Modeling an economic evaluation of a salt fluoridation program in Peru

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Abstract

Objective: This article models the cost-effectiveness, from a societal viewpoint, of a dental caries prevention program using salt fluoridation for children 12 years of age, compared with non-intervention (or status quo) in Arequipa, Peru.
Methods: Standard cost-effectiveness analysis methods were used. The costs associated with implementing and operating the salt-fluoridation program were identified and measured using 2009 prices. Health outcomes were measured as dental caries averted over a 6-year period. Clinical effectiveness data was taken from published data. Costs were measured as direct treatment costs, programs costs and costs of productivity losses as a result of dental treatments. The incremental cost-effectiveness ratio was calculated. A hypothetical population of 25,000 12-year-olds living in Arequipa, Peru was used in this analysis. Two-way sensitivity analyses were conducted over a range of values for key parameters.
Results: Our primary analysis estimated that if a dental caries prevention program using salt-fluoridation was available for 25,000 6-year-old children for 6 years, the net saving from a societal perspective would total S/. 11.95 [1 US$ = S/. (2009) 3.01] per diseased tooth averted when compared with the status quo group. That is, after 6 years, an investment of S/.0.32 per annum per child would result in a net saving of S/.11.95 per decayed/missing/filled teeth prevented.
Conclusions: While the analysis has inherent limitations as a result of its reliance on a range of assumptions, the findings indicate that for the situations prevailing in Peru, there are significant health and economic benefits to be gained from the use of salt fluoridation.

For more than 60 years, laboratory, clinical and community research have studied the action of fluorides in preventing dental caries, and the use of fluoride is accepted as a safe, effective, efficient, and appropriate mechanism for the prevention of dental caries (1,2). In addition, the use of fluorides (Fs) is recognized as one of the most successful measures for the prevention of disease in the history of public health (3).

F can be delivered to individuals as a dental preventive measure using a variety of mechanisms, however, there are two major community-based options: water fluoridation and salt fluoridation. In fact, the World Health Organization (1) classified water and salt as highly cost-efficient vehicles for Fs, supporting their implementation as a community health measure. Currently, more than 300 million people benefit worldwide from water fluoridation (4). Until a couple of decades ago, salt fluoridation was used in Colombia, Hungary, and Switzerland, but almost nowhere else (5). Today, salt fluoridation is provided to over 100 million people in Europe alone and to millions in Latin America (e.g., Colombia, Costa Rica, Jamaica, Mexico, Uruguay). Additionally, more than 500 million people world wide use fluoridated toothpaste (6).

In Latin America fluoridation was introduced in the 1950s and 1960s in the forms of water and salt fluoridation. In the 1990s salt fluoridation existed in nine countries and water fluoridation in at least fourteen countries of the Americas.

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At about that time, countries in the region began to prefer salt as the vehicle for F. By 2005, according to information from the Pan American Health Organization, a salt fluoridation program, in at least the planning stages, existed in 20 countries of the Americas (7). However, in some of these countries, salt fluoridation is only in its initial stages (i.e., feasibility stage, baseline studies), and the actual salt fluoridation process has not commenced (8).

The value of salt as a vehicle for the administration of Fs for caries prevention has been evaluated in Peru since the 1960s. In an attempt to decrease or control dental caries in the Peruvian population, the Ministry of Health adopted salt as the vehicle for F. In 1984, a law was passed mandating the addition of Fs to salt for human consumption (D.S. 15–84-SA). In 1985 the Peruvian Ministry of Health agreed on a technical norm for enriching table salt for human consumption with F, as the main method for administering F to the Peruvian population (9). Fluoridated salt is widely available to consumers at supermarkets and retail stores throughout the country. The cost of a kilo of F-salt in Lima ranges from S.\1.40 to S.\ 1.50. (S/.= *Nuevos Soles*, the Peruvian national currency [1 US$ = S/. (2009) 3.01].

