Caries experience among schoolchildren in relation to community fluoridation status and town size

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The objective of the present study was to determine the caries experience of schoolchildren aged 7–12 years from the Southeast area of São Paulo State, Brazil, in 1998, according to town size and fluoridation status. Data for this cross-sectional study were based on the data bank from the Epidemiological Survey of São Paulo State provided by the State Health Department. After stratification by fluoridation status and town size, 29 towns were randomly selected to represent the Southeast area of São Paulo State, Brazil, and a total of 13,480 schoolchildren were randomly selected for this study. Calibrated dentists performed clinical examinations according to the WHO criteria. Caries experience and prevalence were significantly lower in fluoridated areas (1.9 DMFT, 2.1 dmft, 20% caries free) than in non-fluoridated areas (2.4 DMFT, 2.4 dmft, 13% caries free). According to town size, DMFT and caries prevalence were significantly higher in small towns (2.3 DMFT, 13% caries free), followed by medium-sized (2.1 DMFT, 17% caries free) and large cities (1.6 DMFT, 27% caries free). Among 12-year-old children, caries prevalence was predominantly moderate or high in small and medium-sized municipalities, whereas in large cities it was moderate or low. The results suggest that water fluoridation is an essential public health measure and that town size may affect caries distribution in the Southeast area of São Paulo State. □ *Demography; dental caries; epidemiology; fluoridation*

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Water fluoridation has been recognized as one of the 10 major public health achievements of the 20th century by the Centers for Disease Control and Prevention in the United States. In addition, this preventive measure has increased social equity by reducing the dental caries inequalities between the different socio-economic status strata (1).

In the scientific literature there are many reports referring to the beneficial effects of water fluoridation on the reduction of caries prevalence. In a recent and well-performed review about the safety and efficacy of water fluoridation, McDonagh et al. (2) evaluated 214 studies and verified an association among water fluoridation and an increase in the proportion of caries-free children, as well as a decrease in the number of teeth with lesions. In Britain, a 40% to 50% reduction in caries prevalence was observed in 5- and 12-year-old children (3). A 31% to 52% decrease in caries was found in the permanent dentition of children aged 7 to 9 years in Singapore (4). Reductions higher than 40% in DMFT were observed in children aged 7–12 years in Brazil. Besides these studies, several publications recognizing the benefits of water fluoridation can be found in the literature (5–10).

On the other hand, after interruption of water fluoridation, no increase in the frequency of caries in deciduous teeth was detected in Kuopio, Finland (11); in La Salud, Cuba, it was observed that caries prevalence remained low or reduced in children aged 6–13 years (12) and in former East Germany, the caries levels decreased significantly at age 12 years (13). In Brazil, a decrease in caries incidence among 11- and 12-year-old schoolchildren residing in a non-fluoridated town was also demonstrated (14).

Thus it seems that other factors in addition to the presence of fluoride in the water supply may have had an effect on the epidemiological trends of dental caries. In fact, statistical differences in DMFT among cities with similarly sized populations, independently of the presence or absence of fluoride in drinking water, have not been related. Furthermore, according to Griffin et al. (15), water fluoridation may not be cost saving for cities with populations of less than 5,000. Taking into account these facts and the caries decline in both fluoridated and non-fluoridated areas, it is important to determine the current influence of water fluoridation on caries prevalence in developing countries on the basis of town size. Therefore, the objective of the present study was to determine caries experience in relation to fluoridation status and town size in municipalities of São Paulo State, Brazil.

Materials and methods

The Epidemiological Survey of São Paulo State, Brazil, was carried out in 1998 with the purpose of evaluating oral health patterns. The study was approved by the Research

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Table 1. Number and percentage of schoolchildren aged 7–12 years examined according to town size and fluoridation status. Southeast area of São Paulo State, Brazil, 1998

	Fluoridation status					
	Fluoridated areas		Non-fluoridated areas		Total of schoolchildren	
Town size	*n*	%	*n*	%	*n*	%
Large	2,451	81	591	19	3,042	100
Medium-sized	2,404	60	1,575	40	3,979	100
Small	3,551	55	2,908	45	6,459	100
Total no. of schoolchildren	8,406	62	5,074	38	13,480	100

Ethics Committee of the School of Public Health/ University of São Paulo (Faculdade de Saúde Pública/ Universidade de São Paulo—FSP/USP), process number 62/98.

