



Relationship between daily fluoride intake from diet and the use of dentifrice and human plasma fluoride concentrations

Vanessa E.S. Cardoso^a, Gary M. Whitford^b, Marília A.R. Buzalaf^{a,*}

^a Department of Biological Sciences, Bauru Dental School, University of São Paulo, Brazil

^b Department of Oral Biology, Medical College of Georgia, Augusta, GA, USA

Accepted 6 December 2005

KEYWORDS

Fluoride intake;
Plasma fluoride;
Diet;
Dentifrice

Summary The literature contains reports of the relationship between the fluoride concentrations in drinking water and human plasma. None of these studies, however, documented individual levels of daily fluoride intake, which can vary considerably among individuals served by the same water supply. Furthermore, while water can be an important source of fluoride, other sources, especially fluoridated dentifrices, also contribute substantially. This 2-day study with five 25–35-year-old subjects in each of three communities (Bauru, 0.6–0.8 ppm F; Domélia, 0.7 ppm F; Floresta, 0.3 ppm F) determined plasma fluoride concentrations and fluoride intake from diet and the use of dentifrice which, together, approximate total daily fluoride intake. The purposes were to determine: (1) the extent to which plasma fluoride concentrations approached levels known to affect the quality and quantity of bone; (2) the relationship between fluoride intake and plasma concentrations. Plasma was collected at 4-h intervals starting at 0800 h and ending at 2000 h each day. Average fluoride intakes from diet and the use of dentifrice in the three communities ranged from 0.16 to 0.82 mg/day and from 0.29 to 3.16 mg/day, respectively. The overall average plasma concentrations in the three communities were 0.44, 0.45 and 0.54 $\mu\text{mol/l}$ ($P < 0.005$). They were directly related to intake from the use of dentifrice ($P = 0.030$) and to total intake ($P = 0.033$), but were not related to dietary intake ($P = 0.176$). In conclusion, despite fluoride intake from various sources, the plasma fluoride concentrations of the study subjects remained at levels far below those associated with effects on bone production.

© 2005 Elsevier Ltd. All rights reserved.

Introduction

The metabolism of fluoride in laboratory animals and humans is characterised by: (1) rapid and extensive absorption from the gastrointestinal tract; (2)

* Corresponding author at: Al. Octávio Pinheiro Brisolla 9-75, Bauru-SP 17012-901, Brazil. Tel.: +55 14 3235 8346; fax: +55 14 3234 3164.

E-mail address: mbuzalaf@fob.usp.br (Marília A.R. Buzalaf).

distribution to all soft tissues in which the intracellular: extracellular concentration ratio varies according to the magnitude of the pH gradient across the cell membrane; (3) extensive but reversible uptake by calcified tissues that contain 99% of the fluoride in the body; (4) rapid excretion in the urine.^{1,2} From a pharmacokinetic point of view, plasma is regarded as the central compartment because it is this fluid into which and from which fluoride must pass for its distribution and excretion. Thus, plasma fluoride concentrations reflect the concentrations elsewhere in the body, including those in bone.^{2–5}

Plasma fluoride concentrations between 0.5 and 1.5 $\mu\text{mol/l}$ are typical among humans who drink water with a fluoride concentration close to 1.0 ppm (52.6 $\mu\text{mol/l}$).² The first known change in normal physiological function following acute exposure to a high dose of fluoride, a transient decrease in the ability of the kidney to concentrate the urine appropriately, begins to occur at a plasma fluoride concentration of 40 or 50 $\mu\text{mol/l}$ in humans⁶ and rats.⁷ In the chronic treatment of osteoporosis with large daily doses of fluoride, the therapeutic window for plasma fluoride concentration is regarded as being between 5 and 10 $\mu\text{mol/l}$.^{8,9} In this range, the production of osteoid is enhanced and the formation of new bone may follow. Concentrations below this range generally have no effect on bone.^{8,10,11}

Plasma fluoride concentrations are not regulated homeostatically. Instead, they are directly related to both the level and duration of chronic intake. This fact has been supported by several reports describing the relationship between the concentrations of fluoride in the drinking water and plasma.^{4,5,12–14} Taves and Guy, for example, found that plasma concentrations ranged from 0.4 to 4.3 $\mu\text{mol/l}$ in communities where the water concentrations ranged from 0.1 to 5.5 ppm.⁵ None of these studies, however, measured the amounts of water ingested by individual subjects, so the relationship between fluoride intake and plasma fluoride concentration has not been well defined.

