PREDICTING COSTS, BENEFITS AND EFFECTS OF ALTERNATIVE FLUORIDE INTERVENTIONS FOR KUWAIT

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تواجه الدول مع اختلاف تقدمها صعوبات في توزيع موارد الدخل لتغطي الخدمات العامة فقرار الصرف على الخدمات العامة تتحكم به عدة عوامل ، كالعوامل الاجتماعية والسياسية والثقافية والاقتصادية وهذا ينطبق على أي مجتمع عموماً .
فكثيراً ما تضاف ميزانية تكميلية للميزانية العامة لتأمين متطلبات ضروريات الحياة ولهذا نحتاج دائماً إلى التحليل والدراسة والبحث في موضوع التكلفة والفائدة والتأثير في القطاع العام (الجدوى الاقتصادية) .
ولتطبيق ذلك في المجال الصحي وللدراسة الجدوى الاقتصادية لعلاج ما تطرح الأسئلة التالية :
١ — هل من الأفضل تطبيق هذا العلاج دون الآخر وبنفس التكاليف ؟ .
٢ — أو ما الفائدة من هذا البرنامج العلاجي وما تكاليفه مقارنة بآخر ؟ .
وخدمات طب الأسنان لا تخرج عن هذا النطاق وهي تستحوذ على نصيب كبير من ميزانيات بعض الدول .
وتعتبر الوقاية أهم الوسائل لتجنب الأمراض . وللوقاية من أهم الأمراض التي تصيب الفم والأسنان وهو تسوس الأسنان أثبت العلماء خلال الخمسين سنة الماضية مما لاشك فيه أهمية استخدام الفلورايد .
وفي بحثنا هذا نستعرض أشكال ونماذج استخدام الفلورايد للوقاية من تسوس الأسنان ونقارن بينها ونتوقع جدواها الاقتصادية في الدول الخليجية . فاستخدام الفلورايد في مياه الشرب وفي ملح الطعام وحبوب الفلورايد والمضمضة بمحلول الفلورايد ومعجون الأسنان بالفلورايد واستخدام الفلورايد في عيادة الأسنان كل هذه الأشكال نبحث مدى فائدتها وتأثيرها ثم تكلفتها في الدول الخليجية .

Given that public sector budgets are increasingly stretched to meet competing demands, there is a growing need to analyze and report on the costs and benefits of public sector investments. Economic evaluation of costs, benefits and effects provides a valuable framework for thinking about choices in healthcare. Economic evaluation asks the question.- *"Is this procedure, service or programme worth doing when compared with other things we could do with the same resources?" or "What are the benefits from this treatment or from this programme and what are the costs, and do the former exceed the latter?"*
Oral diseases pose a significant burden on the economy of both the industrialized and emerging states. The prevention of dental caries - a major oral disease - by fluoride has been well proven over the last 50 years world-wide. Water fluoridation has long been considered the most effective of the fluoridation methods. In this article, the authors examined several modalities of caries prevention through fluoride use - water fluoridation, salt fluoridation, school fluoride rinse programmes, fluoride tablet programmes, fluoride toothpaste, and professionally applied fluorides - and predict benefits, effects, and costs in Kuwait. Salt fluoridation, water fluoridation, and fluoride tablets provide maximal benefits, while salt fluoridation provides the best cost/effect ratio. Salt fluoridation also provides the consumer the option of whether to use it or not, while also shifting the burden of cost from the public sector to the consumer. Salt fluoridation has proven highly successful in Switzerland, and France has recently become the leading producer of fluoridated salt. The results predicted here can allow the decision-maker the choices of whether to accept or reject alternative and competing fluoride disease prevention modalities taking into consideration benefits, costs, public perceptions and the cost either to the public sector or the consumer.

Introduction

All countries regardless of their stage of development, face difficult choices in the allocation of resources to competing activities.