Economic evaluation (EE) is an integral part of the process of decision-making about any preventive program. EE is accepted as a method of appraisingl of health care programs and is widely used. Despite this – and with the exception of water fluoridation and dental sealants – the use and application of EE of dental caries prevention programs remains limited. However, recently the number of studies describing EE in oral health has increasedand it is likely to become more important in the future (10).

Several EEs of the different vehicles for F are available in the literature. However, in Latin America, with the exception of EE of salt fluoridation (11-13), water fluoridation (14), fluoridated milk (15), and a mixed Fs program (16), no published EEs were available. In particular, no EEs of dental caries prevention programs were found in Peru. Consequently, no data can be used as a reference for national programs. This emphasizes the need and relevance of EE that, in a systematic way, analyzes the costs and consequences of alternative measures for the reduction of inequities in oral health in the Peruvian population. EE of Peruvian programs would allow conclusions to be made, which reflect the uses and practices for the local reality, and not those of developed countries where EE are available. Most, if not all EEs, are so context specific that they cannot be used to inform policy debate in other populations (17).

The aim of this article was to model the cost-effectiveness, from a societal viewpoint, of a dental caries prevention program that used salt as a vehicle for children 12 years of age, compared with non-intervention (or status quo) in Arequipa, Peru.

Methods

This study used data from the Arequipa Region (1,139,599 inhabitants) (18). Arequipa is located in the south of Peru. Geographically, it contains coastal regions, mountainous regions, volcanic areas and a large city, Arequipa. As such, it is a good reflection of the diverse conditions prevalent in Peru.

The form of EE used in this study was cost-effectiveness analysis (CEA). In CEA, costs of alternative programs are measured as economic costs and outcomes are measured in units of effectiveness [decayed/missing/filled teeth (DMFT)] (19).

Costs

Using a societal perspective, data on the dental status of 12-year-olds in Arequipa, Peru, and the costs of running the salt fluoridation program, were used to determine the program cost-effectiveness when compared with the (*status quo*) alternative. All the important and relevant costs of a salt fluoridation intervention, at different phases of the project, were identified and accounted for. The shared costs were apportioned appropriately.

Program expenses include the cost of the program coordinator. The coordinator's duties would include the analyses of the distribution log at the community health centers; evaluating whether the fluoridated salt was delivered to the community by taking random samples of the fluoridated products at selling points and sending them for quality control analysis; and managing and supervising the overall functioning of the program. It was judged that these duties could be carried out with a 0.10 full-time equivalent appointment, that is, four hours a week would be dedicated to the salt-fluoridation program.

It was assumed that once every ten years, there would be a clinical evaluation of the program involving a sample of 100 12-year-old children. This evaluation would involve a dentist, a chairside dental assistant, dental instruments, examination supplies and statistical support for the analysis of the data. The dentist and chairside dental assistant salaries were based on the public sector monthly wage. Statistical support costs were based on standard cost charged by the Statistics Department, Universidad Peruana Cayetano Heredia (UPCH), per hour of consultation.

Additionally, it was assumed that a periodic analysis of F urine excretion as well as analysis of the fluoridated salt products would be carried out. For the F urine excretion a sample of 50 children would be evaluated and for salt product analysis, 20 samples per year would be taken (7). For these analyses, standard costs charged by UPCH were used.

Program costs were decided using the available costs reports from the literature. Gillespie and Marthaler (20) reported a cost of US$ 2.5 to 5.0 for sodium F chemical per ton of salt. For the purposes of this analysis, the midpoint was used (i.e., US$ 3.75). According to these authors 553 g of sodium F are required for one ton of salt. The mean daily consumption of table salt for a 12-year-old child was assumed to be 6.37 g, based on reports for Latin America from the literature (21).

Treatment costs, cost of travel to the community health center and the cost of productivity losses, were calculated at the value of a minimum monthly salary in 2009. Restorations and extractions costs were based on public sector fees. Extraction costs were based on the cost of simple procedures, and these procedures would include the costs of the dental examinations.

