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Reduction of caries in rural school-children exposed to fluoride through a Milk-Fluoridation Programme in Araucania, Chile

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Objective To assess the effectiveness of a dental caries prevention programme on the permanent dentition of Chilean rural schoolchildren using fluoridated powdered milk and milk derivatives. ***Basic research design*** The fluoridated products were delivered to 35,000 schoolchildren in the rural areas of the Ninth Region in Chile using the standard School Feeding Programme (PAE). The daily fluoride dose from milk fluoridated products was estimated at 0.65 mg/day, during approximately 200 schooldays/year. Cross-sectional samples of schoolchildren aged 6, 9 and 12 years from study communities and from positive control communities (ongoing APF-gel programme) were examined at the start of the study in November 1999 and after 36 months. ***Results*** No significant differences were found for the DMFT and dmft indices among 6-year-olds in the study and positive control groups either at baseline or 36 months later. Significant reductions (range 24-27%) were observed in the DMFT index in 9 and 12-years-olds of the study communities when clinical data at baseline, in the absence of a fluoridated preventive programme, were compared to those obtained after 36 months of receiving fluoridated milk products. Upon the follow-up examination, the DMFT indices of schoolchildren aged 9 and 12 years old receiving fluoridated milk were not significantly different from those of the positive control comparison group of the APF-Gel programme. ***Conclusions*** Considering the relative costs and technical difficulties involved in both caries preventive programmes, it appears that in rural Chilean communities, fluoridation of powdered milk and milk derivatives is an effective alternative caries prevention programme in areas where either water fluoridation or other community delivered programmes are difficult to apply.

Key words:, APF Gel programme, Chile, dental caries, milk-fluoridation programme, rural schools

Introduction

The prevalence of dental caries in Chile is considered to be high in schoolchildren. In Chile, the Health authorities' policy for community caries prevention is water fluoridation. This programme has been in operation since 1985 (Villa *et al*.; 1998) as an established programme in the Fifth Region and has been gradually expanded since 1996 throughout the country. However, the coverage of the waterworks companies reaches only urban and semi-urban zones. Presently, 80% of the Chilean population has fluoride in its drinking water supplies.

Milk fluoridation might represent a complementary preventive mechanism for children living in communities where water fluoridation or other forms of community-based fluoride delivery (i.e. salt) are not feasible or possible (Künzel, 1993; Mariño, 1995). These communities are mainly rural areas, where children have a higher prevalence of caries and less access to dental care than children from urban or semi-urban areas.

In addition, the existence of established powdered milk and milk derivatives (products that includes a lower proportion of milk) delivery programmes in Chile suggests that these products could be used as a caries prevention vehicle by means of fluoride (F) addition. The Institute of Nutrition and Food Technology (INTA) of the University of Chile developed a successful milk-fluoridation scheme in a Chilean rural community (Mariño *et al.,* 2001). The results obtained in this latter study demonstrated that the overall caries incidence (dmfs) of the participating children aged 3-6-years declined significantly from 11.78 in 1994, to 3.35 in 1999, representing a 72% reduction (Mariño *et al.,* 2001).

The Chilean Commission for School Children Support, JUNAEB, a public institution of the Chilean Ministry of Education, provides a School Feeding Programme (PAE), which includes milk or milk derivatives at breakfast every day throughout the school year (approximately 200 days/year). The PAE Programme is provided free and has been successfully operated for the last 40 years with a wide national coverage of the elementary schools. Under PAE, schoolchildren (6- to 14-years-old, approximately) are entitled to receive 200 ml of milk per day, prepared from powdered milk adding potable water, during their elementary school education.

In order to support those children most vulnerable to dental caries, during the last ten years JUNAEB ran an APF-Gel Programme in the rural areas where water fluoridation could not be implemented. The APF-Gel programme was difficult to implement and its costs were high.

