# Cost aspects of salt fluoridation

GEORGE M GILLESPIE*, THOMAS M MARTHALER**

* Oral Epidemiology, University College, London
** Oral Epidemiology and Preventive Dentistry, Center for Dentistry, University of Zurich

## Summary

*The cost of salt fluoridation in a given country depends primarily on the number of salt factories and on the technical level available in the country. Equipment required may cost US$ 400,000 for large plants producing at least 20,000 tons/year providing salt for populations of several millions. Reliable batch mixers have been built locally for US$ 3,000 to US$ 10,000, with one such mixer capable of producing 10 batches of one metric ton/day or 2,000 to 3,000 tons a year for a population of 350,000 to 500,000. Frequently 85–90% of the costs are devoted to infrastructure; in combination with salt iodization, the cost for fluoride equipment is 30–50% less. Iodization is promoted by WHO, UNICEF, other international organizations and national aid agencies which can indirectly support salt fluoridation. With respect to running costs, the expense for the fluoride chemical is the major factor in small plants producing for example 6,000 tons of salt, i. e. US$ 0.015 to 0.03 per year and capita. The cost for personnel necessary for addition of fluoride and quality control is approximately US$ 0.008/capita/year in small plants and even less in large ones. With adequate implementation, salt fluoridation affords a cariostatic effectiveness equal to that of water fluoridation. When its cost is compared to that of water fluoridation, there may not be much difference regarding initial cost for equipment except in the case of small salt factories where local production of batch mixers may lower initial expenses substantially. Running costs for salt fluoridation are 10 to 100 times lower because the amount of fluoride chemical needed and its handling are up to 100 times less than with water fluoridation. In practice, the cost of salt fluoridation is often so low that many producers did not raise the price of fluoridated salt; this has been the case in Switzerland since 1955 and also in several countries in the Americas today.*

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*Corresponding Author:*
*G. M.Gillespie*
*Oral Epidemiology, University College,*
*15–19 Torrington Place, London WC, England*
*Tel. 44 1732 865072, Fax 44 1732 505478*
*e-mail: ggkwt@yahoo.com*

## Introduction

This year addition of fluoride to drinking water supplies completes 60 years in the USA and Canada. Addition of fluoride to salt in Switzerland started 50 years ago. Many cost benefit analyses have since been put forward for water fluoridation (INTERNATIONAL DENTAL FEDERATION 1981, BURT 1997, GARCIA 1989, GRIFFIN 2001). Water fluoridation is effective and economical in large cities and is cheapest in city-states like Hong Kong or

Singapore where few water plants supply the majority of a population of approximately one million. Conversely, a country like Australia needs more treatment points for the more isolated communities, and Ireland for instance needs multiple installations to fluoridate the drinking water for about 70% of its 3.8 million population. Under such circumstances, the cost is higher because of increasing installation and maintenance costs, and coverage of defined areas is limited to that part of the population served by the water distribution systems; in fact, water fluoridation cannot be implemented in many sites owing to political, technical, social and cost concerns.

As with water fluoridation, the number of production sites of salt is an important cost determinant of any salt fluoridation project. Modern production has favored large salt factories, particularly in subtropical and tropical industrialized states with solar salt production. In the mid-forties for example, there were hundreds of producers in Spain, but by the year 2000 few of them remained. Developing countries of Central and Southern America like Nicaragua, Guatemala, Honduras have a number of small producers and processors. Ecuador provides 80% coverage of the entire population with one big processor site. Similar situations exist in other developing regions. Large processors have installed equipment for continuous or large batch mixing using a wet mix; small plants often use a dry mix and have improved dry mixers and laboratory capability. The cost of salt fluoridation at national or area level is determined by need and existing conditions such as number, capacity, and distribution of producers of salt. When considering the costs of salt fluoridation an assessment must be made of technical standards like equipment, quality control, maintenance and the level of technical training of personnel. These are some of the initial steps of planning salt fluoridation projects (MARTHALER & PETERSEN 2005). If minimal technical levels are not pre-existent, the cost of improving the basic production will increase the cost of addition of fluoride.