While fluoride in water remains contributory, it is no longer the most important source of fluoride. Dental products containing fluoride, especially dentifrices, which are now almost universally used, are important sources of fluoride.¹⁵ Additionally, fluoride intake from beverages, such as soft drinks, fruit juices, teas and flavoured milk, should also be considered among the important sources.^{16–20} The present study was undertaken to determine the relationship between plasma fluoride concentration and fluoride intake from diet and the use of dentifrice, and to determine whether plasma fluoride concentrations fell within the range known to affect the quality and quantity of bone (i.e. 5–10 $\mu\text{mol/l}$).

Materials and methods

Subjects

Fifteen healthy subjects aged 25–35 years participated in this 2-day study, which was approved by the Ethics Committee for Human Research of the Bauru Dental School, University of São Paulo, Brazil. The nature and purposes of the study were explained verbally and in writing to the subjects, who signed an informed consent document approved by an international review board. The subjects were free of acute and chronic medical problems, and none of them were taking prescription medications for any disease. The subjects (both genders) were residents of three different communities in Brazil. Bauru and Domelia had controlled water fluoridation programmes (0.6–0.8 and 0.7 ppm, respectively), while the drinking water in Floresta contained 0.3 ppm from natural sources. In Bauru, the subjects drank non-fluoridated, bottled mineral water (0.025 ppm) but ate food prepared with water from the public water supply. In Domelia and Floresta, the subjects drank and ate food prepared with water from the public water supply. The subjects did not have private wells at home but their drinking water sources were equipped with activated carbon filters, which do not remove fluoride.²¹ The dentifrices used by the subjects contained disodium monofluorophosphate, that, according to the labels, contained either 1000 or 1500 mg F/kg.

Fluoride intake

During the two consecutive weekdays of this study, the subjects were allowed to eat and drink according to their own preferences. Duplicate portions of all foods and drinks consumed by the subjects were collected by them and analysed for fluoride.²² In an effort to ensure that all foods and drinks were included in the duplicate portions, subjects were also asked to maintain 24-h dietary records of all foods and drinks ingested. The solid foods, water and beverages were combined, weighed and homogenised in known volumes of de-ionised water. Portions of the homogenates were frozen at -20°C to await analysis.

Fluoride intake from dentifrice was estimated on one occasion for each subject as follows. The subject placed the usual amount of their usual brand of dentifrice on to a pre-weighed brush, which was then weighed again. The dentifrice weight was calculated and recorded. The subject then brushed their teeth and expectorated the saliva-paste slurry into a calibrated beaker containing de-ionised

water. If it was their custom, they then rinsed their mouth as many times as desired with de-ionised water and expectorated the rinse(s) into the same beaker. The paste remaining on the toothbrush was also collected using a stream of de-ionised water. Fluoride intake was calculated as the difference between the amount placed on the brush and that contained in the beaker. The amount of fluoride was multiplied by the number of times the subject reported brushing each day to estimate the daily intake from the use of dentifrice. Total daily intake was calculated as the sum of intake from diet and the use of dentifrice.

Blood collection

Blood samples (approximately 5 ml) were collected from an arm vein and transferred to test tubes containing 15 μ l of heparin at 0800, 1200, 1600 and 2000 h on both study days. It has been reported that some batches of heparin contain significant amounts of fluoride.² The heparin used as the anticoagulant in this study was determined to have a fluoride concentration of 0.184 ppm. Thus, the heparin contributed a negligible amount of fluoride (2.76 ng) to each 5-ml blood sample.

