sources, such as ingested toothpaste. There is evidence that the prevalence of dental fluorosis has increased (4).

Early researchers empirically determined and described an "optimal" fluoride intake of 0.05–0.07 mg of fluoride per kilogram of body weight (F/kg bw) (5–7). McClure estimated that children who ingested water optimally fluoridated at 1.0 ppm, in addition to other dietary sources, received about 0.05 mg F/kg bw, which later became the basis for the so-called "optimal" fluoride intake. It is unclear exactly how the upper limit of that range came into existence. This range has since been designated or stated as the optimal level for fluoride intake by many researchers, although there has been no scientific validation of this range for being considered "optimal." There has never been a clear definition as to what the range is optimal for; is it for caries prevention or is it for the prevention of fluorosis?

This "optimal" range was estimated before the widespread use of topical fluorides and other fluoride exposures, and prior to the generalized, widespread distribution of beverages. Historically, tap water has been the primary source of fluoride for most children. However, with improved access to a wide variety of other beverages, water may no longer be the primary beverage consumed. Contemporary US dietary intakes suggest there has been an increase in the consumption of prepackaged foods and beverages, and children are now exposed to a wide variety of fluoride containing foods, beverages, and supplements (8,9).It is important to look at many of these different sources of fluoride intake in light of the increasing prevalence of dental fluorosis and greater emphasis on esthetic perceptions currently being seen in the United States and other developed nations (4).

In 1997, the Institute of Medicine (IOM) released its upper limit recommendations for dietary intake of fluoride (10). The upper limit is defined as the level below which there is unlikely to be any adverse health effects in healthy people. The IOM recommended these upper limits to be: 0.7 mg/day for children from birth to 6 months of age, 0.9 mg/day for 7 to 12 months of age, 1.3 mg/day for 1 to 3 years of age, and 2.2 mg/day for 4 to 8 years of age. These upper limits based on 0.1 mg F/kg body weight and average weights for children of those ages are meant to avoid the adverse cosmetic effect of moderate enamel fluorosis. The IOM also released adequate intakes (AIs) for fluoride ingestion (10). AIs are used as guides for nutrient intakes for individuals and are generally regarded as compatible with health. The IOM AIs for fluoride are: 0.01 mg F/day from birth to 6 months, 0.5 mg F/day for 7 to 12 months, 0.7 mg F/day for 1 to 3 years of age, and 1 mg F/day for children 4 to 8 years of age.

Few studies have looked at the amount of fluoride consumed by children from solid foods. Most of the previous dietary fluoride studies looked primarily or exclusively at the estimated fluoride intake from beverages, with or without foods, commonly consumed by children. These studies generally did not examine the *actual* foods being consumed by a group of children, but instead used a "market basket" approach or linked fluoride level assay results to dietary surveys (5–7). More recent studies estimated the amount of fluoride consumed from foods by children, but they were done in countries that have different diets, climates, and standards of living than our own, thus precluding generalizability to US children (4,11–13). A few studies have looked at the dietary fluoride intake of samples of populations more similar to the United States, but only included a small number of children and the data were only collected at one point in time (14,15).

The purposes of this paper are to describe fluoride intake from birth to 60 months of age from dietary sources using data collected from diet diaries and to assess relationships of demographic characteristics with patterns of fluoride intake. These dietary sources consist of only solid and liquid food items, and not fluoride supplements or therapies. An emphasis has been placed on the fluoride intake from solid foods, as previous studies, including our own, have focused more on fluoride intake from beverages (8,16,17).