Expenditure decisions in the public sector are the result of the interaction of social, economic, cultural and political factors within existing organizational structures. Given that public sector budgets are increasingly stretched to

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meet competing demands, there is a growing need to analyze and report on the costs and benefits of public sector investments. Economic evaluation (costs, benefits, effects of investments) provides a valuable framework for thinking about choices in health care.[1]

Economic evaluation asks the question: *"Is this procedure, service or programme worth doing when compared with other things we could do with the same resources?" or "What are the benefits from this treatment or from this programme and what are the costs, and do the former exceed the latter?"*[2]

The organized consideration of multiple factors involved in the decision to commit scarce' monetary resources is then available to the decision-maker, rather than the reliance on or application of simple intuitive or "gut" feelings. Economic evaluation can be useful in illuminating issues and helping policy makers arrive at informed decisions.[3]

The distinguishing feature of economic evaluation has its basis in the notion of 'scarcity' (Table 1). That is, resources in society are insufficient to allow for the pursuit of all desirable objectives.[4] For instance, while the eradication of oral diseases is a noble goal, it does not necessarily follow that either adequate resources are available or that society is willing to commit such resources, while foregoing other opportunities to improve society.

Oral diseases pose a significant burden on the economy of both the industrialized and emerging states.[5] The prevention of dental caries - a major oral disease - by fluoride has been well proven over the last 50 years worldwide.[6-8] In this article, the authors examined different modalities of prevention of diseases through fluoride use and predict benefits, effects, and costs in the Gulf States. Water fluoridation, salt fluoridation, school fluoride rinse programmes, fluoride tablet programmes, fluoride toothpastes, professionally applied fluorides, and sealants with and without the parallel use of daily fluoride supplements were evaluated. Predicted results for salt fluoridation to determine the 'sensitivity' of the results by varying one parameter were also re-examined. This sensitivity analysis allows consideration for potential uncertainties in the variables.[2]

Table 1. Short glossary of terms.

Cost-Benefit Analysis: economic analysis in which a monetary value is assigned to both the costs and outcomes of alternative actions. Both the benefits and outcomes of each alternative action are then compared in dollar terms.
Cost-Effectiveness Analysis: economic analysis in which the costs of alternative actions with a specific outcome are compared.
Discount Rate: the rate used to adjust benefits and costs to reflect comparable values for factors occurring at different times.
Economic Evaluation: the comparative analysis of alternative courses of action in terms of both their costs and consequences.
Marginal Cost: the additional cost incurred by modifying an existing action of programme to change an outcome; for example, the additional cost to the consumer to purchase fluoridated table salt rather than unfluoridated table salt.
Notion of Scarcity: resources in society are insufficient to allow the pursuit of all desirable objectives.
Sensitivity Analysis: a measurement of how much results are affected by changes in the costs and outcomes studied.
Willingness-to-Pay: this is the traditional measure of benefit in economic analysis. In this context, consumers would presumably be prepared to pay a certain sum of money to have sound teeth rather than decayed/missing/filled teeth.

Differing interventions implemented in Kuwait are examined including the decision to stop the fluoridation of water in the early 1980s.

Materials and Methods

Average costs were determined by a search of the literature through market analysis, and supplier estimates, and costing reports of contracted health programmes in Kuwait. The efficacy of each intervention (% of caries reduction) is based on published international data. Expected or projected disease data is based on 1984 and 1993 national oral health surveys undertaken in Kuwait, with an assumption that at age 20 years, the decayed, missing and filled permanent teeth (DMFT) would be the same as observed in 1984. To carry out the economic evaluation of costs versus benefits, the Net Present Value formula was used for analysis of each intervention's

costs and benefits. A benefit/cost ratio and a cost/effect ratio were then determined. While some costs are available at the Gulf States level, the authors also used international data for purpose of analysis. The discount rate of 5% was used in the calculation (Table 2). For this analysis, costs from birth up to age 20 years were examined. In the case of salt fluoridation, a sensitivity analysis varying one parameter - cost to the consumer - was carried out.

Table 2. Variables used for calculation.

Benefits $ value of saved teeth only, based on a decay rate of 4.5D, age 20, at the last survey 1984.

Baseline cost of filling estimated cost of one filling in Kuwait in 1996 @ $ 83.35, and adjusted for yearly increases to the year of intervention. Intervention years for filling are year 6 and 13 here.

Baseline cost of prevention costs based on costs cited in the literature, or in Kuwait, or in Gulf Cooperation Council countries, with a 5% annual projected increase (I).

Years of programme intervention (n) vary from 6 to 20 years, see Tables 3, 4.

Lost opportunity costs value of money lost to programme compounded @ 5% yearly.

Discount rate (r) 5% used here.

