Fluctuations in Public Water Fluoride Level in Bauru, Brazil

Marília A. R. Buzalaf, DDS, PhD; José M. Granjeiro, DDS, PhD; Carla A. Damante, DDS; Flávia Ornelas, DDS

Abstract

Objectives: *The aim of this study was to monitor the quality of public water supply fluoridation in Bauru, in the state of São Paulo, Brazil.* ***Methods:*** *Water samples collected three times a week during four weeks in 20 areas of distribution of water were supplied by the City Water Department of Bauru, São Paulo, Brazil. Fluoride was analyzed using the ion-specific electrode (Orion model 9409) after sample buffering with an equal volume of TISAB II. Data were compared to fluoride concentration reported by City Water Department.* ***Results:*** *Fluoride content ranged between 0.01 ppm and 9.35 ppm (n=240). There was great variation among the different areas of distribution of water, as showed by the Levene test (P<.001). Kruskal-Wallis test showed a statistically significant difference in mean fluoride concentration among different areas (P<.001). Mean fluoride concentration was less than the optimum concentration (0.8 ppm) in 89 percent of samples. The values reported by the City Water Department were always higher than the analyzed fluoride concentrations.* ***Conclusions:*** *Based on the results from this study, more rigorous surveillance and monitoring of water fluoridation in Bauru is recommended. [J Public Health Dent 2002;62(3):173-76]*

Key Words: water fluoridation, dental caries, dental fluorosis, fluoride, dental public health.

Public water fluoridation is one of the greatest disease-prevention measures of all time. Its many advantages include safety, low cost, ease of administration, and benefits to the entire community, regardless of age, socioeconomic status, or education (1). Fluoride has a spillover or diffusion effect because fluoridated drinking water is incorporated into foods and drinks, thus reaching the population in nonfluoridated areas (1-3). A reduction of 70 percent in caries of permanent teeth and 40 percent in primary teeth can be observed in children who live in fluoridated areas (4,5).

Considering fluoridation of water only, studies have shown that 0.7 ppm of fluoride is the best concentration for maximum protection against caries while producing low levels of fluorosis (6-8). In such tropical countries as Brazil, optimum fluoride levels in water may vary from 0.6 ppm to 0.8 ppm, with acceptable levels between 0.5 ppm and 1.0 ppm, depending on the mean annual temperature (9). Many articles in the literature describe fluctuations in the fluoride level of public water supply as a common occurrence, and the majority of them observe fluoridation under the recommended dosage for that region (10-17).

Fluoridation of Public Water Supply in Bauru. Water fluoridation was first introduced in Brazil in 1953 at Baixo Guandu, in the state of Espírito Santo. Bauru, in the state of São Paulo, is located at 683 m above sea level, has a mean annual temperature of 24.2°C, and started fluoridation of its water supply in 1975. At that time, a dry feed system was used. In a dry feed system, the amount of dry chemical compound (sodium fluorosilicate) is measured and then added to a mixing tank, where it is mixed with water and delivered to the main flow of water (18).

In 1981, some systems changed to a saturator feed, in which solutions of sodium fluoride in constant strengths are pumped directly into the main flow of water (18). By the same year, a hydrofluosilicic acid system was installed in some wells, which consists of a small metering pump that adds solutions of the acid directly into the water supply (18). Since 1999, the system measures immediate water flow and adjusts amounts of fluoride (hydrofluosilicic acid) according to this flow.

Bauru has a water treatment station that uses water from Batalha River and 29 wells, and distributes water to the city and region. The City Water Department is responsible for water treatment and fluoridation. Water is collected three times a day in each area of distribution and analyzed in their laboratories to maintain good quality. Because these data are not published, it was considered appropriate to verify the fluoride content in public water supply from Bauru and to compare these results with those obtained by the City Water Department.