## Methods

This was a secondary data analysis conducted on data collected as part of the Iowa Fluoride Study (IFS). The overall goal of the IFS has been to investigate the dietary (foods, beverages, and supplements) and non-dietary (dentifrices, dental rinses, and gels) fluoride exposures and intake and their relationships with dental fluorosis and caries in both the primary and permanent dentitions. The IFS is a prospective, longitudinal investigation concerning a cohort recruited at birth from eight Iowa hospitals from March 1992 to February 1995, and has been discussed in more detail previously (8,16,17). Institutional review board approval and parental consents were obtained. At recruitment, the following initial baseline data were collected from the mothers while they were still in the hospital with their newborns: their age, educational level, family income, number of children in the household, water sources, and infant feeding plans. A composite socioeconomic status (SES) was estimated for each child as follows: a) low SES was defined as family income ≤$30,000 and mother not having a 4-year college degree; b) high SES was defined as family income ≥ $50,000 and/or mother having graduate or professional schooling; and c) middle SES was defined as everything else. Food frequency questionnaires and 3-day food and beverage diaries were sent to the mothers when the children were aged 6 weeks and at ages 3, 6, 9, 12, 16, 20, 24, 28, 32, 36,40, 44, 48, 54, 60, 66, and 72 months (8,9).

Parents were asked to complete 3-day food and beverage diaries. They were to record all foods and beverages that the child consumed during a 72-hour period, including one weekend day and two weekdays. For each day that dietary data were recorded, the parents were asked to list the day, date, if the child was in day care, and if the child was ill that day or not. The parents were instructed to list the time of day the foods and/or beverages were consumed, the location where the foods or beverages were consumed (i.e., at home, day care, or out), type of food or beverage, brand name, and other details, such as the size of the

container, method of preparation, and the amount the child ate and drank. If water was consumed as a beverage or used during food preparation, the parents were requested to indicate the water source (i.e., tap, bottled, etc.). For mixed dishes such as casseroles, sandwiches, etc., the parent was requested to list the individual ingredients and their amounts. If the child went to day care, then the parents were requested to ask the day care provider to record everything that the child ate and drank while at the day care. A summary was included to instruct parents and providers on how to record portion sizes. A contact number was included in case the parents had any further questions (18).

Individual water sources and those using filtration were analyzed for fluoride concentration annually and when water sources changed. Nonfiltered public water sources' fluoride concentrations were obtained from the Iowa state health department on a monthly basis. Ready-to-drink beverages and ready-to-eat foods were purchased and assigned fluoride levels based on extensive analyses by category conducted as part of the IFS. The IFS research team has analyzed thousands of food and beverage items for fluoride content (19–22). Parents also provided children's body weights, allowing the IFS team to calculate fluoride intake per unit body weight for each time period (9).

The 3-day food and beverage diaries provided the ability to capture specific details regarding the fluoride exposures of the children. The diaries included the brand name of the product consumed, the flavor of the product, whether it was diet or regular (if applicable), container size, etc. The 3-day food and beverage diaries were product-specific, allowing the IFS team to assign specific fluoride values to each food and beverage listed in the diaries (18).

## Statistical methods

Basic descriptive statistics are reported at each of the analyzed time points. Dietary fluoride intakes were not normally distributed. Distributions of dietary fluoride intake were described in percentiles.

Data were analyzed using SAS (Version 9.1.3 Service Pack 4, 2008, SAS Institute Inc., Cary, NC, USA).

## Results

Demographics of the entire recruited population are summarized in Table 1. Parents overall were relatively well educated and of higher SES. The study sample was predominantly white, similar to the population of Iowa.

The sample sizes at each analyzed time point are reflective of the children for whom 3-day food and beverage diaries were completed at each analyzed time point. Sample sizes ranged from 376 to 670. Response rates were higher at younger ages and trended lower with ongoing attrition as the age of study participants increased. Table 2 shows the estimated daily total fluoride intakes (in milligrams) from food and beverage sources by age as analyzed from the 3-day food and beverage diaries. The distributions were positively skewed, with the means being consistently higher than the medians. The largest absolute and proportional differences between the means and medians were found at 6 and 9 months of

age. Maximum intakes tended to be four to five times as great as the means. When evaluating estimated dietary fluoride intakes as reported in the diaries, about 25 percent of children at 6 months of age ingested amounts greater than the tolerable upper intake limit (UL) of 0.7 mg/day. Again, using dietary fluoride intakes as reported from the diaries at 12 months of age, about 5 percent of the children ingested amounts greater than the tolerable UL of 0.9 mg/day. At 24 and 36 months of age, using intakes reported from the diaries, less than 5 percent of children ingested amounts of fluoride greater than the tolerable UL of 1.3 mg/day. At 48 and 60 months of age, using intakes reported from the diaries, less than 1 percent of the children ingested amounts of fluoride greater than the tolerable UL of 2.2 mg/day.