It was assumed that increases in the decayed and missing components of the DMFT occurred at the same rate each year and that the treatment costs associated with increases in the decayed and missing components of the DMFT score occurred in the year of the increment

Costs of time spent traveling and treatment time were estimated as one hour and a half for each treatment. It was assumed that one dental session of one hour would be necessary to fill a decayed tooth, and that there would be no need to replace restorations.

All costs and savings are expressed in *Nuevos Soles* (S/.), the Peruvian national currency [1 US$ = S/. (2009) 3.01]. Costs and savings were adjusted to the base year price level of 2009 using the consumer price index (June – 2009/Banco Central de Reserva del Peru). Costs and savings were discounted using a discount rate of 3 percent (June – 2009/Banco Central de Reserva del Peru).

Effectiveness

In 2008, the Department of Social Dentistry of the Dental School, Universidad Peruana Cayetano Heredia, in collaboration with the NGO Solaris-Perú, and the Regional Directorate of Health of Arequipa (DIRESA – the regional branch of the Ministry of Health) conducted a regional assessment of dental caries and fluorosis. Oral examinations were conducted using natural light, dental mirrors and sickle probes. Clinical data were recorded following the usual World Health Organization (WHO) criteria and recommendations for dental caries and fluorosis (22), using a stratified cluster sampling technique, covering a standard number of subjects in each specific age group. Radiographic examinations were not performed and teeth were not dried before scoring. Dental status was assessed using the DMFT index. Data for caries experience for 12-year-old children living in Arequipa showed a mean of 5.46 (23).

In order to carry out a CEA it is necessary to have a suitable measure of effectiveness. The effectiveness of a salt fluoridation program in Costa Rica has been reported as being 43.8 percent, with extremes reported in the literature ranging from 34 percent, as the worst scenario of dental caries reduction, to 53 percent, as the best scenario of dental caries reduction (7). Therefore, the outcome after 6 years would indicate that Arequipa children aged 12 years who had access to salt fluoridation from 6 to 12 years of age, that is, during the eruption of their permanent teeth, would show a decline in dental caries experience to a mean DMFT of 3.07.

Sensitivity analysis

As it is possible that some of the assumptions utilized in the primary analysis have a degree of uncertainty, one-way and two-way sensitivity analyses were undertaken to explore the robustness of the results in the face of either individual or simultaneous variation of data assumptions about key parameters. The parameters that were modified were the discount rate, using the rates of 0 percent and of 10 percent, the best and worse effectiveness ranges from the literature were assumed (34 percent versus 53 percent). The condition of employment of the coordinator of the program was also altered [0.05 full-time equivalent (FTE) versus 0.15 FTE].

Results

Program cost categories over 6 years for operating the salt fluoridation program in Arequipa, in a reference population of 25,000 children aged 6 years old at the beginning of the program are summarized for the test community in Table 1.

The savings in costs of dental treatments caused by reduced caries experience were calculated on the basis of the fillings avoided as well as extractions prevented because of reduced caries experience. The estimated avoidance of dental procedures was then costed using the current local rates for fillings and extractions. The savings in expenses for the family for treatment, in terms of production/wage losses avoided as well as transportation costs for traveling to the dental treatment facility were also taken into account (see Table 2).

The estimated discounted costs of dental treatment over the 6 years for the intervention and control groups are shown in Table 2. Costs were about 77.3 percent higher in the control group (S/. 1,741,717 or S/. 11.61 per child per annum) than the intervention group (S/. 982,328 or S/. 6.55 per child per annum) [1 US$ = S/. (2009) 3.01].