In looking for an alternative caries prevention programme that could be more convenient than the APF-Gel programme, JUNAEB took into account the successful results of the previous milk fluoridation scheme (Mariño *et al.,* 2001) and also considered the wide coverage of

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the PAE Programme. Thus, it was decided to assess the feasibility of using milk and milk derivatives as an F vehicle for caries prevention in the rural areas.

The aims of the present study were, i) to compare the effectiveness of the milk fluoridation programme after three years of application, in children aged 9 and 12 years old, residents of communities that had no preventive programmes at baseline, ii) to compare the effectiveness of two different dental caries prevention programmes (milk-fluoridation programme and APF-Gel programme) for the permanent dentition, and iii) to demonstrate that a milk-fluoridation programme is effective and feasible in rural zones of Chile as a complementary preventive programme, while urban and semi-urban areas are covered with potable F water.

Methods

The study protocol was approved by the Chilean Ministry of Health. Letters were sent to the parents of the 826 children in the participating rural schools of the Ninth Region, requesting their consent to being dentally examined and to receiving fluoridated milk.

The Ninth Region of Chile, known as Araucania, is located in the Southern part of the country some 650-800 km from Santiago, the capital city. The total population reached 869,535 in 2002 (according to the last national population census) and the rural areas were estimated as 32.3 % of the region.

The selection of the Araucania Region for this study was based on its mainly rural geographic characteristics. Thus, water fluoridation could not be implemented in most of its communities. Other crucial points considered were that, according to previous studies, the children had a high caries prevalence, low socioeconomic status and limited access to dental care.

Population and Sample

The study included three cohorts of rural schoolchildren from thirty one municipalities of the Ninth Region of Chile. For technical and administrative reasons, there were a number of rural schools that in the previous years to this study were not covered by any fluoride preventive programme. At baseline (1999), children aged 6, 9 and 12 years attending these schools were clinically examined and their caries experience was measured using the DMFT and dmft indexes. These scores were considered the baseline control (no intervention) values. After the baseline clinical examination, these schools were included in the fluoridated milk programme. Many more schools were also included in this latter programme but the follow up study was carried out on children attending the above mentioned schools. Thus, the study group consisted of children who participated in the milk-fluoridation programme, while the children participating in the APF Gel programme were considered as the "positive" control group. Only two municipalities including several schools that were historically covered by the APF-Gel programme were on this programme for comparison purposes. The APF-Gel programme was implemented from 1990 on, and included two 5-minute applications preceded by cleaning and drying of teeth, using a saliva ejector, by trained dentists.

Cross-sectional samples of children aged 6, 9 and 12 years from rural schools, present at school on the day of the clinical examination (in late 1999, at baseline; and in November 2002, at follow-up) were included. The sample size was determined using Cohen's criteria to obtain an effect size of five-tenths (0.5) [(raw control group mean – raw test group mean) / standard deviation] at the significance level of 0.05 and a power of 0.80. According to these criteria, the minimum sample size was 100 subjects in both the test and control groups for each age group (total number = 600), which were selected from 34 rural schools. Previous data on dmft and DMFT in the rural areas of the Ninth Region and the corresponding standard deviations were used as preliminary estimators.

Children were identified by date of birth. Although migration in these communities is low, children participating in the study were those with continuous residence in these rural communities. They were randomly selected in both baseline and follow- up studies from the same 34 schools.

The average daily F ingestion (200 times a year) from fluoridated milk products was set by the Health Ministry at 0.625 mg F/day among children 6 to 14 years old. Thus, the average F concentration of F-milk as drunk was 3.13 mg F/l. The fluoridating agent used was MFP, since its use with powdered milk was successfully applied in previous studies (Mariño *et al.,* 2001). The fluoridated products were delivered to approximately 35,000 schoolchildren in the rural areas of the Ninth Region using the standard School Feeding Programme (PAE) of JUNAEB. Fluoridated powdered milk and milk derivatives were prepared by a well-known powdered food manufacturing company. These products were delivered to franchised companies for distribution to the rural schools. The Nutrition and Environmental Health Departments of the Chilean Ministry of Health authorized and supervised the addition of Disodium monofluorophosphate (MFP) to the powdered milk products. The MFP used throughout the study was pharmacopoeia grade, imported from Albright and Wilson, U.K. Schoolchildren in the positive control group consumed the same type of products, only without the addition of MFP. These children received a topical F gel application every six months.