First, the cities of the Southeast area, as well as of other areas of São Paulo State, were pre-stratified according to the size of the town and fluoridation status. The towns were classified in conformity to three town size categories as large (more than 50,000 inhabitants), medium-sized (10,000–50,000 inhabitants) and small (fewer than 10,000 inhabitants) and according to two types of artificial fluoridation status: fluoridated areas (FAs) and non-fluoridated areas (NFAs). Water fluoridation data were gathered from official information and the presence of areas with natural high fluoride levels has not been related. Thus, from a total of 138 towns in the Southeast area of São Paulo State, 29 were randomly selected to represent the quoted area.

The sample size was defined according to World Health Organization—WHO (16) recommendations for areas that present moderate or high caries prevalence. Public and private schools were randomly selected in each city from the official records supplied by the State Education Department. Next, the subjects aged 7–12 years were chosen at random in each school, making a total of 13,480 schoolchildren. The sample distribution in relation to town size and fluoridation status is presented in Table 1. The overall gender distribution was 49% males and 51% females.

Four groups, comprising an average of 16 dentists each, participated in calibration sessions. Training was divided into theoretical discussions and practical activities, amounting to about 40 h for each group. Inter-examiner reliability, assessed by percentage of agreement, was above 85%, which is an admissible value according to the WHO (16). To assess the consistency of each examiner, duplicate examinations were conducted on 10% of the sample.

Oral examinations were carried out over a period of 3 months and were performed at school in well-lit and aerated classrooms, or outdoors close to a water source. All children lay down on school desks and the examiners stood in a 12:00 o'clock position in relation to the child's head. The instruments used for dental examinations were dental mirrors and CPI probes. Caries were diagnosed according to the WHO criteria (17).

Data were annotated on individual records proposed by FSH/USP, processed using the Epi-Info software version 5.01 and analyzed with the EPIBUCO Program. A substantial amount of time was directed to cross-checking data entry and only 0.1% of the fields for dental caries was not valid. Among the 7 to 12-year-old schoolchildren, 13% did not show up at the examination.

Caries experience was expressed using the DMFT and dmft indexes. Children who presented both dmft and DMFT = 0 were considered to be caries free. In addition, the mean caries experience for those with the disease (DMFT > 0) was calculated by excluding the schoolchildren having no caries experience (DMFT = 0).

In order to explore the caries experience for schoolchildren aged 7–12 years according to fluoridation status and town size, they were pooled to form a single group. This was possible since the final study sample included children of different ages in the same proportion as that in the target population.

Since the DMFT and dmft indexes did not present a normal distribution, data were analyzed statistically by non-parametric tests with an alpha = 0.05 for statistical significance. The chi-squared test was applied to determine the differences in caries-free children and in those who showed DMFT > 0. The Mann-Whitney test and the Kruskal-Wallis one-way analysis of variance (ANOVA) with Dunn's method were used to evaluate differences in mean DMFT and dmft.

Table 2. Mean DMFT for schoolchildren according to age and fluoridation status. Southeast area of São Paulo State, Brazil, 1998

		Fluoridation status	
Age	*n*	Fluoridated areas DMFT (*s*)	Non-fluoridated areas DMFT (*s*)
7	2,185	0.6 (1.2)[b]	0.9 (1.3)[a]
8	2,290	1.1 (1.5)[b]	1.5 (1.7)[a]
9	2,358	1.7 (1.8)[b]	2.0 (1.9)[a]
10	2,403	2.1 (2.1)[b]	2.6 (2.4)[a]
11	2,159	2.5 (2.5)[b]	3.4 (2.8)[a]
12	2,085	3.3 (3.2)[b]	4.4 (3.5)[a]

(*s*) = standard deviation.
Means followed by different letters are statistically different within the same age by the Mann-Whitney test ($P < 0.001$).

Table 3. Mean DMFT for schoolchildren according to age and town size. Southeast area of São Paulo State, Brazil, 1998

		Town size		
Age	*n*	Large DMFT (*s*)	Medium-sized DMFT (*s*)	Small DMFT (*s*)
7	2,185	0.5 (1.0)[b]	0.7 (1.2)[a]	0.8 (1.4)[a]
8	2,290	1.0 (1.4)[b]	1.4 (1.6)[a]	1.3 (1.6)[a]
9	2,358	1.4 (1.7)[b]	1.8 (1.7)[a]	2.0 (2.0)[a]
10	2,403	1.7 (2.1)[b]	2.5 (2.2)[a]	2.5 (2.2)[a]
11	2,159	2.1 (2.2)[c]	2.8 (2.5)[b]	3.2 (2.9)[a]
12	2,085	2.8 (3.0)[b]	3.7 (3.4)[a]	4.0 (3.4)[a]

(*s*) = standard deviation.
Means followed by different letters are statistically different within the same age by the Dunn test ($P < 0.05$).