Tables 3 and 4 present the estimated fluoride intakes from all beverages and all solid foods (excluding beverages), respectively, as analyzed from the diaries. Again, the distributions are skewed, with means being consistently higher than the medians. This is more pronounced in the total fluoride from beverage data than the total fluoride from solid foods data, as well as the 6- and 9-month intakes. For example, at 6 months of age, children in the 90th percentile and above received more than 2.3 times the amount of fluoride from beverages as the mean. At 9 months of age, children in the 90th percentile and above received more than 2.2 times the amount of fluoride from beverages as the mean. At 6 months of age, children in the 90th percentile and above received more than 2.6 times the amount of fluoride from solid foods as the mean.

Table 5 illustrates the distribution of estimated percentages of daily total dietary fluoride intake from solid foods as recorded in the 3-day food and beverage diaries. Means were consistently higher than the medians. Mean solid intakes were about 40 percent of total dietary intakes for ages 12–60 months. About 25 percent at each age from 12 to 60 months received ~50 percent+ of intake from solids, and ~10 percent received 60–70 percent+ from solids from 12 to 60 months.

When estimating daily fluoride from specific solid food categories, at 6 months of age, baby foods provided the highest levels of daily fluoride intake with a mean value of 0.01 mg F/day. At 12 and 24 months of age, grains, cereals, and starches (with or without water) provided the highest levels of fluoride intake (mean values of 0.05 mg F/day and 0.07 mg F/day, respectively). Grains, cereals, and starches (with or without water) provided the highest levels of fluoride intake from solid foods for 36 months (mean value of 0.08 mg F/day), 48 months (mean value of 0.08 mg F/day), and 60 months (mean value of 0.09 mg F/day) of age as well.

When estimating daily fluoride intake from specific beverage categories, at 6 and 12 months of age, powdered concentrate infant formula prepared with water provided the highest levels of daily fluoride intake (mean values of 0.34 mg F/day and 0.09 mg F/day, respectively). At 24 and 36 months of age, water by itself provided the highest levels of daily fluoride intake (mean values of 0.09 mg F/day and 0.10 mg F/day, respectively). At 48 and 60 months of age, water by itself provided the highest levels of daily fluoride intake from specific beverages as well (0.11 mg F/day and 0.12 mg F/day, respectively).

## Discussion

When considering the results from this study, one can see that some children received substantial amounts of fluoride from dietary sources alone, not taking into consideration the amount of fluoride that is ingested from non-dietary sources (supplements, dentifrices, etc.), which has also been shown to be substantial. This high level of fluoride ingestion from dietary sources alone places these children at increased risk for developing dental fluorosis.

At 12 months of age, we found that children ingested an estimated mean of 0.35 mg of fluoride from beverages and solid foods per day. Chowdhury *et al.* used the duplicate plate technique, as well as estimations of the amount of breast milk consumed, during a 3-day period to estimate that children 11 to 13 months of age residing in a fluoridated area of New Zealand ingested a mean amount of 0.26 mg of F/day. Chowdhury *et al.* found that there was a high degree of breast-feeding for the infants. This could account for the lower levels of fluoride when compared to the results of this study, since human milk is very low in fluoride (23).

Very few of the children were exclusively breast-fed (i.e., did not receive other beverages or food except water). At 6, 9, and 12 months of age, only 1.4 percent, 0.1 percent, and 0.1 percent of the sample, respectively, were exclusively breastfed. A larger percentage of children received at least some breast milk at 6, 9, and 12 months of age (27.1 percent, 18.4 percent, and 11.8 percent, respectively). Fluoride intake during infancy probably would be lower for other samples with much higher breast-feeding rates.