Sample Calculation for Water Fluoridation @

n = 20 years Estimated Efficacy = 50%
I = 5% Fillings = occur in year 6 and year 13, 50% each
r = 5%

1. **Net Present Value$_{Costs}$**

$$= \frac{\text{(Baseline costs) (expected annual increase @ 5\% yr.}^{n}\text{) (n) + (lost opportunity costs compounded @ 5\%/yr.}^{n}\text{) (n)}}{(1 + r)^n}$$

$$= \frac{(\$0.51)\,(1.0 + .05^{20})(20) + (\$0.51 \times 0.5)\,(1.05^{20})\,(20)}{(1.0 + 0.5)^{20}}$$

^{NPV}cos,s =$10.65

2 **Net Present Value$_{Benefits}$**

$$= \frac{\text{(Baseline Cost of filling) (2.25 Saved Teeth) (0.50, yr 6) (1.05 annual cost increase}^{n=6}\text{) (1.05 compounded/yr}^{n=14}\text{) + (Baseline Cost of Filling) (2.25 Saved Teeth) (0.50, yr 13) (1.05 annual cost increase}^{n=13}\text{) (1.05 compounded/yr}^{n=7}\text{)}}{(1 + r)^n}$$

$$= \frac{(\$83.35)\,(2.25)\,(0.50)\,(1.05^{6})\,(1.05^{14}) + \$83.35)\,(2.25)\,(0.50)\,(1.05^{13})\,(1.05^{7})}{(1 + .05)^{20}}$$

^{NPV}Benef,,s = *187a87

B/C Ratio = $ 187.50 / 10.65

17.64

18 rounded

Results

Table 3 provides estimates of annual costs for different preventive fluoride modalities in different countries. In the analysis, it is important to note that costs can be incurred either in the private sector or the public sector- while this does not affect the economic evaluation, it can weigh on the decision making process. When public sector budgets are restrained, as is the present case in the Gulf States, it may be quite appropriate to transfer small costs to the individual. This holds true for salt fluoridation and bottled fluoridated water in our analysis. Both of these interventions can be paid for by either the consumer directly or by the State through subsidies.

Table 3. Estimated annual per capita costs ($ U.S.) of fluoride regimes in selected countries.

Method	Efficacy	USA	Switzerland	Kuwait	Kuwait	Kuwait	Other
	(Caries Reduc-tion)			Private Sector	Ministry of Health	Contracted School Health Programmes	
	%	1990	1990	1996	1996	1996	
Community Water Fluoridation	50-60	$0.51 (Ave)[a] (Range $0.12-$0.75)					
Salt Fluoridation	50-60		$0.20-$0.40[b]	$0.10[c]	$0.10[c]	-	
Fluoride Supplements (Tablets)	50-60	$3.10(Ave)[a] (Range $0.81-$5.40)					
Bottled Fluoridated Water (at OJppm) a. New consumer b. Regular consumer	50-60	N.A. N.A.	-	$96.86[d] $2.20[d]	-	-	
Fluoridated Mouthrinses in Schools	30	$1.15(Ave)[a] (Range $0.52-$1.78)				$1.50	
Professionally Applied Fluorides (2X/year)	30	$60[a]	-	$67.00[c]	-	-	
School-Based Topical Gel Fluorides (mass application)	30	-	-	-	-	4.38[h]	
School-Based Fluoride Toothpaste Application/ Home-Based Fluoride Toothpaste Application	25			$6.68[f]			$6.69 (London)S
Other							
Sealant per tooth	55-77	$30/Tooth[a]		$33.5[e] /tooth	-	14.45[h]	

Sources

a. US Dept. of Health & Human Services
b. WHO Fluorides & Oral Health
c. Ministry of Health, Policy Notes, Dental Services
d. Market Estimates, Kuwait
e. Kuwait Dental Association, Suggested Fees
f. Unilever Arabia estimates
g. Infoscan, England
h. School-based Oral Health Programs, Kuwait

Table 4 provides an estimate of benefits accrued in the form of reduced disease (caries) based on known disease rates in Kuwait. A dollar value is placed on these benefits. By design, the Benefit/Cost results (B/C ratios) are an undervaluation because many other benefits are not included, as it is difficult or near impossible to place a monetary value on these other benefits. Several such benefits are listed in Table 5.

Table 4. Estimated costs, effects and benefits of selected fluoride prevention regimes over twenty years, Kuwait.

