Economic evaluation of dental caries prevention: a systematic review

Carina Källestål, Anders Norlund, Birgitta Söder, Gunilla Nordenram, Helena Dahlgren, Lars G. Petersson, Folke Lagerlöf, Susanna Axelsson, Peter Lingström, Ingegerd Mejàre, Anna-Karin Holm and Svante Twetman

National Institute of Public Health, Stockholm, Sweden; The Swedish Council on Technology Assessment in Health Care, Stockholm, Sweden; Department of Odontology, Karolinska Institute, Huddinge, Sweden; Faculty of Odontology, Gothenburg University, Gothenburg, Sweden; Centre for Oral Health Sciences, Malmö University, Malmö, Sweden; Oral and Maxillofacial Unit, Länssjukhuset, Halmstad, Sweden; Department of Odontology, Umeå University, Sweden

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The aim of the present study was to perform a systematic review of economic evaluations of caries prevention. A search in Medline from 1966 until May 2003 and a manual search in a number of journals identified 154 references, 74 of which were included. There were 17 original studies including an economic evaluation, and these form the basis of the present article. The rest were reviews, model studies and reports concerning economic practice in dentistry. The results show that the reviewed original studies on economic evaluation of caries prevention do not provide support for the economic value of caries prevention. The scarcity of well-conducted studies, as well as contradictory evidence in the reviewed articles, makes it difficult to judge the health-economic effect of the studied caries-prevention methods. ☐ *Caries; economic evaluation; prevention; review*

Carina Källestål, National Institute of Public Health, SE-103 52 Stockholm, Sweden. Tel. +46 8 5661 3648, fax. +46 8 5661 3505, e-mail. carina.kallestal@fhi.se

On the basis of a survey of Swedish dentists conducted by the Swedish Council on Technology Assessment in Health Care (SBU), and in which the effects of dental caries prevention were pinpointed as an important area for assessment of evidence (1), the SBU decided to initiate a systematic review of the literature on caries prevention. An economic assessment forming part of this review was published in Swedish and included studies of economic evaluations performed on original studies, economic evaluations performed using model data from earlier studies and reviews of economic evaluations (1). The review included a model estimation of costs for some preventive measures using data on present caries prevalence and costs from the Swedish dental care services. The aim of the present article is to summarize that systematic review of original studies of economic evaluations of caries prevention.

Methods

Articles were searched with the help of an information specialist in two ways, from Medline (1966 until May 2003) and by hand in the articles found in the Medline search. The following search terms were used: dental caries, prevention and control, cost analysis (including cost-effectiveness, e.g., comparison of treatments within the same disease, concerning costs and effects; cost-benefit, e.g., comparison of investments in treatments, effect expressed as monetary benefit, compared to costs; cost-utility, e.g., comparison of treatments within the same disease or for different diseases, effect expressed as utility like quality adjusted years, compared to costs). Articles written in the Nordic languages, English, German, Spanish, French, and Italian were searched for. Only articles reporting original research and reviews were included. Letters, editorials, etc., were excluded. In all, 154 articles were identified from Medline. The two reviewers read the abstracts and decided to order 48 references in full text. From the manual search, additional articles were added. The systematic review of economic evaluations of caries prevention finally included 74 articles, 17 of which were original studies, 9 were reviews, 24 evaluations of models and 12 described economy of dental practice. The 17 original studies are reviewed in the present article. The excluded articles and the reasons for exclusion are listed in Table 1.

The 17 articles were read in full text by two of the authors and assessed using two protocols, one for the quality of the odontological content, the other for the health-economic quality based on the checklist published by Drummond et al. (2). An independent reviewer judged articles published by the reviewers. The odontological and health-economic quality grade was judged as high (A), medium (B), or low (C). The predetermined criteria for the quality grade are shown in Table 2. The health-economic evidence value low (C) was given when the economic evaluation and the costs were not clearly presented. In articles where alternatives had been included and the cost assessments were comprehensive, but where analysis of

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Table 1. Excluded studies and the main reason for their exclusion

Reason for exclusion	Authors and publication year (reference)
No cost analysis	Alanen (2000) (19)
No cost analysis	Fiset (2000) (20)
Compared two ways of administrating sealants	Werner (2000) (21)
Same data as in Morgan (1998) (7)	Morgan (1997) (22)
On organization of dental care	Hannerz & Westerberg (1996) (23)
Same data as in Morgan (1998) (7)	Crowley (1996) (24)
Large attrition rate	Louw (1995) (25)
Reported time-use in dental care	Swedberg (1993) (26)
Retrospective study	Widenheim & Birkhed (1991) (27)
Method to describe health	Froberg & Kane (1989) (28)
Same data as in a model study	Manau (1987) (29)
No cost data	Clark (1985) (30)

sensitivity and of discounting was missing, the evidence value medium (B) was given. The articles were first judged in relation to odontological evidence value and thereafter in relation to their health-economic evidence value. The total evidence value was never higher than that of the odontological evidence value. Based on the quality assessed articles, the final level of evidence for the conclusions was set according to Table 3.

Results

Of the 17 original articles reviewed (Table 2), there were 4 studies concerning fissure sealants (5–8), 3 concerning fluoride rinsing (9–11), while the others concerned fluoride tablets (4, 12), fluoride varnish (11, 13), and whole preventive programs (3, 14–17). The use of chlorhexidine was evaluated in only one study (18), as was water fluoridation (19).

