Efficiency of fluoride programs in the light of reduced caries levels in young populations

Helena Forss

Oral and Maxillofacial Department and Department of Otorhinolaryngology, Kuopio University Hospital, Kuopio, Finland

Forss H. Efficiency of fluoride programs in the light of reduced caries levels in young populations. Acta Odontol Scand 1999;57:348–351. Oslo. ISSN 0001-6357.

Since the late 1930s, when the efficacy of fluoride in caries prevention was first detected, various efficient methods for fluoride delivery have been developed. Nowadays, fluoride is used for caries prevention on a global scale, the most widely used methods being fluoridated toothpaste and water fluoridation. The latter is a typical community-based prevention method, whereas the former method relies on individual motivation. The goal of an efficient community-based fluoride program is to maintain a constant low level of fluoride in as many mouths as possible at as low a cost as possible. Initially, water fluoridation and other community-based programs were highly efficient, but nowadays in societies in which the major part of the population is using fluoride toothpaste and caries levels are low, population-based programs show a low efficiency. As an example, even though water fluoridation was withdrawn in Kuopio, there have been no dramatic effects on the dental health of children and youths. In societies with well-attended, community-based, free dental health care for children and youths, the dental motivation of individuals is, in general, very high and the use of fluoride for caries prevention may be taken care of at the individual level. □ *Caries prevention; community-based programs; efficiency; fluoride*

Helena Forss, Oral and Maxillofacial Department, Kuopio University Hospital, P.O. Box 1777, FIN-70211 Kuopio, Finland. Tel. +358 17 174 025, fax. +358 17 174 027, e-mail. helena.forss@kuh.fi

In recent years, there has been increasing discussion on the correct policy and cost-effectiveness of caries-prevention programs in western countries (1, 2). In contrast to earlier experience with the use of fluorides in caries prevention, the efficiency of caries prevention programs is much more difficult to show nowadays. In the light of recent studies, the aim of this article is to evaluate the efficiency of fluoride programs in societies where dental motivation is high and caries levels in young individuals are low.

Concepts and definitions in health economic evaluations

When evaluating health-promoting preventive methods, a systematic approach can be chosen to analyze their effects on health in relation to the economic resources used. In health economics the following explanations and definitions relevant in this context are commonly used.

Efficacy is the medicinal or health-promoting effect of the tested agent or method (Hausen, 1999, pers. comm.), whereas effectiveness is the clinical effect of a technology, like medicine, treatment procedure, etc. (3). Although these two words are fairly close in meaning and are often used synonymously, they are not identical. The word "efficacy" is totally neutral in terms of costs or resources used, while the word "effectiveness" contains an assumption of the economic use of resources when used in a health economical context.

Efficiency is the clinical effect of a technology in relation to used resources (3), or the effects or end results achieved in relation to the effort expended in terms of money, resources, and time (4). If a highly effective preventive method demands considerable resources, it may show a low efficiency in spite of good preventive results.

In analyzing and assessing various courses of action and their results in relation to the resources used, formal methods are used in health economics. For example, these include cost-effectiveness analysis, which is a study of how to achieve a given goal with the least resource allocation, or how to allocate the available resources to maximize output. Cost-effectiveness analysis may be used to determine the least expensive way of achieving a stated objective, whereas cost-benefit analysis is a study in which the costs and benefits of alternative courses of action are compared, usually measured in monetary terms (3). The latter is a formal and systematic way of choosing among alternative investments in public projects. It attempts to measure the benefits of a program strictly in monetary terms and to relate the benefits to the costs of achieving them. Simple cost-benefit analyses often ignore the unmeasurable, intangible, or indirect benefits (5).

Summary of accumulated knowledge on the effectiveness of fluoride programs

The literature on the use of fluorides in caries prevention is immense. The effectiveness and efficiency of fluoride programs have been evaluated repeatedly (for review, see e.g. 6–9). The main aspects of the accumulated knowledge

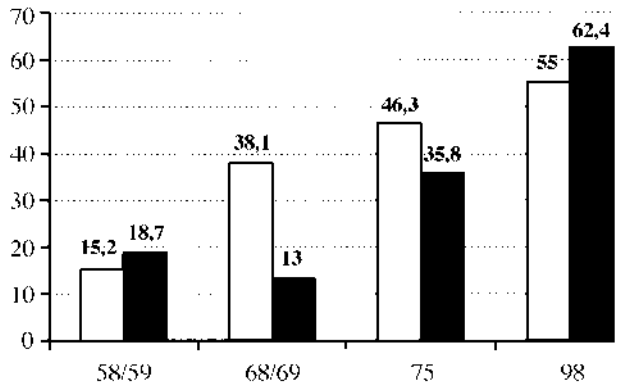

Fig. 1. Percentage of caries-free 7-year-old children in Kuopio and Jyväskylä in different years. Water fluoridation in Kuopio was started in 1959 and stopped in 1992. Data adapted from Nordling and Tulikoura (11) and Savola (12) and from municipal health records (by kind permission of the directors of dental services in Kuopio and Jyväskylä) (□ Kuopio, ■ Jyväskylä).

