The Effectiveness of Salt Fluoridation Programs to Prevent Dental Caries in the Region of the Americas.

E. D. Beltrán,[a] R. Báez,[b] and S. Estupiñán-Day[c]

[a] Epidemiologist, Consultant to the Pan American Health Organization.
1008-G Oak Chase Drive. Tucker, Georgia 30084, USA

[b] WHO Collaborating Center in Oral Health. The University of Texas Health Science Center San Antonio.
7703 Floyd Curl Dr. San Antonio, Texas 78284, USA

[c] Oral Health Regional Advisor. Pan American Health Organization
525 Twenty-Third St. N.W. Washington, DC 20039, USA

During the last four years thirteen countries in the region of the Americas have initiated or strengthened salt fluoridation programs with the main purpose of preventing dental decay. These countries have received direct technical assistance from the Pan American Health Organization (PAHO) and the World Health Organization (WHO) Collaborating Center in San Antonio (UTHSCSA). Four additional countries, i.e., Colombia, Costa Rica, Jamaica, and Mexico have consolidated programs with seven or more years of implementation. These countries have conducted at least two national surveys of dental caries and dental fluorosis, one at baseline and the other 5-7 years later. The objective of this review is to analyze and compare epidemiological parameters for dental caries and fluorosis at baseline and at the end of the latest epidemiological evaluation in each of these four countries in order to estimate the effectiveness of their salt fluoridation programs. Jamaica initiated a salt fluoridation program in 1987. Results of the first evaluation, eight-years later, showed an 84 per cent reduction (PR) in caries prevalence representing a compound annual percent reduction (CAPR) of 15.2 per cent. Costa Rica's program –initiated at the same time– showed reductions of 42 PR and 12.6 CAPR after four years. Additionally, the results of a second epidemiological evaluation, to be conducted in the spring of 1999, will be presented. Preliminary results from the state of Mexico, showed a 46 PR and 6.7 CAPR after nine years. Both, Mexico and Colombia are finishing national epidemiological evaluations and their data will be evaluated and presented accordingly. These results show the high beneficial effect of using fluoridated salt for human consumption in the prevention of dental caries. As expected, benefits are higher when the prevalence of dental caries is high at the starting point. All thirteen countries that have initiated salt fluoridation in the last four years contemplate an epidemiological evaluation of program effectiveness after seven years, or sooner if the country considers it necessary.

1. INTRODUCTION

Dental caries in a preventable infectious disease that if left untreated leads to tooth loss and edentulism. During the 1930s a series of studies conducted by McKay and Dean lead to the discovery of a direct association between fluoride concentration in the drinking water (measured in parts per million) and dental fluorosis and an inverse association between fluoride and the prevalence of dental caries. By the mid 1940s enough information was available to initiate community trials in the United States and Canada, where fluoride at 1ppm was added to the drinking water.

Thereafter, this public health practice, known as *water fluoridation* has been extensively used in the United States and elsewhere [1]. The technical requirements to fluoridate the water include a controlled water processing plant, fluoridation equipment (pumps, saturators, dry feeders and auxiliary equipment), and the fluoride chemicals (generally sodium fluoride or sodium silicofluoride) [2]. The requirement of having water processing plants make water fluoridation unfeasible for many countries with large rural areas or with deficient water processing systems. In 1964, the Pan American Health Organization (PAHO) co-sponsored a community trial in Colombia to test the feasibility of fluoridated the salt for human consumption [3]. Previous studies in Europe [4-5] had shown that 250 mg of F^- added to 1 Kg of salt was as effective as 1 mg F^- (1 ppm F^-) added to the drinking water. In 1977, the First International Symposium on Salt Fluoridation, concluded that:

> "...table salt is an ideal vehicle for administering fluoride, and salt fluoridation is an effective and safe measure for partial control of dental caries... its wider use should be encouraged and supported." [6]

Thereafter, many countries in the region of the Americas sought *salt fluoridation* as a valid alternative to prevent dental caries at the population level. At present time, four countries, i.e., Colombia, Costa Rica, Jamaica, and Mexico, had consolidated population-wide salt fluoridation programs. These countries have conducted at least two epidemiological studies, one at baseline and the second 4-7 years later, and measured the prevalence and severity of dental caries in representative samples of 12-year-old children, the age-indicator for dental caries proposed by the World Health Organization. The objective of this study was to analyze and compare dental caries severity at baseline and at the end of the latest epidemiological evaluation in two of these countries, i.e., Costa Rica and Jamaica, in order to estimate the effectiveness of their salt fluoridation programs. At the time of writing this document, the complete data from the second evaluations in Colombia and Mexico are not available for analysis.