## Initial cost of fluoridation; cost of equipment for batch mixing and other investments

Most salt fluoridation projects use target concentrations of either 250 mgF/kg or 200 mgF/kg, irrespective of which chemical is added. For the sake of simplicity, this paper presents cost estimates for salt with 250 mgF/kg. The amount of NaF required to obtain this concentration is 553 g per (metric) ton of salt. Batch mixers vary from rotary paddle and rotary ribbon mixers to rotating mixers and mixing cones. Usually made of stainless steel, they are frequently used for mixing food products or animal feed. Capacity often is one ton, but models for batches from 500 kg–5 tons or more are now available. The cost of standard mixers is in tens of thousands of US$. In developing countries where wages are low, paddle mixers of stainless steel with a capacity of 1–5 tons, complete with motor, may be constructed in-house or at small local workshops for US$ 3,000 to US$ 8,000 (MILNER 2000), but an upper limit of US$ 10,000 may seem more realistic for good quality construction. Depending upon the capacity of the refinery, several mixers working in parallel may be necessary, but modern machines are now on the market mixing from one up to several tons of salt within a few minutes. This is in contrast to the cost of US$ 70,000 estimated 30 years ago in Finland for a mechanical mixer type plant for 4,000–6,000 tons salt/year including US$ 48,000 for a packing machine (TALA 1986).

Mobile continuous spray machines can be obtained through UNICEF for US$ 7,000 to 10,000. This so-called wet method is preferentially used in large salt factories. A concentrated solution, based on potassium fluoride compounds, is sprayed continuously at a controlled rate onto a continuous flow of salt. The amount of salt passing under the spraying nozzle must be continually measured for proper dosage of the concentrated fluoride solution. Such equipment may already be in use for addition of iodine.

Salt iodization for preventing iodine deficiency diseases (IDD) is recognized, practiced and promoted as the most economical and cost effective method throughout the world (INTERNATIONAL CONFERENCE ON NUTRITION 1992). Accordingly, salt iodization is often already implemented in countries for which salt fluoridation may be envisaged. This is a considerable advantage because a laboratory and trained technical personnel are already present. Addition and surveillance of both iodide and fluoride can be carried out in combination, which lowers the respective costs. Examples of iodide equipment costs (1995) are US$ 85,000 for a 1 ton batch spray mixer to US$ 400,000 for a 5-ton/hr mobile continuous spray mixer; 85–90% of this sum is necessary for infrastructure. Total cost of iodization ranges from US$ 4.00 to US$ 15.00/ton (DE JONG 2005).

Other additives are anti-humectants, free-flowing agents, calcium carbonate, etc. In certain situations, a premix of fluoride combined with iodide (such as Yodo-cal) may be used. Yodo-cal is a mixture of eight parts by weight calcium carbonate and one part potassium iodate. Obviously, it must be ensured that the added fluoride exists in ionic form immediately after dissolution (MARTHALER & SENER-ZANOLA 1985). This is indispensable since otherwise the topical effect on the erupted teeth would be less than optimal or even absent.

It is evident that the cost of the equipment is variable and is approximately proportional to the size of the salt factory. In large plants, the cost of installations can be as much as US$ 200,000. Alternatively, locally made mixers may lower the price of the installations. Table I illustrates that salt production is very varied in American countries south of the USA. In spite of these variations, several countries of varying size were able to develop salt fluoridation schemes at low cost covering the majority of the population. Large processors are not common in small countries, but may exist in developing tropical countries where raw sea salt is processed locally. Other initial costs relate to the training of personnel responsible for operating the machinery, quality control, and setting up a laboratory for fluoride analysis; again, when the salt is already iodized, this cost is reduced.

## Running cost of salt fluoridation

Fluoride compounds added to salt, important chemical properties and their price are shown in Table II. The chemicals suitable for addition to salt – NaF, anhydrous potassium fluoride and potassium fluoride – have a price of US$ 1 to 10 per kg. When looking at the amount of salt destined for human consumption, an average of approximately 6 kg/person/year is a useful working hypothesis. The consumption of 6 kg corresponds to approximately 16 grams/capita/day. Approximately 8 g per day are ingested whereas another 8 grams are wasted with water in which pasta, potatoes, vegetables and other foods are cooked. The cost of the 6 kg of fluoride/capita/year corresponds to US$ 0.012 and 0.048 (Tab. II), a negligible amount.

