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Availability of fluoride from meals given to kindergarten children in Brazil

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Abstract – *Objectives:* The aim of this study was to evaluate the amount of fluoride supplied daily in the meals given in 44 public kindergarten schools in Bauru, Brazil. In addition, the fluoride concentration of water supplies and its impact on the amount of fluoride found in the meal samples were also investigated. *Methods:* Meal samples and water were collected during 2 weeks (10 working days) in public kindergarten schools. Samples of meals were homogenized with known volumes of deionized water. Fluoride present in meal samples was analyzed with the ion-specific electrode (Orion 9609), after hexamethyldisilazane-facilitated diffusion. Fluoride in water samples was analyzed with the same electrode, after buffering with TISAB II. All the analyses were made in duplicate. *Results:* Fluoride analyzed (mean ± SD) was 0.50 ± 0.20 μg/ml, ranging from nondetectable to 1.42 μg/ml for water samples ($n = 424$) and 0.067 ± 0.059 mg, ranging from 0.007 to 0.580 mg for meal samples ($n = 431$). A weak but significant correlation was observed between the amount of fluoride in meals and fluoride concentration in water supplies ($r = 0.139$, $P = 0.0042$). *Conclusions:* Despite the seemingly small role played by school meals in the total daily fluoride intake, they can contribute to the total fluoride intake of children on a chronic basis, when in association with other fluoride products. Additionally, the impact of fluoridated public water supply on the final fluoride concentration of the school meals analyzed may be regarded as low.

Key words: dental fluorosis; diet; fluoride; meals; public water supply; water fluoridation

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The prevalence and severity of dental fluorosis have increased in the last decade in many countries, including Brazil (1–3). This has been attributed to the widespread use of fluoride from many sources (4, 5). Currently, the main sources of fluoride intake for children who are 1 year old or older are fluoridated water, food and beverages and fluoride toothpaste (6–8).

While it is of interest to know the fluoride concentrations in fresh foods, it is more important from the point of view of fluoride intake to know the concentrations of prepared foods. If the preparation involves placing the food in water, the process may increase or decrease the food fluoride content depending on the fluoride concentration in the water (9).

Dental fluorosis is a long-term effect of excessive exposure to fluoride during tooth development (3). Thus, the limit dose of daily fluoride intake by children at the age of risk for dental fluorosis is an important factor to focus on. The 'optimal' dose of fluoride intake to avoid esthetically compromising dental fluorosis was not experimentally determined. However, an upper dose limit of 0.05–0.07 mg F/kg body weight/day is usually regarded as optimum (6). Thus, all sources that may contribute to the total intake of fluoride in infancy and early childhood should be taken into account.

Considering the need for investigating the several sources of fluoride intake, the aim of this study was to assess the total amount of fluoride provided in school meals given to children attending all (44) public kindergarten schools in the city of Bauru, SP, Brazil. In addition, the fluoride concentration of the public water supply and its impact on the amount of fluoride found in the meals were also evaluated. Finally, based on recent data concerning dose–response, the possible necessity of reducing the fluoride intake, considering the risks and benefits of fluoride for public health, will be discussed.

Material and methods

Sampling

The samples of school meals and the public water supply were collected by the cooks at the 44 public kindergarten schools in the city of Bauru, state of São Paulo, Brazil, during two consecutive weeks (10 working days), in September 2001. This period allowed for provided collection of samples of the school meals' entire menu, as it varies on a daily basis during 2 weeks and then in the third week the first week's menu is repeated.