on the effectiveness of fluorides in caries prevention can be summarized as follows:

- During the early years of water fluoridation (1940s to 1960s), caries levels in fluoridated communities were approximately 50% lower than in communities without water fluoridation
- The first studies on school-based fluoride rinsing programs in the 1960s and 1970s showed a 30–50% reduction in caries increment within 2 to 3 years
- The prevalence of dental caries has declined in most industrialized countries in the past 25 years and this trend is generally attributed to the widespread use of toothpaste containing fluoride
- As the prevalence of caries has declined, community-based fluoride distribution programs, such as water fluoridation, mouth-rinsing programs for schoolchildren, or free distribution of fluoride tablets, have become less efficient.

When trying to extract information about the economic use of resources on caries prevention programs one is forced to use indirect evidence, since real health economic analyses in preventive dentistry are rare. However, the following examples give some indirect evidence of the efficiency of the prevention programs, even though the original studies do not always comprise economic analyses.

Effect of the water fluoridation program in Kuopio, Finland

The town of Kuopio in the eastern part of middle Finland was the only community in Finland and Scandinavia to start a piped water fluoridation program. This was in 1959, when Finland had recovered from war and the standard of living was rising rapidly.

The consumption of sugar was now increasing strongly after years of sugar rationing, and resulting in alarmingly high incidence rates of caries. Within Finland, the caries situation was worst in the eastern and northern parts of the country, where there was no natural fluoride in the groundwater sources. The decision of the authorities in Kuopio to start the water fluoridation program caused a lively and long-lasting discussion on the benefits and possible negative effects of artificial water fluoridation. No other community in Finland was willing to take the same step as Kuopio, even although the health authorities of the state repeatedly recommended water fluoridation programs. Opposing civic groups were very active during all the years of fluoridation and it was claimed that fluoride in water brought about various illnesses and ailments (10). After repeated disputes and bitter local campaigns, the City Council of Kuopio decided to discontinue the water fluoridation program at the end of year 1992.

Partly owing to the constant public interest in water fluoridation, the caries situation in Kuopio was documented carefully and comparisons with other communities were made in order to show the benefits of the program. Jyväskylä, a nearby town located in a low fluoride area with a distribution of demographic and socio-economic characteristics close to those of Kuopio, served as an object of comparison (11–13).

The numbers of caries-free 7-year-old children in Kuopio and Jyväskylä at the beginning of the program and in 1968/1969, 1975, and 1998 are shown in Fig. 1. The 1998 data show the situation 6 years after the program was discontinued. At the beginning of the program, water fluoridation resulted in a clear difference in the number of caries-free children. At the time, it was calculated that the costs of dental care per child were 56 FIM in Kuopio and 94 FIM in Jyväskylä, i.e. the costs in Kuopio were only 60% of those in Jyväskylä. It was estimated that total savings in the dental care of schoolchildren during the first 10 years had been more than 600,000 FIM, which would correspond to approximately 3 million FIM today (11). Savings in the dental care of small children or adults were not estimated.

Next evaluation on the savings in dental care in Kuopio reported the situation in 1975 (12), when the difference between Jyväskylä and Kuopio had diminished. Nevertheless, it was calculated that Kuopio had saved the annual salaries of four dentists and four dental nurses who would have been needed to respond to the need for restorative therapy in the case of no water fluoridation.

However, the difference begins to decrease during the 1970s, and since 1977 only minor, inconsistent differences have occurred between the incidence of caries in children in these two towns. The average DMFT scores of 7-year old children in Kuopio and Jyväskylä from 1959 to 1998 (in Table 1) show the same development.

The effects of the discontinuation of water fluoridation have been studied by Seppä et al. (14) and the results of the first 3-year period without water fluoridation reflect, unexpectedly, that the rate of caries has not increased but,

Table 1. Average DMFT scores of 7-year-old children in Kuopio and Jyväskylä. Data adapted from Nordling and Tulikoura (11) and Savola (12) and from municipal health records (by kind permission of the directors of dental services in Kuopio and Jyväskylä)

Year	Kuopio	Jyväskylä
1958	3.0	–
1968/69	1.4	3.1
1975	1.3	1.7
1998	0.16	0.10*

*76.3% of the age group has been examined.

on the contrary, decreased. The average DMFT scores for the 12-year-old children in Kuopio and Jyväskylä are given in Table 2. The decrease in caries incidence is true also for Jyväskylä. In the same time period, the mean numbers of fluoride varnish and sealant applications have decreased sharply in both towns.