At 24 months of age, we found that children ingested an estimated daily mean of 0.48 mg of fluoride from beverages and solid foods, as calculated from diet diaries. de Almeida *et al.* used the duplicate plate technique, on two separate days over a 1-week period in two seasons (winter and summer). They found that 33 Brazilian children, living in fluoridated areas (mean of 0.76 ppm water fluoride level), with a mean age of 27 months, ingested a mean of 0.31 mg of fluoride per day from dietary sources, with most of the children's fluoride intake from water and milk (mainly powdered milk reconstituted with fluoridated water). The differences between our results and these are most likely attributed to different assessment techniques and other sources of fluoride, such as beverages containing fluoride, that were consumed by the children in this study. This would explain the relatively large discrepancy in the means between the two studies (24).

Rojas-Sanchez *et al.* found that children with a mean age of 28 months residing in optimally fluoridated Indianapolis ingested a mean daily amount of 0.54 mg of fluoride from foods and beverages, as collected by the duplicate plate technique on 2 or 3 separate days over a 1-week period (25). For children residing in fluoridated areas, this study found mean daily amounts of 0.52 and 0.54 mg of fluoride ingested from solid foods and beverages at 24 and 36 months of age, respectively, which corresponds very well with the findings of Rojas-Sanchez *et al.* despite the differences in assessment techniques.

Martínez-Mier *et al.* found, through collection of duplicate plates on two weekdays and one weekend day, that 21 children with a mean age of 30 months residing in Mexico City (which does not have water fluoridation, but does have an optimal level of salt fluoridation) ingested

a mean daily amount of 0.52 mg of fluoride from diet only (4). Again, this amount is in close approximation to the mean daily amounts of fluoride found in this study for children residing in fluoridated areas at 24 and 36 months, 0.48 mg and 0.52 mg, respectively.

This study has several limitations. The initial study sample, while recruited from eight different hospitals, was a convenience sample and not truly representative of a defined population. This cohort is a more general representation of healthy children born in those hospitals from mothers who were planning on living in the area for at least 4 years, in order to be able to track dental outcomes. Based on the previously defined SES categorization, the initial sample at recruitment was mostly middle/high SES (76 percent), and the children who stayed in the study long term were with even higher SES, with approximately 80 percent being in the middle or high SES categories. The study sample was predominantly white (97 percent). The feeding habits of children in Iowa, as well the years of data collection also present possible differences from other study populations and time periods. These sample characteristics limit the generalizability of the results.

Another limitation that needs to be mentioned is that data were collected through self-report. It was not possible to validate data on the food and beverage diaries. Since data were only analyzed up to 60 months of age, it is important not to generalize the results beyond this age. Sample sizes varied at the different time points due to attrition and period-specific nonresponse.

This study provided a more detailed look at dietary fluoride intake, in particular fluoride intake from solid foods, when compared to previous studies. Previous studies mostly have reported on solid foods as one general category and were not able to achieve the level of detail found in this study. The nature of data collection and analysis allowed this study to report on specific solid foods that made significant contributions to total dietary fluoride intake.

## Conclusion

This study showed that there was substantial variation in dietary fluoride intake across subjects and across ages. Very few subjects ingested levels of dietary fluoride greater than the tolerable upper limit, which might place them at elevated risk of developing dental fluorosis. A small percentage of subjects had very low levels of dietary fluoride intake. A majority of dietary fluoride intake came from beverages. A smaller percentage of subjects received substantial amounts of fluoride from solid foods, showing that solid foods can be important contributors to dietary fluoride intake, and possibly the risk of developing fluorosis, for some subjects.

Further research is needed in this area to confirm these findings. It would also be beneficial to see if these findings hold true with study populations and age groups different than in these analyses.