Verbal and written instructions were given to the cooks of the schools for collection of duplicate amounts of all food and beverages (school meal sample) offered to the children in the period during which they were at school. Emphasis was placed on the importance of keeping their usual dietary patterns and duplicating the diet offered to one child as accurately as possible. Parts of the food not normally eaten, such as seeds, cores, skin and bones were removed. All duplicate samples were collected in separate plastic containers previously labeled with the dates of collection and then saved for fluoride analysis. All food and beverages collected during the period the children were at school were taken to the laboratory and homogenized in a blender with a known volume of deionized water as one sample. The volume of each processed sample school meal was recorded in a graduated beaker and an aliquot was immediately frozen (−20°C) in properly labeled plastic containers until its analysis. A specific form was used for recording all food used for meal preparation on the days of sample collection. The most common types of food were rice, beans, vegetables (usually carrots, potatoes, pumpkins, peas or corn), beef, chicken, milk, biscuits, pasta, corn meal and sausage. The most common drinks were reconstituted powdered milk and manufactured fruit juices.

The samples of water (around 50 ml) were collected and immediately frozen (−20°C) in properly labeled plastic containers until their analysis.

Fluoride analysis

Meals

Fluoride concentration in meal samples was determined after overnight HMDS-facilitated diffusion (10) using the ion-specific electrode (model 9609, Orion Research, Cambridge, MA, USA). A set of standards (ranging between 0.025 and 3.200 μg/ml F) was prepared, using serial dilution from a 100 μg F/ml NaF stock solution (Orion no. 940907) and diffused in triplicate in the same way as the samples. The millivoltage potentials were converted to μg F/g of homogenate using a standard curve with a coefficient correlation of $r \geq 0.99$. All samples were analyzed in duplicate. The mean repeatability of the readings, based on duplicate samples, was 92.3%.

The total amount of fluoride (mg) in the school meals was calculated by multiplication of the amount of fluoride in the sample by the total volume of the meal after homogenization.

Water

Water fluoride concentration was analyzed using the ion-specific electrode (model 9609), after sample buffering with an equal volume of TISAB II. A set of standards (containing 0.025–1.6 μg/ml fluoride) was prepared, using serial dilution from a 100 μg/ml NaF stock solution (Orion Research). The millivoltage potentials were converted to μg/ml fluoride using a curve with a correlation coefficient of $r \geq 0.99$. All samples were analyzed in duplicate. The mean repeatability of the readings, based on duplicate samples, was 98.7%.

Results

Table 1 shows the mean (±SD) fluoride amount (mg) supplied for children through the meals given in the kindergarten schools for each school and Table 2 shows the same data, for each day of meal collection. Mean fluoride amount supplied for children through the meals given in the kindergarten schools was 0.067 (±0.059) mg, ranging from 0.007 to 0.580 mg. There was also considerable variation between the 10-day averages from the 44 schools, with a range of

Table 1. Mean, SD and range of the fluoride amount (mg) supplied through meals given in different public kindergarten schools in Bauru, Brazil, 2001

Mean	SD	Range	n[a]
0.017	0.007	0.010–0.026	9
0.020	0.009	0.008–0.032	10
0.023	0.008	0.014–0.044	10
0.030	0.012	0.014–0.048	10
0.033	0.015	0.009–0.061	10
0.037	0.018	0.008–0.062	10
0.040	0.027	0.010–0.111	10
0.040	0.039	0.008–0.144	10
0.041	0.016	0.019–0.064	8
0.041	0.032	0.007–0.105	9
0.043	0.021	0.024–0.090	10
0.045	0.015	0.031–0.077	10
0.045	0.022	0.029–0.099	9
0.046	0.029	0.010–0.105	10
0.047	0.021	0.021–0.100	10
0.048	0.022	0.014–0.076	9
0.048	0.030	0.013–0.111	10
0.056	0.021	0.025–0.083	10
0.057	0.026	0.020–0.105	10
0.057	0.031	0.028–0.123	10
0.059	0.040	0.020–0.163	10
0.060	0.031	0.017–0.107	10
0.063	0.047	0.013–0.176	10
0.064	0.021	0.036–0.100	10
0.065	0.042	0.027–0.153	10
0.068	0.027	0.024–0.107	10
0.069	0.024	0.039–0.110	9
0.070	0.043	0.026–0.159	10
0.070	0.030	0.038–0.126	9
0.071	0.023	0.033–0.109	10
0.072	0.051	0.016–0.178	10
0.073	0.034	0.025–0.120	10
0.082	0.030	0.036–0.125	10
0.085	0.040	0.036–0.150	10
0.088	0.062	0.023–0.184	10
0.088	0.037	0.040–0.145	10
0.094	0.028	0.065–0.155	9
0.094	0.051	0.038–0.158	10
0.097	0.045	0.033–0.178	10
0.098	0.050	0.031–0.169	10
0.103	0.049	0.058–0.217	10
0.106	0.120	0.022–0.430	10
0.122	0.164	0.017–0.580	10
0.285	0.111	0.141–0.505	10

