Caries Prevalence in a Rural Chilean Community after Cessation of a Powdered Milk Fluoridation Program

Rodrigo J. Mariño, PhD; Alberto E. Villa, PhD; Andrea Weitz, CD; Sonia Guerrero, CD

Abstract

Objective: *The milk fluoridation scheme established in Codegua, Chile, between 1994 and 1999 demonstrated the effectiveness of powdered milk as a community-based vehicle for fluoride to prevent dental caries. The present study aimed to compare caries prevalence in both the Codeguan control and test communities, three years after ending fluoride distribution through the powdered milk fluoridation scheme, to assess whether the benefits of such milk fluoridation were still present in the test community.* ***Methods:*** *Children 3–6 years old living in Codegua (test community) and La Punta (control community) were examined for dental caries at their educational facilities by three trained and calibrated examiners using natural light, dental mirrors, and sickle probes. Differences in caries prevalence (dmfs) by year of the study were tested for statistically significant differences using the Mann-Whitney U test.* ***Results:*** *Findings from Codegua (1999–2002) indicate that the dental caries experience increased in all age groups following the termination of powdered milk fluoridation. These differences reached levels of statistical significance in the 3-, 4-, and 5- year old group (P<.03). Comparing results from Codegua and La Punta (2002), no statistically significant differences were found.* ***Conclusions:*** *Termination of the powdered milk fluoridation scheme resulted in a deterioration of the dental health of children. After three years, dental caries prevalence was higher than that reached at the end of the scheme and equivalent to that of the control community without fluoride exposure. These results emphasize the need to establish and maintain an alternative mechanism of community-based fluoridation of proven effectiveness for the prevention of dental caries in communities where water fluoridation is not available. [J Public Health Dent 2004;64(2):101-5)*

Key Words: milk, fluoridation, Chile, rural communities, fluorides, dental caries prevalence.

For more than 50 years, laboratory, clinical, and community researchers have studied the action of fluorides in preventing dental caries. This public health measure is now accepted as a safe, effective, efficient, and appropriate mechanism for the prevention of dental caries (1-4). Indeed, the use of fluorides (F) is recognized as one of the most successful measures for the prevention of disease in the history of public health (5). However, considerably less attention has been devoted to the issue of the cessation of fluoridation and its effect on dental caries experience. Due to ethical considerations, it is extremely difficult to conduct this type of study (6,7). However, opportunities may emerge when exposure to fluoridation is stopped for other reasons, such as administrative measures. Burt and his collaborators (6) have referred to this as "opportunistic epidemiology." One such opportunity emerged after the end of the milk fluoridation program in Codegua, Chile.

In Chile, the National Complementary Feeding Program (PNAC), a public nutritional program, has operated successfully for the last 40 years with a national coverage of about 90 percent (8). Under PNAC, every Chilean child is entitled to receive, with no charge, 2 kilos of powdered cow's milk (Purita™) per month, from birth until 2 years old. One kilo of a milk derivative (Purita Cereal™) is delivered monthly to children aged 2–6 years. Taking into account these characteristics, the Institute of Nutrition and Food Technology, the University of Chile, used the PNAC products as a fluoride vehicle for caries prevention. That fluoridation scheme had several unique characteristics: it represented the first instance of the use of fluoridated powdered milk; disodium monofluorophosphate (MFP) was used as the fluoridating agent; every child participating in the scheme received fluoridated milk and milk derivatives; and every child participating in the scheme received fluoridated milk and milk derivatives from birth to 6 years of age, 365 days per year (9).

In the Chilean scheme, children from the test community who had access to powdered milk fluoridation during the eruption of their deciduous teeth showed a decline in dental caries experience when compared to both baseline and a control community. For example, the overall caries experience (dmfs) of children aged 3–6 years from Codegua declined from 11.78 in 1994, to 3.35 in 1999, which represented a reduction of 72 percent (9). This supports Stephen and collaborators' contention (10) regarding the advantages for dental caries prevention in primary dentition when commencing fluoride exposure as early as possible in life.

Several studies have reported on the effect on dental caries after a fluoridation scheme is discontinued. Traditionally, one would expect that when fluoride is discontinued, there would be a parallel increase in dental caries

Send correspondence and reprint requests to Dr. Mariño, School of Health, University of New England, Armidale, NSW 2351, Australia. E-mail: rmarino@metz.une.edu.au. Drs. Villa, WeitZ, and Guerrero are affiliated with the Department of Public Nutrition, Institute of Nutrition and Food Technology, University of Chile, Santiago, Chile. This paper was orally presented at the IV Congreso Nacional de Odontopediatria (VI National (Chilean) Congress of Dentistry for Children, Santiago, Chile, Nov 2002. This study was funded by a grant from the Borrow Foundation. Manuscript received: 5/12/03; returned to authors for revision: 7/15/03; final version accepted for publication: 11/3/03.