In large factories, the cost of the fluoride chemical is a key figure. In a recent request, a refinery producing one million tons of salt per year was exclusively interested in the cost of the fluoride chemical. This factory produces iodized salt using dosage pumps in the continuous, wet addition process. Based on Table II and

*Tab. I Salt production for countries in the Americas using fluoridated salt*

| Country | Population in millions | Total crude salt prod. (000) t/yr | Type of production (000) t/yr | | Salt consumption* (000) t/yr | | | Number of salt processors | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Soln mining | Solar evap | Total | Direct human | Fluori-dated | Large scale >100 K ton/yr | Medium scale 100 to 20 K ton/yr | Small scale >20 K ton/yr |
| Bolivia | 7.9 | 4.5 | 0 | 0 | 45 | 30 | 2 | 0 | 0 | 42 |
| Colombia | 37.7 | 1100 | 600 | 500 | 500 | 140 | 70 | 3 | 5 | 50 |
| Costa Rica | 3.7 | 20 | 0 | 20 | 18 | 13 | 10 | 0 | 2 | 0 |
| Ecuador | 12.2 | 75 | 0 | 75 | 75 | 44 | 36 | 1 | 2 | 10 |
| Jamaica | 2.5 | 1 | 0 | 1 | 16 | 10 | 10 | 0 | 1 | 0 |
| Mexico | 95.8 | 7900 | 600 | 7300 | 1600 | 350 | 250 | 3 | 6 | 10 |
| Peru | 24.8 | 180 | 0 | 180 | 100 | 87 | 40 | 1 | 2 | 50 |
| Uruguay | 3.2 | 0 | 0 | 0 | 40 | 11 | 9 | 0 | 3 | 2 |
| Venezuela | 23.2 | 705 | 0 | 705 | 615 | 85 | 60 | 2 | 2 | 10 |
| **Total** | 211.0 | 9985.5 | 1200 | 8781 | 3009 | 770 | 487 | 10 | 23 | 174 |

Extracted from Milner (2000)

* Consumption means all salt ingested or wasted with cooking water for potatoes, pasta, vegetables and the like; the ingested amount of salt may roughly correspond to 50% of the "Consumed salt", but in cultures in which rice is the most important carbohydrate (Latin America), the ingested fraction tends to be higher.

*Tab. II Fluoride chemicals and cost (US$) for obtaining salt with 250 mgF/kg salt using NaF or potassium fluorides*

| | Sodium fluoride | Potassium fluoride, anhydrous | Potassium fluoride |
|---|---|---|---|
| Formula | NaF | KF | $KF.2H_2O$ |
| Mol. wt. | 42.00 | 58.10 | 94.13 |
| Solubility gm/100 ml | 4.1 | 55 | 100 |
| Range of price for the fluoride chemical, US$/kg | 2.5–5.0 | 2–10 | 1–8 |
| Grams of chemical required for 1 ton | 553 | 765 | 1239 |
| Minimal cost of F-chemical needed for one ton, US$ | 1.38 | 1.53 | 1.24 |
| Maximal cost of F-chemical needed for one ton, US$ | 2.76 | 7.65 | 9.91 |

Rows 1 to 4 from Milner (2000), other rows added

using KF (only potassium fluorides can be used in this situation), the lowest price per ton of this chemical is US$ 2, the highest US$ 10. The answer for the factory therefore was:
Grams KF required for one ton of salt: 764 grams,
Cost of KF: between US$ 1.5 and 7.6 per 764 grams,
Cost of KF per year: between US$ 1.5 and 7.6 million for an annual production of 1 million tons of fluoridated salt.

This illustrates that in large salt factories which are already adding iodine to the salt, other costs necessary for fluoride analysis, quality control and the like, are negligible since most large plants already have laboratories and large workshops for in-house constructions. Handling of large amounts of the fluoride chemical can be mechanized and automated in order to reduce personnel. The producer correctly anticipated that the purchase of the fluoride compound would be the major cost.