[a]Number of samples collected

0.017–0.285 mg fluoride. Table 3 shows the means (±SD) and the range of fluoride concentrations (μg/ml) found in the fluoridated drinking water for each public kindergarten school during the 2 weeks (10 working days), while Table 4 shows the same data, for each day of water collection. Fluoride concentrations ranged between not detectable (ND) and 1.42 μg/ml. Mean (±SD) fluoride concentration when all schools were considered was 0.50 (±0.20) μg/ml.

Table 2. Mean, SD and range of the fluoride amounts (mg) supplied through meals given in different public kindergarten schools in Bauru, Brazil, for the different dates

Dates	Mean	SD	Range	n[a]
09/10/01	0.058	0.047	0.008–0.198	44
09/11/01	0.057	0.039	0.012–0.205	44
09/12/01	0.063	0.048	0.008–0.218	42
09/13/01	0.071	0.055	0.011–0.323	44
09/14/01	0.066	0.058	0.010–0.325	43
09/17/01	0.085	0.112	0.010–0.580	41
09/18/01	0.071	0.060	0.015–0.403	44
09/19/01	0.076	0.077	0.009–0.430	44
09/20/01	0.064	0.041	0.007–0.159	43
09/21/01	0.067	0.044	0.015–0.216	42

[a]Number of samples collected.

A weak but significant correlation was found between the amount of fluoride in meals and the fluoride concentration in water supplies ($r = 0.139$, $P = 0.0042$).

Tables 5 and 6 show the school meals' entire menu when the highest and the lowest fluoride amounts were found, respectively. As seen from Table 5, the most common item consumed when the highest fluoride amounts were found was powdered milk. Table 6 shows that when the lowest fluoride concentrations were seen, except for three schools, powdered milk was not used.

Discussion

All possible sources of fluoride intake should be taken into account when dental fluorosis is addressed. Therefore, this study aimed to assess the daily fluoride intake from meals prepared with fluoridated water in public kindergarten schools. The age of the children attending the schools ranged between 2 and 6 years old. Thus, they were at the age of risk for dental fluorosis, which is from 11 months to 7 years of age for the entire permanent teeth (11).

The amount of fluoride found in the meals analyzed was low, ranging from 0.007 to 0.580 mg. The mean was 0.067 mg fluoride. Considering that a 2-year-old child has a body weight around 12 kg (data not measured in this study), it would represent a daily fluoride dose of 0.006 mg F/kg of body weight/day from the meal, which is quite below the optimal level, which is 0.05–0.07 mg F/kg of body weight/day. Even if we consider the day when the highest fluoride amount (0.580 mg) was found, the same 2-year-old child

Table 3. Mean, SD and range of the fluoride concentrations (μg/ml) in drinking water for each kindergarten school in Bauru, Brazil, September, 2001