The fluoridated products were prepared monthly and their F concentrations were controlled at INTA´s laboratory before each batch was delivered. Additionally, random samples of the fluoridated products, both powdered and liquid ("ready to drink" samples that represented the real F-milk children consumed) were measured frequently (20 samples per month). The F concentration of the liquid samples was found to be within ± 10% relative to the target value (3.13 mg F/l) throughout the entire period of study. Field supervision was carried out by a Regional F-scheme Supervisor in collaboration with the regional PAE supervisors. The presence of F products at the corresponding schools was checked on a monthly basis. The powdered and liquid samples were also collected during these monthly supervision visits.

Fluoride exposure from water was studied before starting the fluoridated milk scheme. The natural fluoride concentrations of the water supplies in the study communities were in the range 0.02- 0.15 ppm.

In Chile, almost 100% of toothpastes contain fluoride since the early 80´s. Thus, in the clinical studies (baseline and follow-up), the frequency of tooth brushing and the use of toothpastes was evaluated using a questionnaire in order to estimate the F exposure from this source. Data obtained showed that 90% of the children used F-containing toothpastes 2 times per day with no significant differences between the programmes (F- milk and APF- Gel) or during the period of the clinical studies (1999-2002).

The average daily ingested F dose (which included the possible ingestion of F from toothpaste) was also estimated before starting the F- milk project measuring the concentrations of F and creatinine of midmorning urine spot samples from (n=80) participating children aged 6-8 years (WHO, 1999). The ratio of fluoride and creatinine concentrations is mathematically related with the 24-hour total amount of fluoride provided that there are no peak ingestions of fluoride throughout the day (WHO, 1999**).** In addition, during the development of the scheme, another two F urinary excretion studies were made:

- Three months after the distribution of the F milk to the participating rural schools began, using the method of 16-hour urine sample collection (WHO, 1999).
- Two years after starting the pilot study by means of 24-hour urine sample collection.

The 24-hour total amount of fluoride excreted with the urine estimated (or measured) by any of the three methods previously described is divided by the body weight of each of the participating children and by 0.35, which is the most likely value of the fractional urinary fluoride excretion (FUFE) according to several authors (Ketley and Lennon, 2000, 2001; Villa *et al*., 2000; Franco *et al*., 2005). In this way the daily F-dose can be estimated on a community basis.

The determinations of fluoride concentration in MFP-fluoridated milk and urine samples were carried out using a fluoride ion selective electrode (Orion model 96-09) connected to an Orion model 940 digital ion analyzer. Creatinine was measured by Molecular Absorption Spectroscopy. The detailed experimental procedures were described in previous papers (Henry, 1964; Villa, 1988; Kolesnik *et al*., 1996; WHO, 1999)

Baseline clinical examinations were carried out in November 1999, and follow-up examinations after 36 months (2002), using cross-sectional samples of schoolchildren aged 6, 9 and 12 years. The children were 6, 9 and 12 years old at the time of each clinical examination, so they were not the same in baseline and follow-up. Examinations were conducted following the international survey study recommendations described by the World Health Organization (WHO, 1997). Examinations were carried out in schools under natural light, using dental mirrors and sickle probes. Children were positioned facing a large window in a schoolroom. Radiographs were not taken and teeth were not dried before scoring. Examinations were conducted by dentists blind to the caries preventive programmes (PAE-F and APF- Gel).