As shown above, small plants also need a laboratory and personnel for chemical analyses and other laboratory work for quality control. The respective costs do not vary much with the size of the plant. A small plant producing 6,000 tons a year (or 20 tons per day) may illustrate the situation. Two full-time jobs would be necessary and would cost US$ 3,000/year per person in a developing economy country, summing up to US$ 6,000. As far as this personnel handles the addition of the fluoride chemical, it is approximately proportional to the size of the plant, but laboratory work for surveillance is not closely linked to the amount of salt produced. Assuming expenses of US$ 6,000 for personnel and US$ 2,000 for reagents, maintenance and other items, an annual cost of US$ 8,000 would be a realistic estimate.

A population of one million needs about 6,000 tons of salt per year. This corresponds to a consumption (sometimes called disappearance) of 16 grams a day, of which approximately half, i.e. 8 grams, are ingested. For a factory of this size, the cost of the NaF is US$ 6,000×2.5 to 6,000×5.0 (Tab. II), or US$ 15,000 to US$ 30,000. Adding the US$ 8,000 for personnel and laboratory, the total running cost for fluoridation would be US$ 23,000 to 38,000 per year. This means that per person and year, the running cost would amount to:
US$ 0.008 for the laboratory personnel and related cost,
US$ 0.015 to 0.03 for the fluoride chemical, resulting in total costs between US$ 0.023 to 0.038 per year and person.

In large plants, which have proportionally larger infrastructures including technical workshops and well equipped laboratories, the cost per person and year is slightly lower because the fluoride chemical may comprise up to 90% of the total cost for adding fluoride.

With an assumed total intake of 8 grams of salt per day and capita (corresponding to a consumption of 16 g per day and capita), the concentration of 250 mg/kg, chosen for the cost estimates in this paper, would lead to an intake of 2 mg of fluoride. This may seem somewhat high, but the 250-level was deliberately chosen in order not to underestimate costs. It may be mentioned that certain countries with comprehensive salt fluoridation programs, for instance Colombia, use a target concentration of 200 mgF/kg (actually 180–220 mgF/kg).

## Cost of salt fluoridation compared to that of water fluoridation

Water fluoridation has for many years been considered to be a useful standard for prevention of dental caries since it is cheap and effective (Proceedings of the International Symposium of

THE 50TH ANNIVERSARY OF WATER FLUORIDATION 1996, BURT 1997). Because of the similarities of water and salt fluoridation – benefit provided to entire populations, independent of age, social class and other circumstances – it is reasonable to compare the costs of water fluoridation and salt fluoridation directly.

The cost and installation of equipment for addition of fluoride to salt is technically much easier than for addition to water. The process and equipment for salt fluoridation are similar to that used for iodization, although analysis of the quality, humidity and mesh size of the salt is necessary. Water fluoridation, on the other hand, requires analysis of water quality and treatment, measurement of flow, and sophisticated pumping devices to add the fluoride-rich solution, prepared in saturation or solution tanks, to water passing through the main distribution pipe. Also large storage room must be available for the fluoride compound.

In the case of salt fluoridation, continuous addition was used primarily by producers for populations of at least 5 million. Batch processing, however, is becoming more frequent. Some European firms, which had functioning continuous addition installations, have obtained new equipment and switched to batch processing. This has become possible through modern large machines which can easily mix 10 tons of salt per hour with the required small amounts of iodine and fluoride chemical.

Regarding running cost, the fact that salt fluoridation requires small amounts of fluoride chemicals and small storage space is of paramount importance. The amount of fluoride chemical is approximately 100 times smaller when compared to that needed for water fluoridation. For fluoridation of 300 to 400 liters, 250 to 400 mg of fluoride are needed to increase the concentration of low-fluoride water (0.0–0.25 ppm F) to the desired 1.0 ppm F. In the case of salt, approximately 50% of the fluoridated salt produced is actually ingested, so that 3 to 4 mg fluoride is sufficient to obtain an ingestion of 1.5 to 2 mg fluoride, respectively.

With water fluoridation, high shipping costs may incur on account of the bulk. A worker in a water fluoridation plant has to manage a mass of fluoride compound 50 to 100 times heavier than in the case of a salt fluoridation plant. Industrial hygiene is another important item. It is obvious that in view of the small amount of fluoride compound needed for fluoridating salt, the danger of grave accidents is minimized. In addition, protection of the workers against pollution is much easier and safety costs are also drastically lower. Only the cost of quality control, which depends on laboratory work, is similar for water and salt fluoridation.