(11-14). However, other studies show that after the stoppage of water fluoridation programs, there was no increase in dental caries in children (7,15-19). In fact, in some of these cases, dental caries incidence fell after the cessation of exposure to fluoridation programs.

However, for some authors, reports of decreases in dental caries experience after the cessation of fluoridation could be attributed to the introduction of other fluoride exposures, such as fluoride mouthrinses, fluoride varnishes, and availability of toothpaste (6,7,19,20). Also, the context of these studies should be taken into consideration, as other reports show that dental caries is not evenly distributed in the population and great variation exists within countries (7,21-23). Studies also indicate that the communities that may benefit most from the effect of fluoride are usually those least able to access the most common vehicles of community-based fluoride, such as water (24). It would also appear that some segments of the population benefit most from the preventive effect of fluoride through a combination of multiple sources (7)—for example, access to fluoride toothpaste, access to a less cariogenic diet, and to a lesser extent access to oral health care services (7,23).

In this way, the social context of the Chilean study differs significantly from those described in the literature (Canada, Denmark, Finland, the Netherlands, and Sweden) regarding the effect of the cessation of water or other methods of fluoridation. In social situations such as those conditions prevailing in rural Chile, these effects have not been studied. From a public health perspective, information from the present study will not only increase present knowledge regarding the use of fluorides, in particular powdered milk fluoridation, but it will also provide the necessary evidence to support maintenance, future expansion, or the introduction of fluoridation schemes under conditions such as those prevailing in Chile.

While in many Latin American countries salt fluoridation is the preferred community-based program, water fluoridation has been in operation in Chile since 1985 (25). Additionally, the existence of established free milk delivery programs indicates that the use of powdered milk fluoridation, although not a national policy in Chile, represents an ideal mechanism for children living in communities where other forms of community-based fluoride are not feasible, possible, or recommended (26,27). Policy makers should ensure that these factors inform future initiatives or new recommendations on fluoride use and public health policies.

The aims of the present study are to report on dental caries prevalence in children 3–6 years old living in the localities of Codegua and La Punta, VI Region, Chile, in 2002, i.e., three years after the cessation of fluoride exposure through powdered milk; and to compare these data with those collected in 1999 after four years' exposure to fluoride in the Codegua powdered milk fluoridation scheme, 1995–99 (8,28). More specifically, the study tested the hypothesis that cessation of exposure to fluorides using powdered milk as the vehicle for fluoride will be related to an increase of the caries experience over a period of three years in the deciduous dentition of children.

Methods

Population and Sample. For the 1995–99 powdered milk fluoridation scheme, two communities from the Chilean 6th region were selected following a matching scheme based on geographic proximity, community size, and similarity with regard to the prevalence of the outcome under study (29). Codegua, an inland municipality some 100 km to the south of Santiago, the Chilean capital city, was the test community. It is located at approximately 600 meters above sea level and had a population of 10,796 in 2002 (30). La Punta, the control group, is a nearby rural community, comparable in size, sociodemographic conditions, and economic activity to Codegua. La Punta is located some 10 km north of Codegua. Administratively, La Punta is dependent on the municipality of San Francisco de Mostazal, where the community health center (CHC) is located. Despite the difference in distance from the CHC in the control community compared to the test community, children from Codegua and La Punta have to go to the regional capital (Rancagua) for dental treatments other than emergencies. Furthermore, these communities were also similar in other oral health-related environmental variables, such as media (TV, radio, print) exposure laws and regulations.

Sources of fluoride exposure were reassessed for children aged 3–6 years living in both communities. It was found that, with the exception of fluoride in toothpaste, after the cessation of the powdered milk fluoridation scheme in Codegua in 1999, fluoride exposure was not present in either community. Regarding the use of toothpaste, aside from any home use, in both communities toothbrushing was done twice a day in all day care centers dependent on the Ministry of Education (31). This assured that the time of commencement of toothbrushing and toothbrushing behavior was standard in both communities.

The study included cohorts aged 3–6 years from two communities: Codegua, the test community, which took part in the 1995–99 powdered milk fluoridation scheme; and La Punta, the control community during 1995–99. Age groups of children allowed for the detection of preventive effects at different lengths of exposure to fluorides. Three-year-old children from the test community were born after the powdered milk fluoridation scheme was discontinued and, therefore, were not exposed to fluoridated milk. Six-year-old children were exposed to powdered milk fluoridation from birth to 3–4 years of age, representing the largest exposure to fluoride from milk under that scheme. For the test community, the 2002 cohort was compared with the equivalent age cohorts, in 1999. Details of these communities have been described elsewhere (9).