Four trained and calibrated examiners performed the examinations and two of them participated in both clinical studies. The examination for the follow-up study was preceded by a recalibration exercise. Examiners were calibrated in the application of diagnostic criteria against themselves and against one of the examiners (AW). Reliability of examiners was determined through the use of the Kappa statistic. In 1999, as well as in 2002, the levels of inter-examiner reproducibility achieved in the replicate examinations of 25 children from each age group were higher than 90%. Intra-examiner reliability, assessed by the repetition of exams in 25 children from each age group showed 'excellent agreement' levels according to Cohen's criteria and the requirements for adequate examiner reliability (National Institute of Dental Research, 1991)

Clinical data was analyzed by Excel-Analyse-it™ and Epi Info 6.04b statistical programmes. Comparisons between the two preventive programmes and between the baseline and follow-up studies were based on the dmft/DMFT values and the proportion of participants free from caries.

The results obtained were tested for statistically significant differences. The Mann Whitney U was used to compare mean dmft/DMFT levels and Chi2 was used to compare % caries free (DMFT=0) in the different groups. For all statistical tests the level of statistical significance was set at $p<0.05$.

Results

Data obtained in the urine samples showed, as expected, a low estimated average daily F dose at baseline (< 0.015 mg F/Kg body weight). In the second urine sample collection, the average daily F dose obtained in the PAE-F children group was 0.035 mg F/Kg body weight. Finally, after two years of receiving F-milk, the amount of F excreted over the 24 hour urine samples showed an estimated daily F dose of 0.045 mg F/Kg body weight (Villa *et al*., 2000).

The results for the 6-years-old group are presented in Table 1. At baseline (1999), the global average value for dmft index was 6.70, while, at follow-up (2002) this value was 6.10. The global average values for DMFT index were 0.41 and 0.32, respectively. At baseline and at the follow-up assessment neither dmft nor DMFT indices were significantly different ($p> 0.05$) among the study and positive control groups. In addition, neither in 1999 nor in 2002, were these indices significantly different when comparing the study group (F-milk) with the positive control group (APF Gel).

The values obtained for the DMFT index and the percentage of children free from caries in the study communities (PAE-F programme), at baseline and follow-up, are presented in Table 2. Comparing the data from both studies (1999-2002), children receiving F milk over 36 months showed significant reductions in the DMFT index in the 9- and 12-years-old groups (range 24-27%), with p values of 0.025 and 0.002, respectively. Overall, 39% of 9 year olds were free from caries (DMFT=0) at the end of the study as compared with 21% at baseline when no preventive programme existed ($p= 0.095$). For 12-years-olds this proportion was 23% compared with 11% at baseline, showing a significant reduction in caries prevalence ($p= 0.016$).

Table 3 presents the data of DMFT values obtained at baseline and at the follow-up study for children par-

Table 1. Caries experience in 6- year-olds at baseline (1999) and follow-up (2002)

Programme	*1999 n*	*2002 n*	*1999 DMFT (Var)*	*2002 DMFT (Var)*	*p**	*1999 dmft (Var)*	*2002 dmft (Var)*	*p**
APF Gel	100	88	0,48 (0,94)	0,409 (0,911)	0,61	6,41 (17,1)	5,54 (14,8)	0,14
PAE-F	117	69	0,34 (0,73)	0,23 (0,44)	0,33	6,95 (14,72)	6,58 (14,39)	0,52

Values within brackets are not significantly different ($p > 0.05$); p^* = p-value for the comparison of mean values of both indices within the same row

Table 2. Caries experience in 9- and 12- year-olds from study communities (PAE-F programme) at baseline and follow-up.

Age group	*1999 n*	*2002 n*	*1999 DMFT (Var)*	*2002 DMFT (Var)*	*p**	*1999 DMFT=0 (%)*	*2002 DMFT=0 (%)*	*p**
9-years-old	122	107	1,77 (1,9)	1,35 (2,21)	0,025	21	39	0,095
12-years-old	121	132	4.02 (7.67)	2.98 (6.39)	0.002	11	23	0.016

p* = p-value for the comparison of mean values of both indices within the same row

Table 3. Caries experience in 9- and 12- year-olds at baseline (1999) and follow-up (2002) from study communities (PAE-F programme) and positive control group (APF Gel).