## Cost benefit compared with water fluoridation

It has been shown above that the running cost of salt fluoridation is at least 10 to 100 times lower than that of water fluoridation. As to the cariostatic effectiveness of salt fluoridation, the WHO (1994) Technical Report (page 20) stated, "the results suggest that the effectiveness of fluoridated salt in inhibiting caries is substantial, of the same order of magnitude as that of fluoridated water when the appropriate concentrations and use are achieved". This conclusion has since been confirmed by the results obtained in Costa Rica, Jamaica, the State of Mexico and Uruguay (summarized by MARTHALER 2005). "Appropriate use" implies that to warrant meaningful effectiveness on a public health scale, at least 80 or preferably 90 percent of a population should benefit from the scheme (MARTHALER 2005).

Cost benefit with water fluoridation is customarily related in terms of cost and degree of prevented treatment against projected cost of reparative services assuming that fluoridation was not in effect. A recent analysis of cost benefit in the United States utilized a more comprehensive approach and took into consideration an estimate for the cost of days absent from work and lost productivity (HADDIX et al. 1996). Benefit was also estimated for a one-year and multiple year basis with provision for a discounted rate over time (GRIFFIN 2001). However, for the purpose of this paper it has been considered that in view of a similar health benefit resulting from fluoridated water and salt, such factors do not need to be considered. In addition, in most of the Latin American countries using or envisaging salt fluoridation, the majority of the population has no access to dental treatment as practiced in the highly industrialized countries, and estimates of treatment cost saved would be unrealistic; this situation is common in developing countries. Therefore, this approach is not pursued further. It is evident that this type of benefit would be equal in view of the equivalent effectiveness of fluoridation of water and salt when used by the large part of a population. It may be added that cost benefit analyses do not take into account the benefit provided to those who do not suffer pain or have improved general health as a result of fluoridation.

In the United States where 60.5% of the total population have access to fluoridated water, the annual cost per capita was estimated at US$ 0.50 (US DEPARTMENT OF HEALTH AND HUMAN SERVICES 2002). Analysis showed an annual cost per person ranging from US$ 2.94 in small communities (<5,000) to US$ 0.46 in larger ones (>20,000) at a 0% discount rate (GRIFFIN 2001).

As stated above, the installation cost for large salt fluoridation plants may amount to US$ 200,000. MILNER (2000) defines large plants as those producing at least 100,000 tons of salt per year, providing salt for 6.25 million consumers. Installation costs would thus be US$ 200,000/6,250,000 = US$ 0.032 per capita. To pay back the investment in 10 years, the amount (interest not considered) per capita/year would be US$ 0.0032. It has been shown that the running cost for salt fluoridation was found to be US$ 0.023 to 0.038 per capita/year. Accordingly, when the repayment of US$ 0.0032 is added, the total cost per year of fluoridating salt is between US$ 0.0262 and 0.0412 per capita/year.

It is possible that minor expenses were not included in these calculations. Nevertheless, the range of US$ 0.0262 to 0.0412 per capita/year is less than one tenth of the cost of US$ 0.46 per capita/year for water fluoridation in the big cities of the USA. Production costs per ton of fluoridated salt in medium size or even smaller plants (see the above cost estimates for plants producing 6,000 tons per year) are not much higher than in large plants. Coverage of regions with a majority of villages of less than 5,000 inhabitants with fluoridated salt would cost US$ 0.05 to 0.10 capita/year, whereas water fluoridation would cost approximately US$ 1.5 per person and year according to GRIFFIN (2001).

Recent criticisms of the "classical" results of water fluoridation indicate that school age children in modern industrialized countries, whose level of caries is 50 to 80 percent lower than in the 1950–1970 period, do not match the "classical" 50% reduction. This is at least in part due to frequent use of topical fluoride and, when caries prevalence is below 2.0 DMFT at the age of 12, to the preponderance of pit and fissure caries, which are less responsive to fluoride. In the case of water fluoridation, the customary cost benefit ratio was 1:15 to 1:20; this means that for one US$ invested in water fluoridation, US$ 15 to 20 of treatment cost was saved. In view of a lowered effectiveness of fluoridated water and also of fluoridated salt, a cost-benefit ratio of 1:10 to 1:14 may be assumed. Since salt fluoridation is at least 10 to 100 times cheaper, the cost benefit for comprehensive salt fluoridation programs is between 1:100 and 1:140.