Convenience samples of 50 children in Codegua and 50 children in La Punta in each age cohort attending public kindergartens were examined. Thus, 200 children in these four age cohorts were examined, all of whom were life-long residents in each community. The sample size for each community (n=200) provided a power of 0.80 using Cohen's criteria (32) to obtain an effect size of 0.5 [(raw 1999 dmfs mean–raw 2002 dmfs mean)/standard deviation]. This is defined as a moderate effect size (32), in a unidimensional test, at the significance criterion of 0.05 (32). Additionally, these sample sizes were considered a reasonable coverage of each age group, considering that in both communities each of the age groups was

made up of about 200 individuals.

Clinical Examinations. In 2002 the round of examinations utilized the same diagnostic criteria as the milk fluoridation study (1995–99). That is, examinations were conducted under natural light, using dental mirrors and sickle probes at educational facilities or at the home of some 3-year-olds, in both communities. Children were positioned facing a large window in a schoolroom, teeth were not dried before scoring, but they were cleaned when detritus prevented assessment. Caries diagnostic criteria followed those of the World Health Organization (33) and the National Institute of Dental and Craniofacial Research (34). Clinical data were recorded on standard WHO forms (SUP/92/33580). Radiographic examinations were not performed. Dental status experience was assessed using the dmfs index for deciduous dentition.

Three examiners trained and calibrated in the use of the dental caries index conducted the examinations. Two of them (SG, RM) were also in the team for the 1994–99 powdered milk fluoridation study. The examinations were preceded by a recalibration exercise. Examiners were calibrated against themselves and against one of the other examiners (SG) in the application of diagnostic criteria. Reliability of examiners was determined through the use of the kappa statistic. Inter- and intraexaminer reproducibility achieved in the duplicate examinations of 24 children reached "almost perfect agreement" levels (i.e., kappa >0.90) according to Cohen criteria (35).

Data Analysis. Descriptive statistics were used to summarize demographic information and percentage distribution of caries experience using the dmfs index by exposure group and by year of the study (i.e., 1999 and 2002). Differences in caries experience (dmfs) by exposure group and by year of the study were tested using the Mann-Whitney U test and chi-square test. For all statistical tests, the level of statistical significance was set at $P<.05$.

The Committee of Ethics of INTA, University of Chile, approved the protocol of this study. Letters were sent to the parents and/or guardians of each child in these two communities, requesting consent for dental examinations.

Results

In 1999, 252 children aged 3 to 6 years were examined in Codegua and 240 children of the same age range were examined in La Punta. In 2002, there were 201 children from Codegua and 207 from La Punta who fulfilled the previously defined criterion for age. The age-specific mean numbers of decayed, filled, and missing primary surfaces in children from Codegua, the former study community, and La Punta, the former control community, by year are shown in Table 1. Caries experience data from Codegua in 2002 show that, for ages 3, 4, and 5 years, differences were statistically significant when compared with data from 1999. The exception was the 6-year-old group where, although there was an increase in caries history, it did not reach statistical significance ($P>.05$). In La Punta, although there was some variation in the mean dmfs values, these differences were not statistically significant between 1999 and 2002. Mean dmfs values of children in Codegua and La Punta in 2002 were not significantly different at any age.

Table 2 shows the age-specific proportion of children free from dental caries experience (dmf=0) between 1999 and 2002 in Codegua and in La Punta. For Codegua, these comparisons show statistically significant decreases in the proportion of children free from caries experience when comparing data from 2002 with data from 1999. Again, results from the 6-year-old group did not reach statistical significance. On the other hand, the proportion of caries-free children in La Punta between 1999 and 2002 did not show statistically significant differences. In the same way, the proportions of caries-free children in Codegua and in La Punta in 2002 were not significantly different.

Discussion

The Codegua powdered milk fluoridation program was available to all children 0–6 years of age living in Codegua for a four-year period. Termination of this milk fluoridation

TABLE 1
Age-specific Mean Number of Decayed, Missing, and Filled Tooth Surfaces (dmfs) and Standard Deviations in 3–6-year-old Children Living in Codegua and La Punta (Rural Chile) in 1999 and 2002

	Codegua			La Punta			La Punta-Codega
Age	1999	2002	*P**	1999	2002	*P**	*2002 P**
3 years	1.52 (2.48)	5.20 (10.54)	.01	3.85 (5.67)	3.28 (6.16)	NS†	NS†
n	60	50		59	50		
4 years	3.18 (7.27)	5.73 (9.12)	.03	4.22 (5.00)	6.91 (9.34)	NS†	NS†
n	64	48		60	55		
5 years	3.03 (4.83)	5.85 (6.85)	.02	5.61 (7.05)	8.43 (10.38)	NS†	NS†
n	66	52		59	51		
6 years	5.63 (6.23)	7.94 (7.91)	NS†	8.79 (8.89)	12.33 (12.64)	NS†	NS†
n	62	51		62	51		
3–6 years	3.35 (5.68)	6.19 (8.70)	.001	5.65 (7.08)	7.74 (10.36)	NS†	NS†
n	252	201		240	207		

*Mann-Whitney U test.
†Nonsignificant.