## References


1. Burt, BA., Eklund, SA. Dentistry, dental practice, and the community. 6. MO: Elsevier Saunders; 2005.
2. Horowitz HS. The effectiveness of community water fluoridation in the United States. J Public Health Dent. 1996; 56(5 Spec No):253–8. [PubMed: 9034970]
3. Centers for Disease Control and Prevention. Recommendations for using fluoride to prevent and control dental caries in the United States. Morb Mortal Wkly Rep. 2001; 50:1–42.
4. Martinez-Mier EA, Soto-Rojas AE, Urena-Cirett JL, Stookey GK, Dunipace AJ. Fluoride intake from foods, beverages and dentifrice by children in Mexico. Community Dent Oral Epidemiol. 2003; 31(3):221–30. [PubMed: 12752549]
5. McClure FJ. Ingestion of fluoride and dental caries – quantitative relations based on food and water requirements of children one to twelve years old. Am J Dis Child. 1943; 66(4):362–9.
6. Singer L, Ophaug R. Total fluoride intake of infants. Pediatrics. 1979; 63(3):460–6. [PubMed: 582065]
7. Ophaug RH, Singer L, Harland BF. Dietary fluoride intake of 6-month and 2-year-old children in four dietary regions of the United States. Am J Clin Nutr. 1985; 42(4):701–7. [PubMed: 4050730]
8. Levy SM, Warren JJ, Davis CS, Kirchner L, Kanellis MJ, Wefel JS. Patterns of fluoride intake from birth to 36 months. J Public Health Dent. 2001; 61(2):70–7. [PubMed: 11474917]
9. Levy SM, Warren JJ, Broffitt B. Patterns of fluoride intake from 36 to 72 months of age. J Public Health Dent. 2003; 63(4):211–20. [PubMed: 14682644]
10. Institute of Medicine, Food, and Nutrition Board. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride. Washington, DC: National Academy Press; 1997.
11. Schamschula RG, Un PSH, Sugár E, Duppenthaler JL, Tóth K, Barmes DE. Daily fluoride intake from the diet of Hungarian children in fluoride deficient and naturally fluoridated areas. Acta Physiol Hung. 1988; 72(2):229–35. [PubMed: 3227863]
12. Zohouri FV, Rugg-Gunn AJ. Sources of dietary fluoride intake in 4-year-old children residing in low, medium and high fluoride areas in Iran. Int J Food Sci Nutr. 2000; 51(5):317–26. [PubMed: 11103297]
13. Franco AM, Martignon S, Saldarriaga A, Gonzalez MC, Arbelaez MI, Ocampo A, Luna LM, Martinez-Mier EA, Villa AE. Total fluoride intake in children aged 22–35 months in four Colombian cities. Community Dent Oral Epidemiol. 2005; 33(1):1–8. [PubMed: 15642041]
14. Guha-Chowdhury N, Drummond BK, Smillie AC. Total fluoride intake in children aged 3 to 4 years – a longitudinal study. J Dent Res. 1996; 75(7):1451–7. [PubMed: 8876596]
15. Zohouri FV, Maguire A, Moynihan PJ. Sources of dietary fluoride intake in 6–7-year-old English children receiving optimally, sub-optimally, and non-fluoridated water. J Public Health Dent. 2006; 66(4):227–34. [PubMed: 17225816]
16. Levy SM, Kiritsy MC, Slager SL, Warren JJ. Patterns of dietary fluoride supplement use during infancy. J Public Health Dent. 1998; 58(3):228–33. [PubMed: 10101699]
17. Warren JJ, Levy SM, Kanellis MJ. Prevalence of dental fluorosis in the primary dentition. J Public Health Dent. 2001; 61(2):87–91. [PubMed: 11474919]
18. Rankin SJ, Levy SM, Warren JJ, Gilmore JE, Broffitt B. Relative validity of an FFQ for assessing dietary fluoride intake of infants and young children living in Iowa. Public Health Nutr. 2011; 14(7):1229–36. [PubMed: 21450138]
19. Van Winkle S, Levy SM, Kiritsy MC, Heilman JR, Wefel JS, Marshall T. Water and formula fluoride concentrations: significance for infants fed formula. Pediatr Dent. 1995; 17(4):305–10. [PubMed: 7567636]
20. Kiritsy MC, Levy SM, Warren JJ, Guha-Chowdhury N, Heilman JR, Marshall TM. Assessing fluoride concentrations of juices and juice-flavored drinks. J. Am Dent Assoc. 1996; 127(7):895–902. [PubMed: 8754464]
21. Heilman JR, Kiritsy MC, Levy SM, Wefel JS. Fluoride concentrations of infant foods. J Am Dent Assoc. 1997; 128(7):857–63. [PubMed: 9231600]