	1999					*2002*				
	APF-Gel		*PAE-F*			*APF-Gel*		*PAE-F*		
Age group	*n*	*DMFT (Var)*	*n*	*DMFT (Var)*	*p*	*n*	*DMFT (Var)*	*n*	*DMFT (Var)*	*p*
9-year-olds	100	1.11 (2.0)	122	1.77 (1.90)	<0.001	139	1.61 (2.70)	107	1.35 (2.21)	0.30
12-year-olds	100	3.09 (5.23)	121	4.02 (7.67)	<0.001	113	2.47 (5.21)	132	2.98 (6.39)	0.13

p^* = p-value for the comparison of mean values of both indices within the same row

ticipating in both programmes (PAE-F and APF Gel). At baseline (1999) children aged 9 and 12 years without any F-preventive programme presented significantly higher DMFT scores than children already participating in the APF-Gel programme ($p<0.001$ for both age groups). After three years of F-milk implementation, the DMFT indices in schoolchildren aged 9 and 12 years receiving fluoridated milk were not significantly different from those of the positive control group ($p> 0.05$).

Discussion

Results obtained after three years of milk fluoridation indicated that it is possible to reduce the prevalence and severity of children's dental caries in their permanent dentition. In the group of 9-year-olds this is a relevant finding because these children started with the F-milk scheme upon entering elementary school (6-year-olds), without a previous preventive programme. As shown in Table1, there were no significant differences in the caries experience between the 6-year-olds that were assigned to the preventive F-milk programme at baseline versus follow-up. Data obtained in the clinical examinations of 9- and 12-year-olds in the study group (with F-milk) showed a reduction in the mean number of teeth affected by dental caries ranging from 24 to 27% (Table 2). Thus, the significant reduction obtained in their DMFT index mostly represents the effectiveness of the F-milk received over a period of 36 months, since the use of fluoride toothpaste was similar for children in the study group both at baseline and at follow-up studies. On the other hand, when these results are compared with those of the positive control group (APF Gel) at follow-up (Table 3), the differences in the DMFT values between both groups were not significant. This finding does not necessarily mean that the scores in both groups were the same since the statistical power of the sampling design would have allowed the identification of differences equal or higher than 20%. However, the higher DMFT value found for the study group for children aged 12 years can be explained considering that they were 9-years-old when they entered into the F-milk programme while the children belonging to the positive control group were receiving APF-Gel applications since they were 6-years-old.

In the group of 6-year-olds, there were no significant differences in the dmft and DMFT indices between both groups either at baseline or at follow-up, most likely illustrating the absence of a preventive caries programme in rural areas during the pre- elementary school period.

Results obtained in this study are consistent with those from previous studies that also found positive results in the prevention of dental caries through F-milk (Russoff *et al*., 1962; Stephen *et al*., 1984; Gyurkovics *et al*., 1992; Pakhomov *et al*., 1995; Mariño *et al*., 2001). According to accepted knowledge, the caries preventive action of fluoride occurs in the oral cavity and particularly in the plaque-enamel interface. A recent study (Petersson *et al*., 2002) showed that after ingestion of F-milk (5 mg F/l) the increase of F-concentration in whole plaque is similar to that obtained after ingestion of fluoridated water (5 mg F/l). Thus the previously discussed results as well as those from the current study can be interpreted as a topical effect due to F-milk intake.

The percentage reductions in caries incidence obtained in this study are approximately similar to those obtained after 56 months of water fluoridation in Santiago, Chile, for the permanent dentition in the same age groups (Villa & Guerrero, 2001). Children residing in Santiago had been exposed to water fluoridation at an F concentration of 0.6 mg F/l. This finding suggests that it is possible to obtain beneficial results in caries prevention for permanent dentition either with water or milk as the vehicle for fluorides.