TABLE 2
Percentage of Children Free from Dental Caries History by Age: Comparisons Between 1999 and 2002 in Codegua and in La Punta and Between Codegua and La Punta in 2002

	Codegua			La Punta			La Punta-Codegua
Age (Years)	1999 (%)	2002 (%)	P*	1999 (%)	2002 (%)	P*	2002 P*
3	63.3	42.0	<.05	37.3	52.0	NS†	NS†
4	53.1	35.4	<.05	31.7	34.5	NS†	NS†
5	50.0	32.7	<.05	33.9	29.4	NS†	NS†
6	27.4	19.6	NS†	16.1	11.9	NS†	NS†
3–6	48.4	32.5	<.01	29.6	31.9	NS†	NS†

*Chi-square test.
†Nonsignificant.

scheme resulted in a deterioration of the dental health of these children. In 2002, three years after the powdered milk fluoridation scheme ended, caries prevalence was higher than that reached at the end of the scheme and equivalent to that of the control community without fluoride exposure. The 6-year-olds in Codegua may still have some residual benefit from their earlier exposure to milk fluoridation. Nonetheless, the study suggests some level of deterioration of their dental health.

Findings from both La Punta and Codegua do not support the reported trend in reduction in caries prevalence in either fluoridated or nonfluoridated communities. On the contrary, the data presented here follow the conclusion of several studies of caries dynamics after community fluoridation schemes are discontinued (11), i.e., there was a clear trend toward deterioration in dental health following the termination of the powdered milk fluoridation.

The objectives of the Ministry of Health in Chile are to improve the health of the population and to reduce health inequalities by improving the health of the most disadvantaged groups in Chilean society (36). For these purposes, the Chilean has set some goals in dentistry, which include the reduction of dental caries indices, increased access to oral health care services, and increased water fluoridation coverage (36). In fact, although there are alternative vehicles for fluorides, fluoride in communal water supply has been described as offering a cost-effective way for lowering the risk of caries in low-income, deprived communities (37).

The influence of place of living, that is rural versus urban, has been reported as a mediator for oral health status (38,39). It is generally accepted that children living in rural areas have poorer oral health than those living in urban areas. Lack of access to fluoridated water supplies, low participation in dental caries-preventive programs, and less exposure to fluoride through toothpaste have been the main reasons for these differences (18,40). In the case of Chile, children living in rural areas, in particular small rural localities where no water fluoridation is expected to be introduced, are virtually left without a method of continuous fluoride exposure, aside from any home use of fluoridated toothpaste. These children should constitute the target group for the implementation of an alternative mechanism of fluoridation of proved effectiveness for the prevention of dental caries.

Estimates of the Chilean population living in small rural areas where water fluoridation is not available, and will never be under current conditions, are about one-and-a-half million, or 10 percent of the Chilean population, and 78 percent of all rural areas (30,41). The present results emphasize the need to establish an alternative vehicle to fluoridated water for these communities. Milk as a vehicle for fluoride acquires great relevance in programs targeting those communities, under the situations prevailing in Chile (i.e., an ongoing, free, powdered milk distribution program).

Milk fluoridation might be considered a short-term measure (24), as it cannot be implemented over a lifetime span. This is because these programs cannot be implemented easily beyond the age when children leave mandatory education (year 12 in Chile). Nonetheless, communities such as the one under study here and others contemplated in an expansion of the powdered milk fluoridation program in Chile (42) were never considered under other, more traditional, community-based fluoridation vehicles used in Chile (i.e., water). In those communities, as in any other situation, oral health cannot be addressed solely by providing clinical treatment. Strategies are needed to ensure access to oral health promotion and oral disease prevention policies, approaches and programs capable of reducing oral health inequalities using all available evidence.

In the past, researchers have questioned the use of milk as a vehicle for fluoride (27). There are still many logistical or practical situations that might render milk an unsuitable vehicle for fluorides. However, the authors' contention is that, for situations equivalent to those prevailing in Chile, powdered milk fluoridation would be appropriate. It would be unfortunate for policy makers, health planners, and public health officers not to base their decisions on all available evidence about alternative vehicles for fluoride and the overall potential of milk fluoridation in areas where other mechanisms of community delivered fluoridation are not possible or available.

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