A	B	C	D	E	F	G	H	I
Method	**Efficacy**	**Expected Decayed Teeth**	**Cost at Baseline per Year/per Person**	**Present Value Costs**	**Permanent Teeth Saved**	**Present Value Benefits[3]**	**B/C Ratio (Col. G/ Col. E)**	**C/E Ratio (Col. E/ Col. F)**
	(% Caries Reduction)	Age 20 - Kuwait	$	$	(Col. B x Col. C)	$	$	$
Salt Fluoridation	50	4.5	$0.10 (consumer)	$2.10 (20yrs)	2.25	188	89	1
Community Water Fluoridation	50	4.5	$0.51 (USA Ave)	$10.65 (20yrs)	2.25	188	18	5
Fluoridated Mouth rinses in Schools	30	4.5	$1.15 (USA Ave)	$16.93 (14yrs)	1.35	152	9	13
Fluoride Supplement (Tablets)	50	4.5	$3.10 (USA Ave)	$45.57 (14yrs)	2.25	188	4	20
Bottled Fluoridated Water (at 0.7ppm) - New Consumer	50	4.5	$ 96.86 (KT)	$2034.00 (20yrs)	2.25	188	<1	>100
Bottled Fluoridated Water (at 0.7ppm)- Regular Consumer	50	45	$ 2.20 (KT)	$44.45 (20yrs)	2.25	188	4	20
School-Based Topical Gel Fluoride (mass application)	30	4.5	$4.38	$64.39 (14yrs)	1.35	152	2	48
Professionally Applied Fluorides	30	4.5	$67.00	$985.00 (14yrs)	1.35	152	<1	>100
School Based Fluoride Toothpaste Application/ Home-Based Fluoride Toothpaste Application	25	4.5	$6.68	$140.27 (20 yrs)	1.12	127	<1	>100
Other								
Sealants without daily fluoride supplement	55	4.5	$134.00	$276.00[b]	2.47	226	<1	>100
Sealants when combined with daily fluoride supplement	77	4.5	$134.00	$276.00[b]	0.66	60	<1	>100

a. Based on estimate cost of compound amalgam filling, Kuwait, 1996 of KD 25 X US$ 3.34 = US$ 83.35, 5% yearly increase in costs, 5% discount rate

b. 4 teeth sealed year 6 and 4 teeth sealed year 12

Table 5. Some expected benefits from prevention programs.

A. Individual

- Healthy child
- Improved diet and nutrition
- Reduced loss of school time
- Lowered oral disease rate
- Lowered caries rate in deciduous and permanent dentition
- Development of dentally happy child
- Reduction of fear
- Reduced travel time and work absence of parent
- Improved general health
- Maintenance of disease-free oral cavity through primary school
- Improved provider/patient relationship
- Reduced risk of abscesses, toothache, tooth extraction, general anaesthesia

B. Community

- The community is moved along the continuum of disease-health
- The time and stress of parental involvement is reduced
- The community is able to use the 'saved' time and funds on other socially urgent activities

C. The Government

- Work time of employees is increased due to reduced absences for travel to clinic with their children
- Future health costs are reduced though reduction of disease
- Future lives are saved or improved through reduced morbidity and mortality
- Total quality of life increases in each person
- "Scarce Resources" (money) can be shifted to other government projects

A monetary value is difficult to place on the above factors, many of which are abstract in nature. However, some factors have clear monetary values, as noted.

A sensitivity analysis of the salt fluoridation results (Table 6) was carried out by changing the value of one parameter - the cost to consumer. As the costs increase to the consumer, the B/C ratio is significantly reduced, but remains favourable vis-a-vis other interventions.

Table 6. Sensitivity analysis cost of fluoridated salt in Kuwait over 20 years discounted to 1996.

Fluoridated Salt	Efficacy	Expected D' Age 20, KT	Cost at Baseline per Year per Person	Present Value[a] Cost $	Permanent Teeth Saved	Present Value[b] Benefits $	B/C Ratio	C/E Ratio
A	50%	4.5	$0.10	$2.10	2.25	$187.90	89.0	0.9
B	50%	4.5	$0.20	$4.20	2.25	$187.90	44.5	1.9
C	50%	4.5	$0.30	$6.30	2.25	$187.90	29.8	2.8

D (decayed); B (benefit); C (cost); E (effect)
a. In this case, all costs are absorbed by the consumer
b. Benefits are saved fillings; other future benefits not valued