Results

According to age, caries experience was significantly lower in schoolchildren residing in fluoridated areas (Table 2). Among children aged 7, 8, 9, 10, and 12 years, the mean DMFT was significantly higher in small/medium-sized towns than in large cities, whereas among children aged 11 years there were significant differences between small towns, which showed higher DMFT, and medium-sized/large cities (Table 3).

The mean disease experience for schoolchildren presenting DMFT > 0 was significantly higher in small/medium-sized cities than in large cities for 8-, 10-, and 12-year-old children, whereas for 11-year-old children there was a significant difference only between small and large cities (Table 4). At 12 years of age, caries prevalence was predominantly moderate or high in small and medium-sized cities, and moderate or low in large cities.

Considering the 7–12-year age group, the caries experience was significantly lower in deciduous and permanent teeth, as well as in those showing DMFT > 0 and the percentage of caries-free children was significantly higher in FAs than in NFAs (Table 5).

According to town size, large cities presented a significantly lower dmft/DMFT and a higher percentage of caries-free children than small and medium-sized towns. Considering cities of the same size, DMFT and DMFT > 0 were statistically higher in NFAs than in FAs. On the other hand, the number of caries-free schoolchildren and the number of those showing DMFT > 0 in FAs were not significantly different from NFAs in small towns, in contrast to medium-sized and large cities (Table 6).

Discussion

In this study we assessed caries experience in 7 to 12-year-old children residing in fluoridated and non-fluoridated areas of the Southeast of São Paulo State, Brazil. Although a Brazilian law from 1975 requires all cities to add fluoride to the water supply, several of them are deprived of this benefit. In this study, 38% of the subjects examined lived in non-fluoridated communities.

It should be pointed out that this study did not take the fluoride history of schoolchildren into consideration since some may have moved from fluoridated to non-fluoridated areas and vice versa, or the time when water fluoridation was implemented in each municipality. Despite the availability of official information about fluoridation, few cities have monitored daily fluoride levels in the water distribution system. Furthermore, it is important to mention the 'halo' effect, i.e. the diffusion of beverages and food processed in FAs but consumed in NFAs, which might spread some benefit of the fluoridation of the water supply to non-fluoridated communities.

As can be seen in Table 2, the DMFT index increases with age. This is a common occurrence since increasing age leads to an increasing chance for a tooth to develop dental caries.

Although other possible fluoride sources in NFAs could be producing the halo effect, e.g. fluoridated dentifrices, which have been available in Brazil since 1989 (6), mouthrinses at schools, and professionally applied topical fluoride products, caries experience and prevalence were significantly higher in NFAs than in FAs (Tables 2 and 5). These results are similar to those obtained elsewhere (5, 9). Although they do not imply causality, it could be suggested

Table 4. Caries experience for schoolchildren with DMFT > 0 according to age and town size. Southeast area of São Paulo State, Brazil, 1998

		Town size		
		Large	Medium-sized	Small
			For DMFT > 0	
Age	*n*	DMFT (SD)	DMFT (SD)	DMFT (SD)
7	696	2.0 (1.1)[a]	2.2 (1.1)[a]	2.3 (1.3)[a]
8	1,143	2.4 (1.2)[b]	2.6 (1.4)[a]	2.5 (1.3)[a]
9	1,469	2.7 (1.3)[a]	2.8 (1.3)[a]	3.0 (1.7)[a]
10	1,665	3.0 (2.0)[b]	3.4 (1.9)[a]	3.4 (1.9)[a]
11	1,583	3.4 (1.9)[b]	3.7 (2.3)[ab]	4.1 (2.6)[a]
12	1,674	4.1 (2.8)[b]	4.6 (3.2)[a]	4.7 (3.2)[a]

(*s*) = standard deviation.
Means followed by different letters are statistically different within the same age by the Dunn test ($P < 0.05$).

Table 5. Caries experience for schoolchildren aged 7–12 years according to fluoridation status. Southeast area of São Paulo State, Brazil, 1998

Areas	dmft (*s*)*	DMFT (*s*)*	For DMFT >0 %†	For DMFT >0 Mean*	Caries free (%)†
Fluoridated	2.1 (2.7)[b]	1.9 (2.3)[b]	58[b]	3.2[b]	20[a]
Non-fluoridated	2.4 (2.8)[a]	2.4 (2.6)[a]	67[a]	3.6[a]	13[b]
P value	<0.001	<0.001	<0.001	<0.001	<0.001

(*s*) = standard deviation.
*Means followed by different letters are statistically different by the Mann-Whitney test.
†Percentages followed by different letters are statistically different by the chi-squared test.

that water fluoridation has fundamental benefits in the Southeast area of São Paulo State, Brazil, since schoolchildren from FAs demonstrated better dental health conditions than those from NFAs. According to Loh (4), this preventive measure has been recognized in Singapore as an economical and safe method and the most effective public health measure available for the prevention of dental decay. Some of its chief advantages are the fact that no active participation of individuals or of the community is required, that all people in the community are reached, including those of low economic status, plus the benefit to both children and adults, the continuous supply of a low dosage, and the cost effectiveness (18).