## The cost of salt fluoridation in situations of free choice

In France, the percentage of fluoridated salt among the total of domestic salt is approximately 30% (Tramini 2005). In Slovakia, it has been at around 5%, but now tonnage is increasing. Consequently the fluoridation equipment is used only intermittently in these countries, a situation which is not favorable in modern systematized production where full use of the investment is desirable.
In France, the 30% usage reduces the cost of the compound from approximately EUR 6,000 to EUR 1,800 for one million persons, a saving of EUR 4,200. The disadvantage in dental health cannot easily be measured, but the cost of "repairing" teeth not saved from caries can be estimated. If we assume that 0.2 teeth per person per year are attacked by caries and that regular use of domestic salt reduces the caries attack rate by 30%, then the 700,000 nonusers would suffer only 98,000 new carious teeth instead of 140,000. Since the cost of one filling is at least EUR 40, the total cost for the 42,000 teeth not protected from caries would be EUR 1.68 million compared with savings of EUR 4,200 resulting from the reduced cost of the fluoride chemical. The full disadvantage of only 30 percent of the population actually using fluoridated salt was analyzed in detail (Marthaler 2005). In fact, these calculations underline the importance of high percentages of market share and extensive community access to fluoridated salt.

## How has salt fluoridation been financed?

Salt fluoridation has mainly been financed by the salt factories. In other cases, financial assistance was provided from private sources, by governments and international agencies or private funding. Examples of different approaches are presented.
When the first salt fluoridation scheme in the world was started in the Swiss Canton of Zurich in 1955, the Executive Council stated clearly that the new type of salt would be put on sale "with additives of fluoride and iodine for their preventive effect against caries in packages of one kilogram at the same price as iodized salt". (The effect against iodine deficiency diseases was not mentioned because the salt had already been iodized for decades.) The same price applied as well to uniodized salt (market share 20% in 1995, since 2000 less than 8% of all domestic salt, i.e. packages of up to one kg). The total cost of fluoride addition was too low to noticeably affect the total annual cost of the United Swiss Saltworks on the Rhine, which produces the brine and carries out all refining steps including the additives, and packaging.
In Switzerland, the sale of domestic fluoridated salt was 8,457 tons per year, of which 84.5% was fluoridated (USSWR 2002), and the resulting consumption of fluoridated salt was 7,146 tons. At the concentration of 250 mg/kg, 5,463 kg of KF at a price of CHF 4.05 were needed, resulting in a cost of CHF 22,126. The population covered (Switzerland minus Canton of Vaud which runs its own salt factory) being approximately 6.8 million, the cost per capita and year was CHF 0.0033 or US$ 0.0026. The cost of the compound was so low because consumption of domestic salt per capita is only 1.24 kg/year or 3.4 g/day; more salt is ingested with bread and food presalted by the food industry. The calculations in the section "Running cost of salt fluoridation" were based on a daily consumption of 16 g of salt (with about half of it ultimately ingested), and the cost for the compound was US$ 0.015 to 0.003/capita/year. While in Switzerland the cost for the compound may be low, wet addition (by spraying) and meticulous quality control (Trachsel 2005) may result in slightly higher costs than estimated in this paper.
Jamaica is certainly a country strongly different from Switzerland. As a first step the Jamaican health authorities resolved to fluoridate all domestic salt and to impose restrictions on the importation of non-fluoridated salt for human consumption. The salt industry absorbed the cost of equipment and fluoride with only a small initial increase in the price of salt. The cost arising for the salt factory was given as US$ 0.01/capita/yr, which suggests that some expenses may not have been considered. The Ministry of Health was responsible for implementing a well planned information and community program (with emphasis on women's groups) prior to introduction of the product in the market, monitoring, and evaluation of impact. The Jamaican fluoridated salt is available to all 16 Caribbean Community (CARICOM) countries and territories through a regional trade agreement*.
In Costa Rica, the government acquired the equipment for the four processing plants in 1986–1990. The large salt cooperative coordinated production, marketing and distribution, and the Ministry of Health (Institute of Health Sciences) assumed responsibility for monitoring and evaluation. Salt costs were not increased, and estimated annual cost/capita/year is US$ 0.06. In Cuba, all costs were absorbed by the government as an "Investment in Health" with the establishment of interdisciplinary groups and an achievement to date of 60% of a projected 90% population coverage. In Uruguay, the equipment and compounds were financed totally by the private sector, and only domestic salt was fluoridated, resulting in a market share of 90% of all domestic salt and a caries reduction of 40% in 12-year-old children.
In Germany, a number of dentists had been interested in salt fluoridation since the 1960s but had little success. Following France's initiative – the first EU country to introduce salt fluoridation – Germany introduced fluoridated domestic salt (250 mg/kg F) in September 1991 with a public campaign (Schulte 2005). Throughout the following 14 years, promotions were centered on caries prevention in general, understandably with emphasis on the role of fluoridated salt. The public relations enterprise involved did this task professionally and with considerable success. In addition, all professional bodies including sick funds and health insurances issued statements in favor of the use of fluoridated salt. These activities resulted in a rising market share of the fluoridated salt among the total of domestic salt (500 g packages) which reached 63% in 2004. In the early nineties, the promotion was financed by increasing the price of the 500-gram packages of the fluoridated salt by EUR 0.03 above the price of the unfluoridated salt. With 10 million persons buying each at least 2 packages of fluoridated salt, the additional revenue in retail sales was about EUR 600,000, and the additional revenues at the salt factory may have been approximately 400,000. Most of this amount may have been needed for production and surveillance, while the promotion costs of EUR 80,000 to 100,000 were a minor part of the additional revenues. In the meantime, free circulation of goods in the EU has increased, prices of salt have become variable and prices for fluoridated salt are in the range of other varieties of edible salt offered.