Discussion

The efficacies of these interventions are well established.[611] The "effectiveness" in the community and the final benefits to the community can differ from the expected efficacy, based on a plethora of variables: provider compliance, patient compliance, coverage, accuracy of application, etc. It is this "community effectiveness" that is of interest to the health planner as an end measure of the intervention efficacy in a particular situation based on one or more such variables. In Table 7, hypothetical examples of the change in community effectiveness for some health interventions when certain para-

meters are adjusted are given. With sealants, community effectiveness by improving such variables as provider compliance, patient compliance, provider diagnosis, or passive fluoridation can be improved. Once the potential community effectiveness is determined, the economist or health planner must examine the Benefit/Cost ratio and the Cost/Effect ratio, in order to provide the decision makers with the appropriate information for planning and implementation. Cost-Effectiveness Analysis is the simpler of the two analyses. Cost-Benefit Analysis is more difficult as it places a monetary value on all benefits, which is impossible or near impossible in some situations.

Table 7. Sample calculations for community effectiveness.

Example	Efficacy	x	Diagnostic Accuracy	x	Provider Compliance	x	Patient Compliance	x	Coverage	=	Community Effectiveness	% of Efficacy Achieved in the Community
Hypertension Treatment												
a) under current conditions	76%	x	95%	x	66%	x	65%	x	90%	=	28%	28/76x100%=37%
b) under conditions of improved provider and patient compliance	76%	x	95%	x	90%	<	90%	x	90%	=	53%	53/76x100%=70%
Sealants												
a) under current conditions in Kuwait (estimated)	55%	x	50%	x	10%	x	90%	x	95%	=	2%	2/55x100%=4%
b) under improved conditions in Kuwait of coverage, compliance, diagnosis, and fluoride supplement	77%	x	90%	x	100%	x	95%	x	95%	=	62.5%	62.5/77x100%=81%

A simplified working formula for this type of analysis is the Net Present Value[12] formula:

$$NPV = \sum \frac{Bn - Cn}{(1+r)^n}$$

where B = all benefits, C = all costs, n = number of years of the programme, r = discount rate.

The 'discount rate' is used to allow comparison of benefits and costs that are generated in different years.[4] Britain publishes the public sector discount rate to be used in evaluations of this type (4-6%).[1] The discount rate can vary by definition; the World Bank defines it as social accounting rate of interest (SARI) - today's interest rate less today's inflation rate.[2] The authors "discounted" future costs and benefits back to the present.[4] If the sum of the benefits is greater than the sum of the costs, the intervention examined could be acceptable.

When making an intervention decision based on an available fixed budget, the decision rule is to accept (A) the maximum benefits program or (B) the least costs program, depending on factors within the political, economic, and health sectors. Based on the analysis here, maximum benefits would be similar for water fluoridation, salt fluoridation or fluoride tablets. In economic terms, salt fluoridation would provide the greatest economic savings (C/E ratio) while still maximising benefits to the community (B/C ratio). In establishing the cost to the consumer of fluoridated salt, the authors are concerned only with the 'marginal' costs, i.e. the additional costs of the added fluoride, as all consumers can be considered salt purchasers. This can also be true for bottled water if the individual is a regular consumer. For community water, the authors are also interested in the marginal costs.

Water fluoridation and fluoride tablets would be the next best alternatives, respectively. In each of these three interventions, benefits are maximised. Alternatively, a decision might be made to minimize costs, for example, in the school based oral health care programmes of Kuwait, with two possible alternatives: (a) tablets or (b) rinses. In this scenario, rinses have a lower Cost/Effect (C/E) ratio, but also less total benefits. Within a fixed budget for the school based oral health care programme, the additional decision might be to maximize disease prevention benefits by reducing expenditures in other areas, and shifting the saved financial resources to the Fluoride Tablet Programme in order to garner the additional benefits for society.

In Kuwait, a decision was reached in 1980 to cease the fluoridation of water. A 30% rise in the caries index in children born after 1980 with a concurrent decrease in the number of children free of caries has been observed (Figs. 1,2).[13] An increase in caries from the 4.5D at age 20 seen in 1984 to 6.0D in the next few years is expected. Increased treatment costs borne by both the private and public sector and a loss of the benefits discussed to the individual and to society can also be logically expected.