Effect of fluoride from natural water

Angelillo and co-workers (15) recently published a paper in which caries and fluorosis prevalence were registered in children from 2 areas in Italy with different levels of natural fluoride in the water. The data concerning the caries prevalence showed that the proportion of caries-free 12-year-old schoolchildren was slightly higher in a low-fluoride area than in a high-fluoride area (Table 3). Multiple regression analysis showed that caries-free status and DMFT index were associated with employment in parents and their socio-economic status and with the children's consumption of sweets but not with place of residence, that is, the level of fluoride in the drinking water. Significant association with the place of residence was found only with the DMFS index.

Previous examples suggest to us that the decline in caries today may have little to do with professional preventive measures performed in dental clinics, and that in societies with a high standard of living water fluoridation may no longer have much effect, let alone efficiency.

Targeted intensified prevention programs for children

In Nordic countries, intensified prevention programs for children and young persons have been the focus of much attention and research. In a 3-year trial, Karjalainen and co-workers (16) studied caries development after replacing supervised fluoride rinses and tooth brushing with unsupervised use of fluoride toothpaste. At the beginning of the period the participants were 7–8 years old. The test group participated in the 2-weekly school-based fluoride rinsing program, which included supervised tooth brushing, while the control group received a new fluoride toothpaste tube (0.15%) for home use every 2nd month. The 3-year DMFT increment was 0.9 for the test group and 0.5 for the control

Table 2. Average DMFT scores of 12-year-old children in Kuopio and Jyväskylä before and after discontinuation of water fluoridation. Adapted from Seppä et al. (14)

Year	Kuopio	Jyväskylä
1992	1.88 (SE 0.16)	2.99 (SE 0.47)
1995	1.62 (SE 0.10)	1.63 (SE 0.23)

group. After 3 years, there were statistically significant differences in favor of the supervised rinsing group, and the authors conclude that during eruption and maturation of permanent teeth, fluoride mouth rinses and supervised tooth brushings should be continued at school. During the 3-year study, however, no time was saved in dental clinic visits, suggesting that even if the program showed some efficacy it may not have been efficient.

Hausen et al. (17) studied whether the targeted intensified prevention could produce any additional preventive effects in a child population with overall low caries activity. Children, who were regarded as at high risk were randomly put into 2 groups and half of them were offered a truly intensified prevention consisting of counseling, fluoride varnish applications, fluoride lozenges, sealants, and use of chlorhexidine rinses. The mean 3-year DMFS increment in the low-risk group was 2.0 and in the intensified prevention group 4.4; in the high-risk group with basic prevention only it was 5.1. The negligible difference implies that intensified prevention produced practically no additional benefit and definitely was not very efficient.

The widespread use of fluoride varnishes is typical of Nordic countries and there are many excellent studies on their effectiveness in caries prevention, but is there still a place for them in the era of low caries levels? Petersson & Westerberg (18) studied the long-term effect of an intensified fluoride varnish program and analyzed the benefit economic net result of such a program compared to a standard fluoride varnish program. Eleven-year-old children received an annual intensified fluoride varnish program with 3 applications within 1 week over a period of 3 years. Children in the control group received fluoride varnish twice a year, and otherwise both groups received the same basic prevention. The proximal caries increment showed a statistically significant difference between the groups at the age 14. Their study also included a cost-benefit analysis in which the costs consisted of the total extra costs for the intensified program for the original 80 individuals in the group. The benefits can be divided into

Table 3. Caries experience in 12-year-old children in communities with different concentrations of fluoride in water. Adapted from Angelillo et al. (15)

	Caries-free (%)	DMFT	DMFS
Low-fluoride area	48.4	1.5 (SD 1.9)	2.6 (SD 3.9)
High-fluoride area	46.8	1.4 (SD 1.7)	1.6 (SD 1.9)

Table 4. Cost/benefit analysis of the 3-year intensified fluoride preventive program. The benefits are calculated over a time-span of 10 years. A = Net benefits due to the prevention of caries increments; B = net benefits due to arrested progression of existing lesions; C = net total costs for the prevention program. All values in SEK fixed prices. Adapted from Petersson and Westerberg (18)

	A	B	C	A + B
Benefits	1,800	3,200		5,000
Costs			3,880	
Results				+1,120

benefits due to the prevention of caries incidence and benefits due to reduced progression of initial lesions, which existed at age 11. Their analysis showed that the benefits of the intensified fluoride varnish program were greater than the costs (Table 4).

Sköld et al. (19) studied an intensified fluoride varnish program in 11–15-year-olds in order to evaluate the caries-preventive effect and costs of such a program. In the course of a year the test group received 3 varnish applications within 1 week, whereas the control group received 1 application per year. After 4 years there were significant differences in caries increments. The authors suggest that the resources invested in the more resource-demanding program for the test group were more than compensated for by the resources saved through fewer fillings. However, they added that considerably more time was used in the program of the test group. The authors do not discuss the efficiency of the prevention program.