22. Heilman JR, Kiritsy MC, Levy SM, Wefel JS. Assessing fluoride levels of carbonated soft drinks. J Am Dent Assoc. 1999; 130(11):1593–9. [PubMed: 10573939]

23. Chowdhury NG, Brown RH, Shepherd MG. Fluoride intake of infants in New Zealand. J Dent Res. 1990; 69(12):1828–33. [PubMed: 2250088]

24. de Almeida BS, da Silva Cardoso VE, Buzalaf MAR. Fluoride ingestion from toothpaste and diet in 1- to 3-year-old Brazilian children. Community Dent Oral Epidemiol. 2007; 35(1):53–63. [PubMed: 17244138]

25. Rojas-Sanchez F, Kelly SA, Drake KM, Eckert GJ, Stookey GK, Dunipace AJ. Fluoride intake from foods, beverages and dentifrice by young children in communities with negligibly and optimally fluoridated water: a pilot study. Community Dent Oral Epidemiol. 1999; 27(4):288–97. [PubMed: 10403089]

**Table 1**

Demographics of the Entire Recruited Population ($n$ = 1,882)

| Variable | Category | Percentage |
|---|---|---|
| Sex | Male | 48.5 |
| | Female | 51.5 |
| Race | White | 97.2 |
| | Other | 2.8 |
| Mother's age | ≤20 years old | 10.6 |
| | 21–25 years old | 22.1 |
| | 26–30 years old | 32.6 |
| | 31–35 years old | 24.6 |
| | >35 years old | 10.1 |
| Income | ≤$19,999 | 23.8 |
| | $20,000-$39,999 | 35.6 |
| | $40,000-$59,999 | 26.4 |
| | >$60,000 | 14.2 |
| Mother's education | High school or less | 21.9 |
| | Some college | 33.9 |
| | College graduate or more | 44.1 |
| Father's education | High school or less | 26.7 |
| | Some college | 27.0 |
| | College graduate or more | 39.0 |
| Socioeconomic status (SES)* | Low | 20.5 |
| | Middle | 40.1 |
| | High | 35.9 |
| | Not listed | 3.5 |

*SES was defined from recruitment questionnaires from 1992 to 1995. Low SES was defined as family income ≤$30,000 and mother did not have a 4-year college degree. High SES was defined as family income ≥$50,000 and/or mother had graduate or professional schooling. Middle SES was defined as everything else.