Methods

Sampling. Water samples collected three times a week during four weeks in 20 areas of distribution of water were supplied by the City Water Department of Bauru, São Paulo, Brazil, from July 28 to August 23, 1999.

Fluoride Analysis. Fluoride was analyzed using the ion-specific electrode (Orion Research, Cambridge, MA, USA, model 9409), after sample buffering with an equal volume of TISAB II. A set of standards was prepared containing 0.0625, 0.125, 0.25, 0.5, 1, 2, 5, and 10 ppm fluoride using serial dilution from a 100 ppm NaF stock solution (Orion). The millivoltage potentials were converted to ppm fluoride using a standard curve with a coefficient correlation of $r \geq 0.999$. The mean reproducibility of the readings, based on the duplicate samples, was 97 percent.

Daily reports of fluoride concentra-

Send correspondence and reprint requests to Dr. Buzalaf, Al. Octávio Pinheiro Brisolla, 9-75, Bauru-SP, Brazil 17012-901. E-mail: mbuzalaf@fob.usp.br. Web site: http://www.fob.usp.br. Drs. Buzalaf, Granjeiro, Damante, and Ornelas are all affiliated with the Department of Biological Sciences, Bauru Dental School, University of São Paulo, Brazil. This work was supported in part by FAPESP. Partial results of this paper were presented at the XXXII Reunión Anual de la Sociedad Argentina de Investigación Odontológica, Mar del Plata, Argentina, November 1999. Manuscript received: 7/26/01; returned to authors for revision: 9/7/01; final version accepted for publication: 12/3/01.

tion in water samples analyzed by the City Water Department were obtained, and used for comparison. Fluoride was analyzed with the electrode (Orion Research, Cambridge, MA, model 9609), after sample buffering with 1/10 of the volume with TISAB III. Reading was made in concentration (ppm), after calibration with standard solutions containing 0.1 ppm, 1.0 ppm, and 10.0 ppm fluoride.

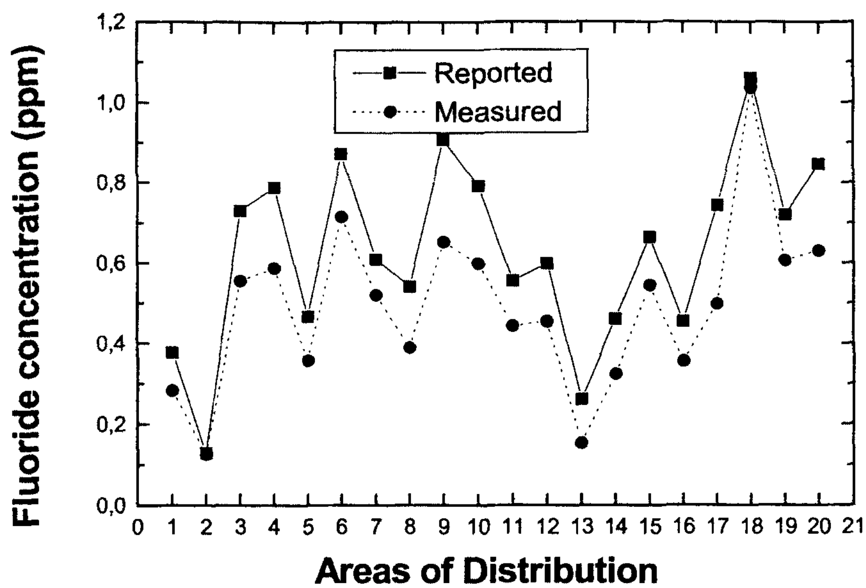
Statistical Analysis. The Levene test was used to analyze the variability among the different areas of water distribution. Because the range of fluo-