Conclusions

In summing up, the results in the previous examples show that both population-strategy-based programs and high-risk strategy-based programs may today reflect a considerable low efficiency in populations with moderate or low caries activity. In other words, the results suggest that if caries prevalence is not very high, a preventive program is seldom less expensive than the respective restorative treatment. However, it has to be borne in mind that in economic analyses unmeasurable and indirect benefits are ignored and thus, e.g., a healthy dentition is not valued as such.

In this article the focus of attention has been on prevention programs in Nordic countries, which is of course a most restricted vision. It must therefore be emphasized that it would be dangerous to generalize the results of studies on efficiency of fluoride programs. Data valid in one part of the world may not be applicable or relevant in other parts. Factors having a strong bearing on the results are socio-economic conditions of the society, use of fluoride toothpaste, and perhaps also secular trends of caries prevalence.

Dentistry, especially preventive dentistry, is not an isolated island in the society. We are strongly dependent on political decision-making and acceptance of our efforts by the public at large. We must be able to give grounded arguments about the benefits and costs of prevention programs and this is possible only through studies conducted in like societies. There is a long and strong tradition of research on preventive methods in Nordic countries. To define the efficiency of fluoride programs with the help of inter-Nordic multicenter studies could be one focus of attention in the next millennium.

References

1. Burt BA. Prevention policies in the light of the changed distribution of dental caries. Acta Odontol Scand 1998;56:179–86.
2. Schwarz E. Is caries prevention cost-effective? Does anybody care? Acta Odontol Scand 1998;56:187–92.
3. Tuominen R. Health economics in dentistry. 1st ed. California: MedEd; 1994.
4. World Health Organization. Statistical indicators for the planning and evaluation of public health programmes. WHO Tech. Rep. Series No. 472. Geneva: WHO; 1971.
5. Horowitz HS, Heifetz SB. Methods for assessing the cost-effectiveness of caries preventive agents and procedures. Int Dent J 1979;29:106–17.
6. World Health Organization Fluorides and oral health. WHO Tech. Rep. Series No. 846. Geneva: WHO; 1994.
7. Newbrun E. Effectiveness of water fluoridation. J Public Health Dent 1989;49 (Spec Issue):279–89.
8. O'Mullane DM. The future of water fluoridation. J Dent Res 1990;69 (Spec Issue):756–9.
9. Riordan PJ. Fluoride supplements for young children: an analysis of the literature focusing on benefits and risks. Community Dent Oral Epidemiol 1999;27:72–83.
10. Lamberg M, Hausen H, Vartiainen T. Symptoms experienced during periods of actual and supposed water fluoridation. Community Dent Oral Epidemiol 1997;25:291–5.
11. Nordling H, Tulikoura I. Kokemuksia Kuopion juomaveden fluorauksesta. Suomen Hammaslääkärilehti 1970;17:517–24.
12. Savola I. Perusteltu kannanotto juomaveden fluoridoinnin tuottamista kustannussäästöistä Kuopion terveyskeskuksen hammashuollossa v. 1975. Hallinto ja terveys 1977;4:66–7.
13. Parviainen K, Ainamo J, Nordling H. Changes in oral health from 1973 to 1982 of 13–15-year-old schoolchildren residing in three different fluoride areas in Finland. J Dent Res 1985; 64:1253–6.
14. Seppä L, Kärkkäinen S, Hausen H. Caries frequency in permanent teeth before and after discontinuation of water fluoridation in Kuopio, Finland. Community Dent Oral Epidemiol 1998;26:256–62.
15. Angelillo IF, Torre I, Nobile CGA, Villari P. Caries and fluorosis prevalence in communities with different concentrations of fluoride in the water. Caries Res 1999;33:114–22.
16. Karjalainen S, Eriksson A-L, Ruokola M, Toivonen A. Caries development after substitution of supervised fluoride rinses and toothbrushings by unsupervised use of fluoride toothpaste. Community Dent Oral Epidemiol 1994;22:421–4.
17. Hausen HW, Kärkkäinen S, Seppä L. Application of the high-risk strategy to control dental caries. Community Dent Oral Epidemiol 2000;28:26–34.
18. Petersson LG, Westerberg I. Intensive fluoride varnish program in Swedish adolescents: economic assessment of a 7-year follow-up study on proximal caries incidence. Caries Res 1994;28:59–63.
19. Sköld L, Sundquist B, Eriksson B, Edeland C. Four-year study of caries inhibition of intensive Duraphat application in 11-15-year-old children. Community Dent Oral Epidemiol 1994;22:8–12.