* The CARICOM Community includes: Anguilla, Antigua, Barbados, Belize, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent, Suriname, Trinidad & Tobago.

Finally, it is noteworthy to have a look at prices of crude salt and of refined salt in the marketplace (sold mainly in 500 g to 1 kg packages). Prices were very different in the six Latin American countries (Tab. III), and considerable variations are also noted within countries. The last column shows that the cost of salt per person and year varies from US$ 0.37 to US$ 6.53. Compared with these large variations, the running cost of adding fluoride to salt – less than US$ 0.05 per capita and year – is truly negligible. In view of the widespread opinion that toothbrushing twice a day "will solve most of the caries problem", it should not be forgotten that for hundreds of millions of people of all ages living in poverty, salt fluoridation would be very beneficial – and it would cost almost nothing.


## Zusammenfassung

Die Kosten der Salzfluoridierung in einem bestimmten Land hängen in erster Linie von der Zahl der Salzhersteller und vom Stand der Technik im Lande ab. Die Ausrüstung für grosse Anlagen, welche jährlich mindestens 20 000 t für mehrere Millionen Benützer fabrizieren, kann US$ 400 000 kosten. Zuverlässige Chargenmischer wurden an Ort für US$ 3000 bis 10 000 gebaut, wobei ein Mischer 10 Chargen von je einer Tonne, also 2000 bis 3000 t pro Jahr, für eine Bevölkerung von 350 000 bis 500 000 bereitstellen kann. Oft werden 85–90% der Kosten für Infrastruktur benötigt; in Kombination mit Salzjodierung kostet die Ausrüstung für die Fluoridierung 30 bis 50% weniger. Die Jodierung wird von der WHO, der UNICEF, anderen internationalen Organisationen und nationalen Hilfsfonds unterstützt, was indirekt auch der Salzfluoridierung zugute kommen kann. Bezüglich der laufenden Kosten stehen bei mittelgrossen Herstellern – mit einer Jahresproduktion von beispielsweise 6000 t – die Kosten der Fluoridverbindung von US$ 0.015 bis 0.03 pro Jahr und Person im Vordergrund. Das Personal für die Fluoridzugaben und Qualitätskontrolle kostet in kleinen Salinen (in Entwicklungsländern) etwa US$ 0.008 pro Jahr und Konsument, in grossen noch weniger. Bei adäquater Durchführung erbringt die Salzfluoridierung dieselbe karieshemmende Wirksamkeit wie die Trinkwasserfluoridierung. Im Vergleich zu dieser sind die anfänglichen Einrichtungskosten ähnlich hoch, es sei denn, Salzmischer können in lokalen Werkstätten billig hergestellt werden. Die laufenden Kosten der Salzfluoridierung sind 10- bis 100-mal niedriger als bei der Wasserfluoridierung, weil die Menge der Fluoridverbindung 100-mal geringer und der Umgang damit entsprechend einfacher ist. In der Praxis sind die Kosten der Salzfluoridierung so niedrig, dass eine Erhöhung des Salzpreises oft unnötig ist, wie z. B. 1955 in der Schweiz der Fall und seither auch in manchen mittel- und südamerikanischen Ländern.