Fluoride analysis

Blood samples were centrifuged at 3000 revolutions/min (rpm) for 5 min. Plasma was collected and analysed for fluoride in duplicate using ion-specific electrodes (Model 9409; Orion Research, Cambridge, MA, USA) and a miniature calomel reference electrode after overnight HMDS (hexamethyldisiloxane; Aldrich Chemical Co., Milwaukee, WI, USA)-facilitated diffusion.^{2,23} Prior to diffusion, 0.20 ml of fluoride-free 6N H₂SO₄ was added to each 1.0-ml plasma sample for pre-diffusion to allow CO₂ to escape into the atmosphere, because excessive amounts of CO₂ can reduce the alkalinity of the NaOH trapping solution and reduce the capture of fluoride. The trapping solution, which was placed in three drops on the inside of the lid of the diffusion dish, was 0.05N NaOH (50 μ l). During the diffusion process, which was conducted at room temperature, the solutions in the non-wettable Petri dishes (Falcon, 1007) were gently swirled on a rotary shaker at 30 rpm. The lid was removed the next day and 20 μ l of 0.20N acetic acid was added to the NaOH trap to form an acetate buffer system (pH 5.0). Diet homogenates were analysed in the same manner as plasma except the samples were not pre-diffused (i.e. fluoride-free 6N H₂SO₄ was not added prior to diffusion).

Fluoride standards (0.00475, 0.0095, 0.019, 0.095 and 0.19 μ g F) were prepared in triplicate, pre-diffused and analysed in the same manner as the plasma samples. Other standards, which were not pre-diffused, were also analysed. By comparison with the millivolt (mV) readings of the pre-diffused standards, it was confirmed that the H₂SO₄ used for pre-diffusion was, in fact, fluoride-free. The final volume of the samples and standards was adjusted to 75 μ l using de-ionised water prior to analysis. In addition, non-diffused standards were prepared using the same reagents (0.05N NaOH and 0.20N acetic acid) that were used to prepare the diffused standards and samples. These were made to have the theoretical fluoride concentrations of the diffused standards. Comparison of the millivolt readings demonstrated that the fluoride in the diffused standards had been completely trapped and analysed (recovery 97–104%).

Fluoride in mineral water and tap water was analysed in duplicate after the samples had been buffered by the addition of an equal volume of TISAB II (Orion Research). Six fluoride standards whose lowest and highest concentrations bracketed the concentrations in these samples were also analysed in duplicate.

Statistical analysis

The data are presented as mean \pm S.D. and were analysed for statistically significant differences using ANOVA, Tukey's post hoc test and linear regression. An alpha value of 0.05 was selected a priori as the indicator for statistical significance.

Results

According to the manufacturers, the seven different brands of dentifrice used by the subjects in this study contained a fluoride concentration of either 1000 (three subjects) or 1500 (12 subjects) ppm as disodium monofluorophosphate. Analyses indicated that the actual concentrations were within 9% of the stated concentrations, except for the product used by Subject 2 in Floresta; this contained 1738 ppm (16% above the stated concentration). One subject reported brushing their teeth once each day (Subject 2 in Floresta), two subjects reported brushing twice each day (Subjects 3 and 5 in Floresta) and the others reported brushing three or four times each day. Each subject in Domelia rinsed with water several times after brushing, as did each subject in Bauru, except for Subject 3 who did not rinse after brushing. The subjects in Floresta rinsed briefly with a small amount of water or did not rinse

Table 1 Fluoride intake from diet and the use of dentifrice and the associated plasma fluoride concentrations in three Brazilian communities