**Table 2**

Estimated Daily Total Fluoride Intake (in Milligrams) from All Dietary Sources *

| Age at diary mailing (in months) | *n* | Mean | SD | Min | 1st %ile | 5th %ile | 10th %ile | 25th %ile | Median | 75th %ile | 90th %ile | 95th %ile | 99th %ile | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 670 | 0.479 | 0.430 | 0.005 | 0.009 | 0.017 | 0.037 | 0.121 | 0.330 | 0.793 | 1.107 | 1.257 | 1.700 | 2.076 |
| 9 | 658 | 0.518 | 0.399 | 0.011 | 0.036 | 0.062 | 0.096 | 0.178 | 0.407 | 0.812 | 1.077 | 1.268 | 1.651 | 1.900 |
| 12 | 602 | 0.349 | 0.292 | 0.022 | 0.041 | 0.074 | 0.105 | 0.160 | 0.251 | 0.449 | 0.756 | 0.904 | 1.465 | 1.880 |
| 16 | 571 | 0.369 | 0.231 | 0.047 | 0.074 | 0.112 | 0.142 | 0.210 | 0.326 | 0.462 | 0.637 | 0.797 | 1.143 | 2.103 |
| 20 | 523 | 0.442 | 0.248 | 0.043 | 0.080 | 0.146 | 0.180 | 0.277 | 0.392 | 0.556 | 0.742 | 0.900 | 1.289 | 1.972 |
| 24 | 492 | 0.483 | 0.278 | 0.032 | 0.117 | 0.182 | 0.217 | 0.301 | 0.418 | 0.592 | 0.809 | 1.021 | 1.554 | 1.986 |
| 36 | 413 | 0.520 | 0.294 | 0.059 | 0.123 | 0.202 | 0.242 | 0.329 | 0.452 | 0.620 | 0.873 | 1.118 | 1.552 | 2.152 |
| 48 | 378 | 0.530 | 0.310 | 0.117 | 0.141 | 0.195 | 0.232 | 0.333 | 0.470 | 0.643 | 0.868 | 1.087 | 1.601 | 2.774 |
| 60 | 376 | 0.551 | 0.313 | 0.118 | 0.152 | 0.215 | 0.247 | 0.337 | 0.490 | 0.683 | 0.919 | 1.136 | 1.859 | 2.451 |

* This includes both solid foods and beverages.

**Table 3**

Estimated Daily Total Fluoride Intake (in Milligrams) from All Beverages

| Age at diary mailing (in months) | *n* | Mean | SD | Min | 1st %ile | 5th %ile | 10th %ile | 25th %ile | Median | 75th %ile | 90th %ile | 95th %ile | 99th %ile | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 670 | 0.464 | 0.430 | 0.005 | 0.008 | 0.012 | 0.028 | 0.104 | 0.309 | 0.776 | 1.094 | 1.247 | 1.693 | 2.076 |
| 9 | 658 | 0.466 | 0.399 | 0.003 | 0.008 | 0.022 | 0.047 | 0.121 | 0.351 | 0.751 | 1.031 | 1.234 | 1.623 | 1.830 |
| 12 | 602 | 0.252 | 0.280 | 0.006 | 0.001 | 0.017 | 0.031 | 0.070 | 0.152 | 0.330 | 0.655 | 0.816 | 1.429 | 1.656 |
| 16 | 571 | 0.242 | 0.208 | 0.003 | 0.001 | 0.028 | 0.048 | 0.103 | 0.196 | 0.319 | 0.485 | 0.598 | 0.994 | 1.912 |
| 20 | 523 | 0.299 | 0.228 | 0.005 | 0.017 | 0.048 | 0.072 | 0.149 | 0.250 | 0.379 | 0.568 | 0.695 | 1.079 | 1.813 |
| 24 | 492 | 0.333 | 0.256 | 0.012 | 0.021 | 0.060 | 0.094 | 0.170 | 0.272 | 0.434 | 0.632 | 0.779 | 1.382 | 1.778 |
| 36 | 413 | 0.358 | 0.268 | 0.006 | 0.017 | 0.071 | 0.104 | 0.177 | 0.298 | 0.447 | 0.688 | 0.917 | 1.220 | 2.017 |
| 48 | 378 | 0.358 | 0.284 | 0.010 | 0.018 | 0.076 | 0.103 | 0.179 | 0.294 | 0.468 | 0.674 | 0.855 | 1.365 | 2.627 |
| 60 | 376 | 0.368 | 0.289 | 0.002 | 0.027 | 0.075 | 0.099 | 0.171 | 0.298 | 0.478 | 0.692 | 0.828 | 1.679 | 2.252 |