The dental caries patterns observed in relation to town size demonstrated that caries experience decreases with increasing town size, and more so among those who present DMFT > 0. Schoolchildren from small towns presented the highest caries prevalence and a significantly higher DMFT than those from large and medium-sized cities, regardless of whether they were from FAs or NFAs. Furthermore, no significant differences in dmft, percentage of DMFT > 0, or caries-free children between FAs and NFAs were found in small municipalities (Table 6). These findings imply that, despite the benefits of water fluoridation, some features of small towns may play an important role in the distribution of dental caries. In fact, because of their size, small towns in Brazil receive less financial support from the federal government than medium-sized and large cities. Thus, several factors such as socioeconomic development, access to oral health care, availability of information about oral health, pattern of food consumption, changing lifestyles, etc., might be responsible for causing these disparities. In addition, the lowest values of the Human Development Index in the year 2000 were 0.645, 0.779, and 0.786 for small, medium-sized and large cities, respectively, demonstrating a better standard of living in large cities.

At the age of 12 years, caries prevalence was predominantly moderate or high in small and medium-sized towns, whereas it was moderate or low in large cities. There is a paucity of caries data in relation to town size in the literature. In other cities of São Paulo State, Brazil, Peres et al. (19) found that most of the small and medium-sized municipalities presented a high caries prevalence, as opposed to a predominantly moderate prevalence in the large cities. Baldani et al. (10) detected a high and moderate caries prevalence in small/medium-sized and large cities, respectively, in Paraná State, Brazil. These results show that the oral health of 12-year-old schoolchildren in the Southeast area of São Paulo State is better than that in the state as a whole and in Paraná. In addition, it seems that large cities present a moderate

Table 6. Caries experience for schoolchildren aged 7–12 years according to town size and fluoridation status. Southeast area of São Paulo State, Brazil, 1998

Town size and fluoridation status	Mean dmft* (*s*)		Mean DMFT* (*s*)		For DMFT > 0 %†		For DMFT > 0 Mean (*s*)*		Caries free† (%)	
Large	1.9 (2.6)[b]		1.6 (2.1)[c]		50[c]		3.1 (2.1)[b]		27[a]	
Fluoridated areas (*n* = 2,451)	1.8 (2.5)	ns	1.5 (2.0)	s	49	s	3.0 (1.9)	s	28	s
Non-fluoridated areas (*n* = 591)	2.1 (2.8)		2.0 (2.5)		58		3.5 (2.4)		22	
Medium-sized	2.3 (2.8)[a]		2.1 (2.4)[b]		62[b]		3.3 (2.2)[a]		17[b]	
Fluoridated areas (*n* = 2,404)	2.0 (2.6)	s	1.8 (2.1)	s	57	s	3.1 (2.0)	s	22	s
Non-fluoridated areas (*n* = 1,575)	2.7 (3.0)		2.6 (2.6)		71		3.7 (2.4)		10	
Small	2.3 (2.8)[a]		2.3 (2.6)[a]		65[a]		3.5 (2.4)[a]		13[c]	
Fluoridated areas (*n* = 3,551)	2.3 (2.8)	ns	2.2 (2.5)	s	65	ns	3.4 (2.4)	s	13	ns
Non-fluoridated areas (*n* = 2,908)	2.4 (2.8)		2.4 (2.6)		66		3.6 (2.4)		12	

(*s*) = standard deviation; s = significant; ns = non-significant, according to the Mann-Whitney test ($P < 0.05$).
*Means followed by different letters are statistically different by the Mann-Whitney test ($P < 0.05$).
†Percentages followed by different letters are statistically different by the chi-squared test ($P < 0.05$).

caries prevalence, while in small and medium-sized towns a moderate to high caries level is observed.

Nevertheless, it is important to emphasize that this is a cross-sectional study and has no previous data. Therefore it is possible that the caries prevalence in small towns has been declining but continues to be high in comparison with that of large cities.

Although water fluoridation is not enough to eliminate caries disease, we suggest that it is an important public health measure in Brazil in reducing caries prevalence and severity as well as the disparities in dental health, and should therefore be maintained or implemented. Finally, it seems that town size influences caries distribution in the São Paulo State, and probably in many other localities in Brazil. However, further studies are needed to confirm this assumption.

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