Community	Subject	F intake, mg/day			Plasma [F], $\mu\text{mol/l}$				
		Diet	Dentifrice	Total	0800 h	1200 h	1600 h	2000 h	Mean \pm S.D.
Bauru	1	0.40	0.16	0.56	0.54	0.56	0.45	0.37	0.48 \pm 0.09
	2	0.30	0.53	0.83	0.50	0.50	0.45	0.32	0.44 \pm 0.09
	3	0.55	1.88	2.43	0.46	0.35	0.50	0.35	0.42 \pm 0.08
	4	0.17	3.58	3.75	0.49	0.40	0.71	0.38	0.50 \pm 0.15
	5	0.23	0.69	0.92	0.58	0.29	0.44	0.35	0.42 \pm 0.13
Mean \pm S.D.		0.33 \pm 0.15	1.37 \pm 1.39	1.70 \pm 1.36	0.51 \pm 0.05	0.42 \pm 0.11	0.51 \pm 0.11	0.35 \pm 0.02	0.45 \pm 0.10
Domelia	1	0.65	1.12	1.77	0.30	0.44	0.42	0.49	0.41 \pm 0.08
	2	0.65	0.05	0.70	0.28	0.41	0.41	0.42	0.38 \pm 0.07
	3	1.06	0.07	1.13	0.63	0.59	0.42	0.63	0.57 \pm 0.10
	4	1.10	0.14	1.24	0.25	0.46	0.29	0.51	0.38 \pm 0.13
	5	0.65	0.07	0.72	0.34	0.48	0.46	0.64	0.48 \pm 0.12
Mean \pm S.D.		0.82 \pm 0.24	0.29 \pm 0.47	1.11 \pm 0.44	0.36 \pm 0.15	0.48 \pm 0.07	0.40 \pm 0.06	0.54 \pm 0.09	0.44 \pm 0.12
Floresta	1	0.11	2.54	2.65	0.58	0.52	0.54	0.58	0.56 \pm 0.03
	2	0.26	1.18	1.44	0.71	0.48	0.47	0.56	0.56 \pm 0.11
	3	0.13	2.88	3.01	0.42	0.39	0.39	0.54	0.44 \pm 0.07
	4	0.07	6.76	6.83	0.75	0.65	0.58	0.54	0.63 \pm 0.17
	5	0.23	2.45	2.67	0.52	0.58	0.52	0.66	0.57 \pm 0.07
Mean \pm S.D.		0.16 \pm 0.08	3.16 \pm 2.11	3.32 \pm 2.05	0.55 \pm 0.11	0.52 \pm 0.10	0.50 \pm 0.07	0.58 \pm 0.05	0.55 \pm 0.10

Data expressed as mean \pm S.D. The fluoride concentrations (ppm) in the water used for drinking and cooking in Bauru, Domelia and Floresta were: 0.025 (bottled mineral water) and 0.70; 0.70 and 0.70; 0.30 and 0.30, respectively.

at all (Subjects 3 and 4). The subjects who did rinse spat out after rinsing. The average (\pm S.D.) weight of dentifrice placed on the toothbrush in Bauru, Domelia and Floresta was 0.73 ± 0.42 , 0.49 ± 0.18 and 1.46 ± 0.40 g, respectively.

Table 1 shows the daily fluoride intake from diet and the use of dentifrice in the three communities. Information on number and composition of meals was obtained from the 24-h dietary records. The dietary intake values for each subject are the averages of the intakes during the 2 days of the study. The average dietary intake ranged from 0.16 mg/day in Floresta to 0.82 mg/day in Domelia. Dietary fluoride intake in Domelia was higher than that in the other communities ($P < 0.001$). Fluoride intake from the use of dentifrice varied considerably both within and among the communities. The highest average intake from dentifrice (3.16 mg/day) occurred in Floresta and was more than 10 times higher than that in Domelia ($P < 0.03$). The average total fluoride intake ranged from 1.11 mg/day in Domelia to 3.32 mg/day in Floresta, a three-fold range. This did not reach statistical significance ($P = 0.080$).

Table 1 also shows the average plasma fluoride concentration for each subject at each collection time in each of the three communities. The overall average concentrations (\pm S.D.) for Bauru and Domelia were nearly identical (0.45 ± 0.10 and 0.44 ± 0.12 $\mu\text{mol/l}$), while that for Floresta (0.55 ± 0.10 $\mu\text{mol/l}$) was 20% higher ($P < 0.005$).