**Table 4**

Estimated Daily Total Fluoride Intake (in Milligrams) from All Solid Foods Excluding Beverages

| Age at diary mailing (in months) | *n* | Mean | SD | Min | 1st %ile | 5th %ile | 10th %ile | 25th %ile | Median | 75th %ile | 90th %ile | 95th %ile | 99th %ile | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 670 | 0.015 | 0.023 | 0 | 0 | 0 | 0 | 0.002 | 0.007 | 0.016 | 0.039 | 0.054 | 0.115 | 0.222 |
| 9 | 658 | 0.052 | 0.054 | 0 | 0 | 0.009 | 0.011 | 0.021 | 0.037 | 0.066 | 0.105 | 0.139 | 0.241 | 0.785 |
| 12 | 602 | 0.097 | 0.071 | 0 | 0.012 | 0.025 | 0.034 | 0.053 | 0.082 | 0.123 | 0.172 | 0.223 | 0.366 | 0.740 |
| 16 | 571 | 0.128 | 0.068 | 0 | 0.031 | 0.050 | 0.061 | 0.080 | 0.114 | 0.157 | 0.211 | 0.245 | 0.399 | 0.532 |
| 20 | 523 | 0.143 | 0.076 | 0 | 0.037 | 0.055 | 0.066 | 0.095 | 0.129 | 0.174 | 0.236 | 0.272 | 0.411 | 0.690 |
| 24 | 492 | 0.150 | 0.076 | 0 | 0.042 | 0.064 | 0.078 | 0.102 | 0.135 | 0.180 | 0.245 | 0.286 | 0.472 | 0.636 |
| 36 | 413 | 0.162 | 0.080 | 0 | 0.048 | 0.075 | 0.089 | 0.111 | 0.148 | 0.196 | 0.246 | 0.291 | 0.452 | 0.765 |
| 48 | 378 | 0.172 | 0.088 | 0.038 | 0.062 | 0.089 | 0.100 | 0.122 | 0.158 | 0.202 | 0.258 | 0.291 | 0.480 | 1.001 |
| 60 | 376 | 0.183 | 0.091 | 0.049 | 0.067 | 0.086 | 0.101 | 0.128 | 0.167 | 0.210 | 0.289 | 0.316 | 0.506 | 0.949 |

**Table 5**

Distribution of Estimated Percentages of Daily Total Dietary Fluoride Intake from Solid Foods

| Age at diary mailing (in months) | *n* | Mean | SD | Min | 1st %ile | 5th %ile | 10th %ile | 25th %ile | Median | 75th %ile | 90th %ile | 95th %ile | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 670 | 7.66 | 12.57 | 0 | 0 | 0 | 0.11 | 0.68 | 2.60 | 8.57 | 22.59 | 34.35 | 66.76 |
| 9 | 658 | 19.06 | 20.99 | 0 | 0.10 | 1.14 | 1.93 | 4.45 | 10.44 | 26.18 | 51.24 | 69.58 | 91.61 |
| 12 | 602 | 38.54 | 23.36 | 0 | 2.08 | 6.49 | 10.43 | 19.29 | 35.43 | 54.23 | 72.72 | 82.36 | 92.73 |
| 16 | 571 | 41.41 | 20.06 | 0 | 6.48 | 12.78 | 17.55 | 25.29 | 39.31 | 55.25 | 69.85 | 80.57 | 93.08 |
| 20 | 523 | 37.63 | 17.88 | 0 | 6.67 | 13.60 | 16.86 | 24.45 | 34.40 | 49.35 | 64.20 | 72.40 | 81.86 |
| 24 | 492 | 36.37 | 17.78 | 0 | 6.45 | 12.75 | 15.66 | 23.03 | 33.64 | 47.92 | 61.85 | 68.06 | 86.68 |
| 36 | 413 | 36.42 | 17.44 | 0 | 8.68 | 13.05 | 17.19 | 23.42 | 33.42 | 45.31 | 60.36 | 69.87 | 84.85 |
| 48 | 378 | 37.86 | 17.02 | 5.10 | 10.67 | 14.73 | 18.13 | 25.16 | 34.52 | 48.26 | 60.21 | 69.61 | 87.69 |
| 60 | 376 | 38.64 | 17.36 | 7.65 | 9.03 | 13.59 | 18.56 | 25.78 | 35.58 | 49.37 | 63.31 | 72.16 | 85.56 |