Cost-effectiveness ratio

Combining the costs of the preventive program with dental treatment costs and comparing them with the costs in the comparison group resulted in an overall net saving of S/. (2009) 711,193 or S/. 28.45 per child (i.e., [S/. 1,741,717–S/. 1,030,524/25,000]) attributable to the preventive program over the 6-year study period. Thus, a public investment of S/. 0.32 (48,195/25,000/6) per annum per child resulted in an

Table 1 Summary of Total Estimated Costs Associated with the Salt Fluoridation Program over 6 Years

Cost category	Amount (S/. 2009)*	% of total
Salaries		
Program coordinator (part-time 0.10 at S./. 2111.75 FTE per month)†	14,803	30.71
Dentist examiner (6 weeks at S/. 1,052.93 FTE per month)‡	1,458	3.02
Dental assistant (6 weeks at S/. 640 FTE per month)‡	886	1.84
Data analysis (40 hours at S/. 40.63 per hour)¶	1,625	3.37
Laboratory services		
Urine excretion analysis (50 samples)§	13,143	27.27
Salt analysis (120 samples)•	5,257	10.91
Consumables		
Program coordinator office rent∞	4,206	8.73
Program coordinator office expenses#	2,103	4.36
Dental instruments**	2,500	5.19
Examination expenses††	100	0.21
Program consumables‡‡	2,115	4.39
Total	S/. 48,195 (US$ 16,012)	100.00

* [1 US$ = S/. (2009) 3.01].
† Program coordinator's wages were based on a dentist coordinator on the public sector.
‡ Dentist, chair side dental assistant salaries were based on the public sector monthly wage.
¶ Standard cost charged by the Statistics Department, Universidad Peruana Cayetano Heredia (UPCH).
§ Standard cost charged by the UPCH: S/. (2009) 45.00 per sample of urinary analysis.
• Standard cost charged by the UPCH per sample of salt analysis S/. (2009) 45.00.
∞ Renting of office space calculated under standard commercial rates at a 10% use time.
Includes furniture, computers, etc., at a 10% use time, power, phone, post, stationary and other expenses associated with the program.
** Includes 100 dental mirrors and probes PALTEX program the Pan American Health Organization (http://new.paho.org/paltex/index.php?option=com_wrapper&Itemid=1658).
†† Includes gloves, masks, paper towel, and other disposable equipment and materials.
‡‡ Additional cost per kg of fluoridated salt consumed by children aged 6-12 years as calculated from the literature (20).

approximate S/. 5.06 reduction in dental treatment costs per child per annum [i.e., (S/. 1,741,717–S/. 982,328)/25000/6].

Table 3 presents a summary of costs, savings and health gains associated with a salt fluoridation program. The preliminary analysis would indicate that net savings (discounted estimates) would be S/. 711,193 (Row C). Row E summarizes the incremental cost-effectiveness ratio for the intervention group compared with the control group for the overall program. The overall ratio was estimated to be a saving of S/. 11.95 per DMFT [i.e., (S/. 1,741,717–S/. 1,030,524)/59,500].

Varying assumptions on both the cost and outcomes side of the equation (sensitivity analysis) resulted in an incremental cost-effectiveness ratio ranging from a net savings of S/. 10.73 to S/. 14.35 per DMFT avoided. The worst result was established by using a discount rate of 10 percent in combination with the worst effectiveness scenario. Conversely, the most favorable result was found using a discount rate of 0 percent for the project combined with the best effectiveness scenario.

Discussion

National available data on oral health in Peru indicates that dental caries has remained highly prevalent in the last 15 years, and that no major improvements in the severity of this condition have occurred over the same period. For example, the DMFT of 12-year-olds was 3.1 in 1991 and 3.5 in 2001 (24,25). Data used in the current study in the Region of Arequipa indicated that dental caries was also highly prevalent in the permanent dentition of 12-year-olds; at that age 97.2 percent of children were already affected. Furthermore, it showed an increment in the mean DMFT score of 5.46 at age 12. This figure is considered severe, according to the WHO criteria (26). In addition, this high level of dental caries remains mostly untreated during the early years, and as age increases, the missing component also increases (23).

According to the CEA of a salt fluoridation program in Peru, this strategy would be a cost-effective mean of controlling dental caries in Peru. Results indicate that after 6 years, children exposed to fluoridated salt would significantly lower their levels of dental caries compared with those that would have occurred in the absence of the salt-fluoridation program. This improvement was achieved at a yearly cost of S/. 0.32 per child (US$ 0.106). On average, this investment would result in a return to society in dental treatment costs of S/. 5.06 per child per annum (US$ = 1.68).