Mean	SD	Range	n[a]
ND[b]	–	ND	10
0.21	0.126	0.02–0.38	9
0.25	0.048	0.18–0.31	10
0.25	0.077	0.14–0.37	10
0.27	0.104	0.18–0.44	9
0.28	0.131	0.11–0.49	10
0.31	0.042	0.23–0.38	10
0.31	0.088	0.20–0.50	9
0.32	0.077	0.24–0.46	10
0.36	0.044	0.25–0.39	10
0.39	0.075	0.23–0.49	10
0.40	0.055	0.30–0.50	9
0.44	0.090	0.31–0.57	10
0.45	0.068	0.36–0.57	10
0.47	0.084	0.35–0.58	10
0.53	0.022	0.50–0.56	8
0.53	0.032	0.46–0.58	10
0.54	0.082	0.43–0.69	10
0.54	0.119	0.38–0.66	10
0.55	0.034	0.49–0.59	10
0.57	0.037	0.52–0.62	9
0.58	0.029	0.51–0.61	9
0.58	0.055	0.48–0.67	10
0.58	0.083	0.41–0.68	10
0.59	0.041	0.51–0.63	10
0.59	0.119	0.41–0.72	10
0.59	0.129	0.40–0.82	10
0.60	0.021	0.55–0.62	10
0.60	0.035	0.55–0.66	10
0.60	0.144	0.32–0.74	10
0.61	0.040	0.54–0.66	10
0.62	0.054	0.49–0.67	10
0.62	0.084	0.49–0.73	10
0.63	0.125	0.41–0.80	10
0.64	0.038	0.58–0.70	10
0.65	0.032	0.62–0.70	10
0.66	0.061	0.56–0.75	10
0.66	0.313	0.30–1.15	8
0.67	0.066	0.55–0.74	10
0.69	0.055	0.63–0.76	10
0.69	0.101	0.58–0.89	7
0.71	0.059	0.59–0.75	8
0.73	0.357	0.30–1.42	9
0.76	0.214	0.43–1.13	10

[a]Number of samples collected during 2 weeks (10 working days).
[b]Not detectable (below 0.02 μg/ml).

could have ingested around 0.048 mg F/kg of body weight from the school meal only, which is close to the lower level of daily recommended optimal intake (6).

If we analyze the amount of fluoride found in school meals as a percentage, it might supply around 10% of the daily minimum recommended fluoride intake (0.05 mg/kg body weight) for a 2-year-old child (12 kg). Thus, these meals alone cannot cause dental fluorosis. However, if the other sources of fluoride intake are considered, the school meals can contribute to the risk of dental fluorosis development when ingested on a chronic basis. Dietary habits during infancy have changed substantially in the last decades, increasing the consumption of commercially available products (4). Thus, some children have access to ready-to-drink chocolate milk, cookies, chocolate bars, snacks, cakes and yogurt. Some ready-to-drink chocolate milk (8), cookies (12) and chocolate bars (13) available in Brazil have been reported to have high fluoride content.

Table 4. Mean, SD and range of the fluoride concentrations (μg/ml) in drinking water of kindergarten schools for different dates in Bauru, Brazil

Dates	Mean	SD[a]	Range	n[b]
09/10/01	0.51	0.23	ND[c]–1.42	41
09/11/01	0.52	0.21	ND–1.13	42
09/12/01	0.51	0.20	ND–0.82	42
09/13/01	0.50	0.19	ND–0.75	44
09/14/01	0.52	0.20	ND–0.89	44
09/17/01	0.51	0.19	ND–1.11	41
09/18/01	0.54	0.22	ND–1.15	44
09/19/01	0.52	0.19	ND–0.89	41
09/20/01	0.50	0.15	ND–0.75	44
09/21/01	0.48	0.14	ND–0.72	41

[a]For SD calculations, ND was considered equal to 0.
[b]Number of samples collected.
[c]Not detectable (below 0.02 μg/mL).

The meals in the kindergarten schools were served in standardized portions. However, it is possible that some children do not ingest the entire portion that is offered; but the inverse situation, i.e. a child ingesting more than a portion, is not plausible as children are not allowed to repeat the portion. Another topic that must be addressed is that, in this study, the kindergarten school cooks were responsible for the collection of the meal samples. They were instructed to collect one portion similar to the one that is given to each child and to save this portion in an identified vial. There is a possibility that the cooks did not collect the portion properly, but we believe this possibility is very low and does not impair the results obtained.