2. METHODS

In 1987, both Costa Rica and Jamaica initiated national salt fluoridation programs with cooperation of the local salt industry [7-8]. Baseline epidemiological surveys were implemented in Jamaica in 1985 and in Costa Rica in 1988. Follow-up surveys were implemented in Costa Rica in 1992 [7] and in Jamaica in 1995 [8].

In these surveys the teeth from a representative sample of school children were examined to detect the presence of dental caries or sequelae (restorations and extractions) using the visual-tactile protocol and diagnostic criteria recommended by the WHO in its third edition [9]. Examinations were carried out by a group of trained and standardized examiners (both dentists and dental nurses). Twelve-year-old children were examined on each selected school using a dental explorer, a mouth mirror and natural light.

All data were collected in standardized forms. For data analysis, the number of decayed (D), missing (M), and restored (F) teeth were counted for each child. This count constitutes the DMF-T index. DMF-T means were calculated for baseline and follow-up data. Percent reductions (PR) and compound annual percent reductions (CAPR) were calculated using the following standard formulas:

$$PR = 100 \times \left[\frac{\left[DMF - T(t_1)\right] - \left[DMF - T(t_2)\right]}{DMF - T(t_1)} \right]$$

$$CAPR = \left[\frac{DMF - T(t_2)}{DMF - T(t_1)} \right]^{1/n} - 1$$

where:

$DMF-T(t_2)=$ the mean at follow-up

$DMF-T(t_1)=$ the mean at baseline

$n=$ the number of years between surveys

3. RESULTS

Table 1 displays the mean DMF-T, percent reduction, and compound annual percent reduction between baseline and follow-up for Costa Rica and Jamaica.

After 8 years, Jamaica experienced a 84% reduction in the DMF-T index which corresponds to a 15.2% compound annual percent reduction. The reduction in Costa Rica was smaller, i.e., 42% representing a 12.6% compound annual percent reduction.

4. DISCUSSION

Both the DMF-T index and annual percent reductions are widely used in dental epidemiology as measures of prevalence, severity, and for assessment of trends of dental caries occurrence in populations. The DMF-T index, is a summation of the number of teeth affected by caries or sequelae, is cumulative and, therefore, increases with age. (Dental caries is an irreversible disease when it has reached the level of cavitation). In consequence, comparisons between populations or trends in time should use the same age cohorts.

The change in mean DMF-T between baseline and follow-up represents the compound effect of secular trends and the effect of preventive programs instituted in the population if available. A recent review of the current trends of dental caries in the Region of the Americas [10] showed a secular trend toward less disease in most countries of the region for which data are available. The causes of this decline are not well known but increase in the exposure to topical fluoride vehicles, such as toothpaste, could be one of the main contributory factors.

In the present study, caries prevalence data from Jamaica and Costa Rica were compared to assess the efficacy of their salt fluoridation programs. In both countries, other fluoride vehicles, mostly fluoridated toothpaste mouthrinses, and gels, are consumed by the population at large or applied by dental professionals. Therefore, part of the caries decline observed should attributed to these other sources of fluoride. However, it is unlikely that the use of these other fluoride sources have varied between the two examination years. Moreover, both Costa Rica and Jamaica have been very effective in eliminating from the market other forms of systemic fluoride, e.g., dietary supplementation of NaF in form of drops or tablets for infants. In consequence the observed reductions in Costa Rica and Jamaica represent a close approximation of the effect of salt fluoridation over the underlying effect of other fluoride vehicles. Ethical reasons preclude the use of negative controls in these programs. However, the secular trend observed in other countries of

Table 1
Mean Decayed, Missing, and Filled Teeth (DMF-T) in 12-year-old School Children Before and After Salt Fluoridation in Costa Rica and Jamaica

	Baseline		Follow-up		Per cent	Compound annual
	Year	Mean	Year	Mean	reduction	percent reduction
Costa Rica	88	8.4	92	4.9	42%	12.6%
Jamaica	84	6.7	95	1.1	84%	15.2%

the region in absence of systemic fluorides are lower than the total effect observed in Costa Rica and Jamaica.