Plasma fluoride concentration as a function of the time of collection was analysed in an attempt to identify evidence for a circadian rhythm. In Bauru, the lowest concentrations occurred at 1200 and 2000 h. The average concentration at 2000 h was significantly lower than the concentrations at 0800 and 1600 h ($P < 0.03$). However, the opposite pattern was seen in the plasma concentrations in Domelia, i.e. the highest concentrations occurred at 1200 and 2000 h. The average concentration at 2000 h was significantly higher than the concentrations at 0800 and 1600 h ($P < 0.05$). There were no significant differences among the plasma fluoride concentrations in Floresta as a function of time, nor were there when the concentrations from all three communities were combined and analysed together ($P = 0.96$).

Plasma fluoride concentration was found to be directly related to total fluoride intake ($r^2 = 0.304$, $P = 0.033$) and to fluoride intake from the use of dentifrice ($r^2 = 0.314$, $P = 0.030$), but was not related to dietary fluoride intake ($r^2 = 0.136$, $P = 0.176$).

Discussion

The literature indicates that plasma fluoride concentrations can be influenced by several variables. Provided that the chronic intake of fluoride remains relatively constant, plasma fluoride concentration tends to increase gradually with age, as does the fluoride concentration in bone.^{4,12,14,24,25} Such

age-related changes appear to be partly due to the more rapid skeletal clearance of fluoride from plasma by younger bone, and partly to the steady-state relationship between fluoride concentrations in the exchangeable pool of bone and the extracellular fluids.^{2,4} Since the kidneys are the major route for the excretion of fluoride, plasma concentrations may also increase in patients whose glomerular filtration rates are chronically less than 25% of normal,^{26,27} and in the latter decades of life when the number of normally functioning nephrons is in decline. Although kidney function tests were not performed in this study, the subjects were healthy adults aged 25–35 years so it is unlikely that these variables affected the findings.

A variable of major importance is the level of chronic fluoride intake. Although drinking water is not the only source of fluoride, it can account for much of it, particularly when the concentration approaches or exceeds 1.0 ppm. Several reports have described the relationship between the concentrations of fluoride in drinking water and plasma. Taves and Guy⁵ analysed plasma obtained from blood banks in five cities in which the fluoride concentration in drinking water ranged from 0.1 to 5.5 ppm. The average plasma concentration ranged from 0.4 to 4.3 $\mu\text{mol/l}$ and was linearly related to the fluoride concentration in drinking water. Ekstrand¹³ reported plasma fluoride concentrations in three Swedish communities with fluoride concentrations in drinking water of 0.25, 1.2 and 9.6 ppm. There were five subjects in each community, from whom eight blood samples were collected during a 36-h period. While there were considerable differences among and within the plasma fluoride concentrations of the subjects in the 1.2- and 9.6-ppm communities, it was clear that they were related to the fluoride concentrations in the drinking water. The average plasma fluoride concentration in the 0.25-ppm community was 0.5 $\mu\text{mol/l}$. Fuchs et al.²⁸ analysed plasma from 20 residents of Gottingen, Sweden, aged 23–71 years, where the fluoride concentration in drinking water was 0.18 ppm. The average plasma concentration was 0.55 $\mu\text{mol/l}$ and the range was from 0.31 to 0.99 $\mu\text{mol/l}$. Husdan et al.¹² analysed serum from 87 male residents of Toronto, Canada, where the fluoride concentration in drinking water was 1.0 ppm. The average (\pm S.D.) concentration for men aged 18–44 years (similar to the age range in the present study) was $0.88 \pm 0.28 \mu\text{mol/l}$.

The studies summarised above related plasma or serum fluoride concentrations in adults to fluoride concentrations in drinking water, but none reported the actual fluoride intake from diet and the use of dentifrice. Three studies of dietary intake by adults living in areas served with water fluoridated at about

1 ppm reported average values ranging from 1.8 to 2.2 mg/day.^{29–31} Although there are many published reports concerning fluoride ingestion from toothpaste by small children, there is a dearth of such information for adults. However, a recent and as yet unpublished study with young adults by one of the authors (GMW) found that an average of 0.12 mg was ingested per brushing (range 0.06–0.21 mg), which would amount to 0.3–0.4 mg/day depending on the frequency of brushing. Thus, it can be estimated that the average daily fluoride intake from diet and the use of dentifrice by adults whose water is fluoridated at about 1 ppm is in the vicinity of 2.5 mg/day. As discussed above, Taves and Guy⁵ and Husdan et al.¹² found average plasma fluoride concentrations of 0.9 and 0.88 $\mu\text{mol/l}$ in fluoridated areas.