Fluoridated water must be considered among the possible sources of fluoride ingestion. In this study, there was an extreme variability in fluoride levels in the public water supply during the same day in all of the kindergarten schools and within an interval as short as 10 days in the same school. Of all the samples analyzed, 59.4% were within

Table 5. School meals' menu when the highest fluoride amounts were found

Kindergarten schools	Dates	mg/F	Water [F]	Meals
28	09/17/01	0.580	0.69	Sweetened rice with biscuits
7	09/17/01	0.505	0.65	Powdered milk with chocolate Sweetened rice with biscuits
12	09/19/01	0.430		Pasta with sausage sauce Manufactured grape juice
7	09/18/01	0.403	0.65	Powdered milk with chocolate Corn meal with chicken
7	09/14/01	0.325	0.54	Powdered milk with chocolate Rice soup containing meat and vegetables
7	09/13/01	0.323	0.62	Powdered milk with chocolate Rice, bean, vegetables and chicken
7	09/19/01	0.318	0.66	Powdered milk with chocolate Rice soup with beef and vegetables

Table 6. School meals' menu when the lowest fluoride amounts were found

Kindergarten schools	Date	mg/F	Water [F]	Meals
8	09/10/01	0.010	0.27	Powdered milk with corn flakes
32	09/14/01	0.010	0.30	Assorted fruits (orange, banana, apple and pineapple) with condensed milk and gooseberry
38	09/19/01	0.010	0.56	Rice, beef and vegetables
29	09/19/01	0.009		Powdered milk with corn flakes
44	09/19/01	0.009	ND[a]	Rice, chicken and vegetables
10	09/10/01	0.008	0.36	Rice, chicken and vegetables
38	09/12/01	0.008	0.60	Rice, vegetables and sausage
40	09/10/01	0.008	0.69	Powdered milk with corn flakes, biscuits and bananas
29	09/20/01	0.007	0.45	Rice, beef and vegetables

[a]Not detectable (below 0.02 μg/mL).

acceptable levels (0.5–1.0 mg/l) proposed by Buendia (14). Hypofluoridation was the most common occurrence, which is in line with previous reports for this city (15).

In this study, the correlation between fluoride in meals and fluoride concentration in water supplies was weak but significant. This confirms previous studies that show an indirect role of fluoridated water on the total fluoride intake, when it is used to prepare or manufacture food and beverages (6) and also to reconstitute powdered milk and infant formulas (16, 17). However, the low correlation found indicates that this role is minor, probably due to the small volume of water employed in the preparation of the school meals, or to a larger contribution of the intrinsic fluoride present in the food and/or beverages. Another factor is the composition of the diet supplied to children. This weak correlation could also be a consequence of the nonregular diet that the children receive at kindergarten schools. When milk is one of the constituents of the Brazilian public schools' menu, soymilk is often offered instead of cow's milk, and soymilk has a higher fluoride content than cow's milk (16, 18).

Considering the amount of fluoride supplied to children in meals given in public kindergarten schools as an additional source of fluoride intake for children on a chronic basis, public measures aiming at minimizing this role should be implemented. As meals are not the sole source of fluoride intake for kindergarten children and that children are exposed to different feeding patterns at home, especially manufactured products, it would be easier to control the fluoride intake from the 'homogenous' diet provided at school than the diet at home. Restrictions on the use of soy and other high fluoride products in the school's menu should be considered. In addition, restrictions on the use of fluoridated water to prepare the food and to reconstitute the beverages or powdered milk given in public kindergarten schools could also be considered. Furthermore, diet counseling should be given to parents in order to avoid the home use of manufactured products with a high fluoride concentration. Additional counseling regarding the rational use of fluoride oral care products, especially dentifrice, should also be given.

In conclusion, the data in this study suggest that despite the seemingly small role played by school meals in the total daily fluoride intake, they can contribute to the total fluoride intake of children on a chronic basis, when in association with other fluoride products. Additionally, the impact of the fluoridated public water supply on the final fluoride concentration of the meals analyzed may be regarded as low.

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