TABLE 1
Fluoride Concentration (ppm) in Water Samples

	Dates*												
Areas	28/07	30/07	02/08	04/08	06/08	09/08	11/08	13/08	16/08	18/08	20/08	23/08	Mean (SD)†
1	0.200	0.448	0.376	0.200	0.260	0.170	0.190	0.330	0.330	0.368	0.296	0.232	0.283 (0.088)
2	0.060	0.050	0.052	0.052	0.052	0.056	0.058	0.334	0.018	0.072	0.072	0.640	0.126 (0.181)
3	0.304	0.672	0.876	0.380	0.320	0.332	0.388	0.492	0.668	0.808	0.704	0.712	0.554 (0.207)
4	0.460	0.688	0.676	0.440	0.432	0.436	0.268	0.544	0.644	1.032	0.704	0.728	0.587 (0.200)
5	0.252	0.432	0.492	0.284	0.212	0.204	0.268	0.420	0.384	0.480	0.568	0.296	0.357 (0.121)
6	0.560	0.716	0.556	0.824	0.636	0.472	0.536	0.576	0.508	1.590	0.872	0.744	0.715 (0.303)
7	0.260	0.544	0.608	0.456	0.336	0.436	0.324	0.448	0.604	0.872	0.904	0.456	0.520 (0.202)
8	0.164	0.328	0.448	0.332	0.200	0.380	0.324	0.532	0.046	0.888	0.064	0.976	0.390 (0.292)
9	0.380	0.676	0.736	0.544	0.532	0.736	0.536	0.696	0.768	0.856	0.624	0.760	0.653 (0.134)
10	0.468	0.660	0.620	0.452	0.464	0.524	0.636	0.656	0.592	0.712	0.608	0.816	0.600 (0.109)
11	0.316	0.636	0.460	0.416	0.392	0.300	0.248	0.428	0.404	0.812	0.600	0.320	0.444 (0.163)
12	0.148	0.508	0.436	0.680	0.628	0.304	0.232	0.312	0.820	1.136	0.024	0.240	0.455 (0.316)
13	0.094	0.136	0.224	0.130	0.130	0.150	0.158	0.174	0.208	0.188	0.152	0.096	0.153 (0.040)
14	0.180	0.372	0.384	0.204	0.256	0.228	0.304	0.592	0.392	0.440	0.288	0.256	0.324 (0.117)
15	0.432	0.936	1.400	0.516	0.448	0.144	0.064	0.300	0.062	1.120	0.776	1.600	0.650 (0.519)
16	0.328	0.392	0.456	0.260	0.292	0.212	0.292	0.348	0.384	0.496	0.424	0.392	0.356 (0.083)
17	0.328	0.552	0.608	0.380	0.448	0.336	0.248	0.464	0.468	0.764	0.728	0.656	0.498 (0.165)
18	0.540	0.728	0.304	0.126	1.196	9.350	0.020	0.018	0.018	0.020	0.032	0.080	1.036 (2.644)
19	0.032	1.224	0.852	0.472	0.472	0.420	0.176	0.632	0.528	1.600	0.448	0.424	0.606 (0.435)
20	0.292	0.748	0.748	0.548	0.592	0.452	0.432	0.436	0.676	0.992	1.048	0.600	0.630 (0.227)
Mean (SD)‡	0.290 (0.153)	0.572 (0.263)	0.566 (0.284)	0.385 (0.193)	0.415 (0.245)	0.782 (2.023)	0.285 (0.162)	0.437 (0.167)	0.426 0.250	0.762 (0.435)	0.497 (0.315)	0.551 (0.355)	

*Samples collected in 1999.
†Mean (SD) fluoride concentration for individual areas during the test period.
‡Mean (SD) fluoride concentration on different days of collection.

FIGURE 1
Differences Between Fluoride Concentrations (ppm) Measured in This Study and Reported by City Water Department



ride concentrations found was too high, the nonparametric Kruskal-Wallis test was used to compare mean fluoride concentration in different areas.