*Tab. III Salt prices for selected countries in the Americas (US$/ton), cost at shipping point (FOB); delivered in the marketplace; and costs per person/year of domestic salt when 3.65 kg are purchased (based on 10 g per person/day)*

| Country | Crude salt (US$/ton FOB)* | Refined/packaged (marketplace) (US$/ton salt) | Cost of domestic salt/person/year (US$) |
|---|---|---|---|
| Bolivia | 8.00 | 180–120 | 0.66–0.44 |
| Dom. Rep. | 93.00 | 1,790–850 | 6.53–3.10 |
| Honduras | 45.00 | 417–210 | 1.52–0.77 |
| Nicaragua | 50.00 | 550–150 | 2.01–0.55 |
| Panama | 83.00 | 630–550 | 2.30–2.01 |
| Venezuela | 12.00 | 350–100 | 1.28–0.37 |

Adapted from Milner (2000)
Remark: In many highly industrialized western European countries, purchase of domestic salt is less than 4 g a day


## Résumé

Les coûts de la fluoration du sel dans un pays donné dépendent en premier lieu du nombre de fabricants de sel et du niveau technique dans le pays. Les investissements pour des installations capables de fabriquer au moins 20 000 t de sel fluoré pour plusieurs millions de consommateurs peuvent s'élever à 400 000 US$. Des machines fiables de mélange par lots ont été construites sur place pour 3000 à 10 000 US$; ces mélangeurs sont capables de traiter 10 charges d'une tonne et fournissent ainsi 2000 à 3000 t de sel par année pour une population de 350 000 à 500 000 personnes.
Souvent, 85 à 90% des coûts sont absorbés par l'infrastructure; en combinaison avec des installations d'iodation du sel, les coûts de la fluoration peuvent se réduire de 30 à 50%. L'iodation est soutenue par l'OMS, l'UNICEF et d'autres organisations internationales et fonds d'entraide, un aspect qui peut s'avérer bénéfique pour la fluoration du sel également. En ce qui concerne les frais d'exploitation, le poste des coûts d'acquisition du composé fluoré, soit 0,015 à 0,03 US$ par an et par personne, est au premier plan chez les fabricants de quantités moyennes, par exemple de 6000 t, de sel fluoré. Les frais du personnel nécessaire pour l'adjonction du fluorure et les contrôles de qualité s'élèvent à environ 0,008 US$ par an et par consommateur dans les petites salines (dans les pays en développement), voire à moins dans les salines plus importantes. Lorsqu'elle est implémentée de manière correcte, la fluoration du sel assure une efficacité d'inhibition de la carie équivalant à celle de la fluoration de l'eau potable. En comparaison avec cette dernière, les frais d'investissement initiaux ne diffèrent guère, à moins qu'il soit possible de construire des mélangeurs de sel à des coûts réduits dans des ateliers locaux.
Les frais d'exploitation pour la fluoration du sel sont de 10 à 100 fois inférieurs à ceux nécessaires pour la fluoration de l'eau potable, du fait que la quantité de fluorure est 100 fois moins importante et que le maniement est simplifié d'autant. En pratique, les coûts de la fluoration du sel sont tellement réduits qu'il n'est souvent pas nécessaire de majorer le prix de vente du sel; tel était le cas en Suisse en 1955 et depuis lors dans plusieurs pays d'Amérique centrale et du Sud.


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