Epidemiological surveillance was implemented in this study by means of baseline and follow-up urinary excretion studies (16-hour collection in 2000; and 24-hour collection in 2002) and F analyses of milk samples from both the schools and the manufacturing company. The urinary samples collected during the trial period were obtained from children that drank F-milk every day at breakfast during the school period and from rural school children belonging to the positive control group as well. The urinary F excretion analyses confirmed that the F-milk had been correctly distributed, i.e. to the rural schools only, and that the estimated daily F ingestion was within the authorized limits. These points were also confirmed by the results obtained on the F concentrations of the powdered and liquid samples of F-milk products (results not shown).

Taking into account the relative costs and technical difficulties involved in the APF-Gel and PAE-F programmes, it appears that given the conditions of rural Chilean communities, fluoridation of powdered milk and milk derivatives is a useful alternative for the prevention of caries in areas where either water fluoridation or other community based preventive programmes are difficult to apply.

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Book reviews

*Child Protection and the Dental Team: an introduction to safeguarding children in dental practice***.**
Harris *et al*. Published by: The Committee of Postgraduate Dental Deans and Directors. London, UK. 2006

This is a concise handbook aimed at all members of the primary dental care team, to ensure they have the information they need in order to carry out their duty in protecting children from harmful situations.

The handbook is divided into 5 sections with a helpful introduction as to how to use the resources contained within it. There is also an accompanying website: www.cpdt.org.uk/www.childprotectionandthedentalteam.org.uk.

Section 1 outlines who should take responsibility for child protection and, understandably, the answer is everyone. In his summing up of the Victoria Climbie case, Lord Laming comments that preventing such tragic outcomes in the future lies 'in doing relatively simple things well'.

Section 2 is helpful in outlining how to recognize abuse –a factor identified in surveys of dental personnel as the reason why more people do not report suspected cases of child abuse. Importantly, this chapter concludes with a section on dental neglect - defined by the American Academy of Paediatric Dentistry as 'wilful failure of a parent or guardian to seek and follow through with treatment necessary to ensure a level of oral health essential to adequate function and freedom from pain and infection.' To aid in this, the pack contains an example of a leaflet for use by primary dental care teams to alert health visitors to incidents where under-5s who are known to require dental care, fail to attend. Since this is a relatively new concept in Europe, the authors are at pains to point out that a charge of dental neglect should be reserved for situations where there is a failure to respond to a known significant dental problem.

Section 3 outlines all the things you need to know and do in suspected cases of abuse or neglect. Flow charts from the Department of Health's document on this topic, with which dental staff will already be familiar, are included, as are instructions new in this publication. Importantly this handbook goes a step further in outlining how a person copes personally with the aftermath of making a referral. The section also raises the spectre of the dentist becoming involved in an oral and dental assessment for a child who has been subject to abuse or neglect and what their role will be in this assessment of the child's overall health. How to manage identified dental neglect is also covered with a helpful case study.

The penultimate section covers practical issues for safeguarding children – tips for best practice in your surgery; issues such as nominating a staff member to take responsibility as a lead on child protection, ensuring the environment is suitable for children -safe and child-friendly and what sort of paperwork you need to have in place to be able to respond appropriately and rapidly in suspected cases.

The concluding section details additional resources and includes pull out sheets that can be readily photocopied - flow charts for action, policy statement for the practice and a record of non-verifiable CPD, as examples.

This is an excellent handbook –my only quibble would be why it is called 'an introduction to safeguarding children in dental practice'? This might be misconstrued as a health and safety document for dental practitioners. In a way it is. I would have liked the subtitle to suggest that it was geared towards the dental care team, to be more inclusive of all in primary dental care, which is what I am sure the authors intend. A minor technicality and as the Chief Dental Officer says in his foreword, Jenny Harris and her team are to be congratulated.

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