Results

Table 1 shows the results of the fluoride concentrations found on different days in all the areas analyzed. Fluoride concentration ranged between 0.01 ppm and 9.35 ppm (n=240). There was a great variability both for the same area in different days and from day to day in one area. The Levene test confirmed this variability (P<.001). The Kruskal-Wallis test showed a statistically significant difference among mean fluoride concentration in different areas (P<.001). Eighty-nine percent of samples had fluoride concentrations below the optimum (0.8 ppm, for winter time). The control range set for Bauru is 0.1 ppm fluoride below or above the optimal concentration. Thus, 82 percent of the samples were below the minimum accepted level.

Figure 1 shows mean fluoride concentration in each area, as analyzed by our laboratories and reported by the City Water Department. Fluoride concentrations reported by the City Water Department were higher than those found in our laboratory analysis.

Discussion

Fluctuations in the fluoride concentration of monthly water samples from both adjusted and naturally fluoridated drinking water have been reported from various regions in the world (11-13), as well as in Brazil (14,19). In our work, a large fluctuation in water fluoride levels was observed, both on different days for the same area (areas 11, 12, 15, 18, 19) and between areas (Table 1, Figure 1). There was a tendency for hypofluoridation in most of the areas, and this is common in other Brazilian cities (14-17). In area 2, fluoride was present on levels above 0.1 ppm in only one day during the period in which samples were analyzed. Areas 6 and 9 maintained a relatively constant level around the optimum throughout the study period. In area 18, fluoride levels as high as 9.35 ppm were found in one of the samples. Curiously, there was no fluoride addition for the subsequent days, which included six collections over a 12-day period.

Many studies have discussed the cause of these fluctuations in water fluoride levels (10,11,13,20). Among the factors cited were size of the population, problems with the fluoride compound used, type and number of water sources, size of the water plant, variations in the main water flow, seasonal variations, water plant operator (e.g., training, age, turnover, and full- or part-time), equipment problems, and type of test to monitor results.

Bauru has 315,835 inhabitants and uses hydrofluosilicic acid, which is considered easier to use than powdered compounds, because it mixes more rapidly and uniformly with the water. Since it is considered a byproduct of agriculture fertilizer manufacturing, its cost is low (21). However, its production is seasonal, which implies that cities have to stock it for certain periods. This could explain interruptions in water fluoridation in some cities (14). In Bauru, the public drinking water comes from surface water (area 4), which supplies the central area of the city, and also from 29 wells. Both of these sources have only trace raw fluoride levels, with no considerable seasonal variations. The 29 wells are compiled into 19 areas of distribution and fluoride has to be added individually to each of them. This helps to explain the large fluctuations we found.

The water plant operators in Bauru are full-time employees, but they don't attend periodic training programs. Most of them have not graduated from college, and we could observe a lack of information concerning the risks of hyper- and hypofluoridation.

When comparing the fluoride levels reported by the City Water Department with the results of our analysis (Figure 1), the reported levels were always higher than measured levels. These differences were also observed in Los Angeles, CA (12); however, in that case the reported data were lower than the analyzed data. This implies that a more rigorous surveillance and monitoring of water fluoridation should be considered in many cities. In trying to explain the differences between the reported and measured levels, it is important to note that fluoride analysis was conducted differently in our laboratory than at the City Water Department. In our laboratory, analysis was conducted in mV and using a set of standard solutions that resulted in standard curves with a coefficient correlation of $r \geq 0.999$. The City Water Department conducted the analysis in concentration and used fluoride standards containing 0.1 ppm, 1.0 ppm, and 10.0 ppm fluoride. Thus, the calibration curve we used was more precise.

The effectiveness of fluoridation depends on how consistently the water plant operator maintains the optimal fluoride concentration. To ensure that water systems sustain an uninterrupted and unvarying optimal fluoride levels at all times, the operator must attend more stringent training programs, not only with respect to the analytical technique itself, but also in relation to the negative effects of the lack of control. Furthermore, a rigorous surveillance and monitoring of water fluoridation must be done.

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