As shown in Table 1, the average total daily fluoride intakes in Domelia and Bauru were 1.70 and 1.11 mg/day; values about 68 and 45%, respectively, of the 2.5 mg/day estimated in the preceding paragraph. The average plasma concentrations were also correspondingly lower. However, the average plasma concentration in Floresta, where the average intake was 3.32 mg/day, was 0.54 $\mu\text{mol/l}$, a value considerably lower than would have been predicted based on the data from Taves and Guy⁵ and Husdan et al.¹² This disconnect between intake and plasma fluoride concentration was also noted, especially for Subject 4 in Bauru. It is possible that the renal and/or skeletal clearances of fluoride from plasma were higher in Subject 4 in Bauru and, especially, Subject 4 in Floresta, but these physiological variables were not measured in this study. It is also possible that the high intake of fluoride from dentifrice by these individuals was not representative of their usual level of intake, but was an artifact caused by the experimental environment. This latter possibility is given some credence for the following reason. Linear regression analysis of the combined plasma fluoride concentrations from the three communities indicated that the concentrations were well correlated with total fluoride intake from diet and the use of dentifrice ($P = 0.033$). When the intake and plasma concentration values from Subject 4 in Bauru and Floresta were removed from the analysis, the correlation was not statistically significant ($P = 0.43$).

Unlike the situation that existed 50 or more years ago, when the diet, principally drinking water, was the major source of fluoride, dental products, especially dentifrices, contribute substantially to fluoride intake nowadays due to their frequent use. Nevertheless, the findings from this preliminary study show that plasma fluoride concentrations in healthy young adults exposed to several sources of fluoride remain at levels far below the lower concentration of

the therapeutic window (5–10 $\mu\text{mol/l}$) for stimulatory effects on bone production.

Acknowledgement

This study was supported by FAPESP Grant #02/10489-2.