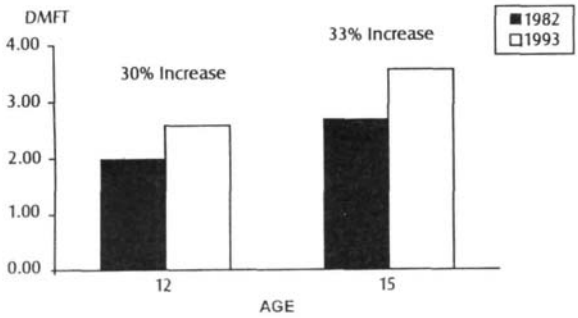
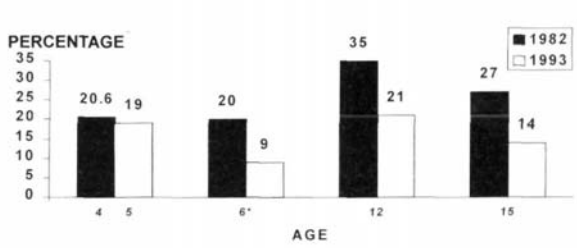


Fig. 1. Change in DMFT in children from 1982 to 1993 in Kuwait.

In the decision-making process, all benefits and all costs should be weighed. In health, this presents a difficulty in that many benefits are abstract in nature and a monetary value cannot easily be attached. In the analysis, the authors only cost the value of a saved filling. However, these other benefits (Table 5) have a clear value to society. Where the B/C ratio is close to 1/1 or below, then these added "unvalued" benefits can improve the B/C ratio in favour of choosing



*Deciduous and Permanent teeth

Source: Glass RL. National Dental Health Survey of Children, Ministry of Health, Kuwait, 1982.

Kuwait National Oral Health Survey, Oral Health of 4, 6, 12 and 15 year old children in Kindergarten and Public Schools in Kuwait, Ministry of Health 1993.

Fig. 2. Percentage of children free of caries at selected ages in 1982 and 1993, Kuwait.

a program over rejecting it as "too costly" for the explicit monetary benefits generated (i.e. saved fillings).[4-12] The use of fluoridated toothpaste is an example of this, as is the application of sealants. Sealants are not considered a cost effective procedure in public health programmes if the only variable factored in is the saved filling (Table 4). When other possible benefits are factored in, the B/C and C/E ratios may become favourable. In the private sector, "willingness to pay" by the consumer for sealants can be used to evaluate the value of this intervention. The "willingness to pay" concept can be a proxy in monetary terms for the perceived benefits valued by society. This concept, however, has limited value in a society where individual resources are severely limited.[2]

The results for each fluoride intervention can be re-examined to test the sensitivity of the results. As salt is clearly the most cost effective, the authors changed one parameter -the cost to the consumer- to test the results, and salt fluoridation remains the most favourable intervention. While several variables (compliance, consumption, costs, efficacy) can be examined, most attempts to deal with the precision of such variables create more problems than they solve.[14]

The results predicted from this economic analysis can allow the decision-maker the choices of whether to accept or to reject alternative and competing fluoride disease prevention modalities, based on the organized consideration of multiple factors.

In conclusion, economic evaluation provides the decision-maker choices to accept or reject alternative and competing fluoride disease prevention modalities. The decision-maker can weigh maximum benefits versus total costs versus least costs. The ratios are examined and based on priorities, differing interventions can be accepted or rejected. The authors' preliminary analysis indicate that fluoridated salt maximizes benefits and provides the least cost alternative within the Gulf States. While fluoridated salt has not been considered in the past as a viable option for the region, it provides a simplified and less costly alternative to other noted methods. Salt is readily available in the Gulf States as a by-product of water desalination. The quality is excellent and the fluoridation process is simple. An additional valuable benefit is that consumption of fluoridated salt is a voluntary activity by the consumer, thus removing a negative argument used against public water fluoridation. Fluoridated salt now reaches some 85% of the public in Switzerland,[15] and France has become the largest producer of fluoridated salt. These results from Europe confirm that, given the choice, the informed public will protect its oral health through the consumption of fluoride supplements in a suitable vehicle.

Economic evaluation is not an exact science. However, its merits are in making all relevant costs and benefits explicit, together with any value judgements, thus contributing to more informed choices for the final decision maker. It aims to ensure that resources are put to their most valuable use for society. Economic evaluation cannot tell us what health programs society should pursue, what preventive programmes we should adopt. These answers are up to society,' and are based on political, social, ethical as well as technical and economic considerations.

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