However, cost-effectiveness should be expressed as the cost (or savings) of the program per saved tooth. Our primary analysis estimated that if a dental caries prevention program using salt-fluoridation was available for 25,000 children aged 6 at the beginning of the program for 6 years, the net saving from a societal perspective would total S/. 11.95 per diseased tooth averted (over 6 years) when compared with a comparison (or status quo) group. That is, after 6 years, an investment of S/. 0.32 per annum per child would result in a net saving of S/. 11.95 (US$ 3.97) per DMFT prevented (i.e., cost-saving ratio of S/. 1:38). This represents not only a reduction in disease, but also a net saving to the community. Moreover, the cost-effectiveness ratio remained positive (i.e., savings to the society) even when more pessimistic assumptions and restrictions were tested.

Other non-dental benefits associated with a reduction in dental caries and improvements in tooth survival were not

Table 2 Summary of Estimated Costs of Dental Treatment in the Intervention and Control Communities After 6 Years of the Salt Fluoridation Program

Treatment item	Total fluoridated salt community (S/.)*	Total non-fluoridated salt community (S/.)*
Restorations†	296,893	526,406
Extractions†	2,800	4,965
Costs of travel to community health center‡	224,770	398,528
Cost of productivity losses¶	457,865	811,817
Total costs	982,328	1,741,717

* [1 US$ = S/. (2009) 3.01].

† The cost of restorations was based on public sector's fees. S/. 4.00 per restoration. We assumed only simple restorations. Extractions are based on the cost of simple procedures. S/. 4.00 per extraction. Both procedures include the costs of the dental examinations. Standard costs charged by June 2009, Centro de Salud Santa Rosa de Pachacutec, Peru.

‡ Cost estimates for child and parent travel. S/. 3.00 per trip.

¶ Calculated at the value of minimum monthly salary in 2009 (S/. 550.00). Cost of traveling time and treatment time.

included in this analysis, because of the nature of this type of EE (19,27). The most obvious non-dental benefits include improvement to the child's quality of life associated with reduced dental caries and better tooth survival, and reduction of discomfort associated with dental treatments. (27,28). These non-monetary benefits were represented by the proxy of averted decayed tooth (29). If these benefits had been included, the impact would have been even greater. On the other hand, the study assumed that the decay component of the DMFT index was restored in the year of the increment, however, there is no guarantee that the necessary treatment would be undertaken.

Findings confirm that, for the situations prevailing in Peru, there are significant health and economic benefits to be gained from the use of salt fluoridation. Salt-fluoridation is cost-effective and an efficient use of society's financial resources. Although this model is imperfect as a result of its reliance on a range of assumptions, as well as the exclusion of additional costs of salt distribution, marketing, etc., we believe that it better reflects the Peruvian conditions, compared with approaches and information from other countries. It is expected that this project would generate useful information for planning, monitoring, and evaluating oral health programs by the National Strategy for Oral Health by the Ministry of Health (RM649-2007) (30), such information is particularly relevant since the Ministry of Health allocates a restricted budget to oral health activities, including the Salt Fluoridation Program. It is also expected that information coming from this project identify opportunities to reinforce the salt fluoridation program and increase awareness among policy makers about effective and efficient methods to prevent, control, and manage oral diseases.

Table 3 Total Estimated Costs, Total Benefits, and Cost-Effectiveness Ratio for the Salt Fluoridation Program

A	Total cost test community	S/. (2009)* 1,030,524
B	Total cost control community	S/. (2009) 1,741,717
C	Net cost [or saving]	[S/. (2009) 711,193]
D	Incremental benefits (DMFT avoided per child) (25,000 × 2.38)	59,500
E	Incremental cost [or savings] per DMFT avoided	[S/. (2009) 11.95]

* [1 US$ = S/. (2009) 3.01.]

DMFT, decayed/missing/filled teeth.

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