References

- Whitford GM. The physiological and toxicological characteristics of fluoride. *J Dent Res* 1990;**69**:539–49.
- Whitford GM. In: Myers HM, editor. *The metabolism and toxicity of fluoride*. 2nd ed. Basel: Karger; 1996.
- Ericsson Y, Gydell K, Hammarskjöld T. Blood plasma fluoride: an indicator of skeletal fluoride content. *J Int Res Commun* 1973;**1**:33.
- Parkins FM, Tinanoff N, Moutinho M, Anstey MB, Waziri MH. Relationships of human plasma fluoride and bone fluoride to age. *Calcified Tissue Res* 1974;**16**:335–8.
- Taves DR, Guy WS. Distribution of fluoride among body compartments. In: Johansen E, Taves DR, Olsen TO, editors. *Proceedings of the AAAS selected symposium 11 on continuing evaluation of the use of fluorides*. Boulder CO: Westview Press; 1979. p. 159–85.
- McCaughy TJ, Dunkley M, Batra MS, Thomson C. Effect of methoxyflurane on renal concentrating power. *Can Anaesth Soc J* 1975;**22**:61–9.
- Whitford GM, Taves DR. Fluoride-induced diuresis: renal-tissue solute concentrations, functional, hemodynamic and histologic correlates in the rat. *Anesthesiology* 1973;**39**:416–27.
- Taves DR. New approach to the treatment of bone disease with fluoride. *Fed Proc* 1970;**29**:1185–9.
- Pak CYC. Fluoride and osteoporosis. *Proc Soc Exp Biol Med* 1989;**191**:278–86.
- Hasling C, Nielsen HE, Melsen F, Mosekilde L. Safety of osteoporosis treatment with sodium fluoride, calcium phosphate and vitamin D. *Miner Electrol Metab* 1987;**13**:96–103.
- Sowers MF, Whitford GM, Clark MK, Jannausch ML. Elevated serum fluoride concentrations in women are not related to fractures and bone mineral density. *J Nutr* 2005;**135**:2247–52.
- Husdan H, Vogl R, Oreopoulos D, Gryle C, Rapoport A. Serum ionic fluoride: normal range and relationship to age and sex. *Clin Chem* 1976;**22**:1884–8.
- Ekstrand J. Relationship between fluoride in the drinking water and the plasma fluoride concentration in man. *Caries Res* 1978;**12**:123–7.
- Cowell DC, Taylor WH. Ionic fluoride: a study of its physiological variation in man. *Ann Clin Biochem* 1981;**18**:76–83.
- Warren JJ, Levy SM. A review of fluoride dentifrice related to dental fluorosis. *Pediatr Dent* 1999;**21**:265–71.
- Cloviss J, Hargreaves JA. F intake from beverage consumption. *Community Dent Oral Epidemiol* 1988;**16**:11–5.
- Pang DTY, Philipps CL, Bawden JW. Fluoride intake from beverage consumption in a sample of North Carolina children. *J Dent Res* 1992;**71**:1382–8.
- Heilman JR, Kiritsy MC, Levy SM, Wefel JS. Assessing F levels of carbonated soft drinks. *J Am Dent Assoc* 1999;**130**:1593–9.
- Buzalaf MAR, Bastos JRM, Granjeiro JM, Levy FM, Cardoso VES, Rodrigues MHC. Fluoride content of several brands of teas and juices found in Brazil and risk of dental fluorosis. *J Appl Oral Sci* 2002;**10**:263–7.
- Buzalaf MAR, Almeida BS, Cardoso VES, Ollympio KPK, Furlani TA. Total and acid soluble fluoride content of infant cereals, beverages and biscuits from Brazil. *Food Addit Contam* 2004;**21**:210–5.
- Buzalaf MAR, Levy FM, Rodrigues MHS, Bastos JRM. The effect of domestic water filters on the water fluoride content and fluoride level of the public water supply in Bauru. *J Dent Chil* 2003;**70**:226–30.
- Guha-Chowdhury N, Drummond BK, Smillie AC. Total fluoride intake in children aged 3–4 years — a longitudinal study. *J Dent Res* 1996;**75**:1451–7.
- Taves DR. Determination of submicromolar concentrations of fluoride in biological samples. *Talanta* 1968;**15**:1015–23.
- Kuo HC, Stamm JW. The relationship of creatinine clearance to serum fluoride concentration and urinary fluoride excretion in man. *Arch Oral Biol* 1975;**20**:235–8.
- Hanhijärvi H, Penttilä I, Pekkarinen A. Human ionic plasma fluoride concentrations and age in a fluoridated community. *Proc Finn Dent Soc* 1981;**77**:211–21.
- Waterhouse C, Taves DR, Munzer A. Serum inorganic fluoride: changes related to previous fluoride intake, renal function and bone resorption. *Clin Sci* 1980;**58**:145–52.
- Schiffel H, Binswanger U. Human urinary fluoride excretion as influenced by renal functional impairment. *Nephron* 1980;**26**:69–72.
- Fuchs C, Dorn D, Fuchs CA, et al. Fluoride determination in plasma by ion selective electrodes: a simplified method for the clinical laboratory. *Clin Chim Acta* 1975;**60**:157–67.
- SanFilippo FA, Battistone GC. The fluoride content of a representative diet of the young male adult. *Clin Chim Acta* 1971;**31**:453–7.
- Singer L, Ophaug RH, Harland BF. Fluoride intake of young male adults in the United States. *Am J Clin Nutr* 1980;**33**:328–32.
- Taves DR. Dietary intake of fluoride ashed (total fluoride) vs. unashed (inorganic fluoride) analysis of individual foods. *Br J Nutr* 1983;**49**:295–301.