Consumption of fluoridated salt in Jamaica showed a high effectiveness in the prevention of dental caries. The results in Costa Rica were lower and the mean DMF-T at follow-up, (4.9) is over 3.0, the WHO objective for the year 2000. Two issues should be considered in this comparison. First, the baseline DMF-T in Costa Rica (8.4) was considerably higher than in Jamaica (6.7). Second, the follow-up period in Costa Rica was shorter than in Jamaica (4 versus 7 years). Therefore, the reduction of acries prevalence in this first evaluation should be expected to be of a lesser magnitude in Costa Rica. Preliminary data from a second evaluation carried out in Costa Rica in 1999–after 12 years of implementing the salt fluoridation program–showed a DMF-T of 2.1, confirming the trend observed in the first evaluation and closing the gap with the results observed in Jamaica.

Additional supporting data to the preventive benefits of salt fluoridation programs comes from the State of Mexico. This state surrounds but not include the Federal District of Mexico, the capital of the country. Salt fluoridation in the State of Mexico started in 1991-2. Data from two state-wide surveys conducted in 1987 and 1996 showed a 46% percent reduction and a 6.7% compound annual percent reduction. Mexico and Colombia are currently finishing national surveys of dental caries as follow-up evaluation of their salt fluoridation programs.

These results show the beneficial effect of using fluoridated salt for human consumption in the prevention of dental caries. Other countries that initiated salt fluoridation programs in the Region are Ecuador and Peru. In 1994, PAHO designed, secure funding, and implemented a multi-year program to reduce dental caries prevalence in the region using systemic fluorides. As part of this plan, salt fluoridation programs were designed and initiated in Bolivia, Dominican Republic, Honduras, Nicaragua, Panama, Venezuela and later Paraguay. These countries have received direct technical assistance from PAHO and the WHO Collaborating Center in San Antonio, Texas (UTHSCSA) in conducting baseline surveys of dental caries. As part of the epidemiological surveillance of the programs, these countries will conduct follow-up surveys after seven years of initiation or sooner if the health authorities in the country consider it necessary. Additional follow-up surveys in the near future include one in Peru planned for the year 2000 and one in Jamaica in the year 2001.

In conclusion, salt fluoridation has demonstrated to be an effective, and practical vehicle to provide appropriate levels of fluoride to the population and, therefore, prevent dental caries.

REFERENCES

1. Murray JJ, ed. Appropriate use of fluorides for human health. Geneva: World Health Organization, 1986.
2. Reeves TG. Water fluoridation. A manual for engineers and technicians. Atlanta: Centers for Disease Control and Prevention, 1991.
3. Mejía R, Espinal F, Vélez H, Aguirre H. Fluoruración de la sal en cuatro comunidades colombianas. VIII. Resultados obtenidos de 1964 a 1972. Boletín Oficina Sanitaria Panamericana 1976; 80(3):205-19.
4. Marthaler TM, ed. Salt fluoridation and caries prevention in Switzerland. Schweizerische Monatsschrift für Zahnheilkunde 1982; 92:250-344.
5. Tóth K. Caries prevention by domestic salt fluoridation. Budapest: Akadémiai Kiadó, 1984.
6. Salt fluoridation: An alternative for the prevention of dental caries. Battle Creek, Michigan: W.K. Kellogg Foundation, 1977.
7. Salas MT, Solano S. La fluoruración de la sal en Costa Rica y su impacto en la

caries dental. Fluoruración al día 1994; 4:13-9.

8. Estupiñán S, Báez R, Sutherland B, et al. Impact of salt fluoridation in preventing caries in Jamaica [abstract]. Journal of Dental Research 1996; 75(Spec Issue):142.
9. World Health Organization. Oral health surveys. Basic methods. 3rd ed. Geneva: World Health Organization, 1987.
10. Beltrán-Aguilar ED, Estupiñán-Day S, Báez R. Analysis of prevalence and trends of dental caries in the Americas between the 1970s and 1990s. International Dental Journal 1999 [In press].