Fissure sealants

All studies had a low evidence value, none was a randomized clinical trial (RCT), and 2 studies had the fissure sealants combined with fluoride rinsing (5, 7). Morgan (7) separated the costs for fissure sealants and fluoride rinsing, while Goggin (5) claimed that the effect of fluoride rinsing was negligible. The cost for a saved tooth surface was AUD 11.80 (Australian dollars) according to the 3-year study (7) and GBP 9.66 according to the 2-year study (5). It is difficult to compare these 2 studies because of differences in follow-up time, years and countries of implementation and currencies utilized.

Leverett (6) performed a study in a geographical area with fluoridated water. The cost-utility ratio was 0.3, implying that the utility—measured as avoided costs of fillings—was 30% of the cost for fissure sealants of all patients included in the study. When only caries-active patients were included, the ratio was 1.0, i.e. the utility equalled the cost. In the study by Simonsen (8), with a follow-up of 10 years and few individuals in the sample, the cost to fill a tooth was 1.6 times higher than to perform a fissure sealant.

Assessing these 4 studies of low evidence value and with contradictory results, it seems that performing fissure sealants is a cost-demanding means of caries prevention

Table 2. Criteria for grading of papers

A (high quality) All criteria stated below should be met	B (moderate quality) All criteria stated below should be met	C (limited quality) One or more of the conditions stated below
Randomization by children	Randomization by children or school class	No or unclear randomization
A representative sample of the population under study; results can be generalized	The population under study defined; results cannot be generalized	The population under study not defined
Double-blind or independent examiners	Double-blind or single-blind	Not double-blinded
For permanent teeth the follow-up ≥3 years' duration	For permanent teeth the follow-up ≥3 years' duration	Less than 3 years' duration or not stated
Defined methods for clinical caries diagnosis	Methods for clinical caries diagnosis not completely described or validated	Methods for clinical caries diagnosis not completely described
Attrition rate reported, explained, not exceeding 10%/year	Attrition rate reported, not explained but not exceeding 10%/year	Attrition rate not reported or exceeding 10%/year
Diagnostic reliability test described	Diagnostic reliability test described	Diagnostic reliability test not described
Bias or confounders taken into account	Bias or confounders taken into account	Bias or confounders not reported or valued

Table 3. Definition of evidence levels

Evidence level		Definition
1	Strong evidence	At least two studies with grade 'A' or a good systematic review
2	Moderate evidence	One study with grade 'A' and at least two with grade 'B'
3	Limited evidence	At least two studies with grade 'B'
4	Inconclusive evidence	Less than two studies with grade 'B'

Table 4. Economic evaluation of original data

Author	Intervention test	Intervention control	Study design	No. of subjects	Age	Drop-outs (%)	Effect	Grade Odont/ Health ec.	Ref. no.
Oscarson (2003)	Preventive program	Compares (a) fluoride toothpaste/ toothbrushing, (b) fluoride tablets, (c) fluoride varnish, (d) individual prevention	Multicenter RCT	3,373 of which randomized 1,165 as a high-risk group	12 years	12–15%	After 4 years mean caries increment: DMFS no significant difference (not shown) DeMFS significant difference intervention (a) and (c) and cost per averted DeMFS SEK 2,043 (at 3% discount)	C/B	17
Morgan (1998)	Fissure sealants	Fluoride rinsing	Prospective cohort	256/266	12–13 years	19/15	AUD 11.80 / DMFT saved Cost-effect ratio = 1.41	C/B	7
Kobayashi (1995)	Fluoride rinsing	No control	Cohort	923–1974 385–1991	16 years	No data	86% less DMFT	C/C	9
Gisselsson (1994)	Chlorhexidine flossing		RCT	59/58/116	4 years	26/26%	38% less caries SEK 32 difference	B/C	18
Sköld (1994)	Fluoride varnish	No fluoride varnish	Case control	134 (65/59)	11 years	3/14%	2.2 DMFS less in test group. Same cost if school time included, else 10% lower for test group	B/C	13
Vehmanen (1993)	Fluoride varnish Fluoride rinsing	No extra fluoride	Case control	71/70/70		10/6/0% at treatment 2 year 28/31/30% at follow-up	Fluoride varnish: Cost-benefit ratio 1.2 for 2 years 1.8 for 4 years Fluoride rinsing: Cost-benefit ratio negative for 2 years, 1.5 for 4 years	B/B	11
Goggin (1991)	Fissure sealants Fluoride rinsing		Cohort	275/257	6 and 10 years	10/7%	71% lower DMFT value GBP 9.66/tooth saved	C/C	5
O'Rourke (1988)	Fluoride tablets	No extra fluoride	CCT	323 + 323	5 years	19%	Cost-benefit/DMFT 2.3:1 Cost-benefit/DMFT + dmft 1.35:1	C/C	4
Strohmenger (1988)	Fluoride rinsing		RCT	100/100	6 years	2%	1 DMFT less in fluoride rinsing group Cost: 11 700 lire/year and child	B/C	10
Simonsen (1987)	Fissure sealants		Case control	33/30	5 and 10 years	16/36%	Cost-effect ratio 1:2, 1.64 higher cost to fill compared to sealant	C/C	8
Donaldson (1986)	Preventive program	None	Cohort	73 88 (total 361)	0–2 years 3–6 years	55%	Cost ratio prevention/filling: 1.18/dmfs, 3.22/DMFS	C/C	14
Klein (1985)	Many preventive programs		Cohort	20052	Grade 1, 2, 5	52%	Water fluoridation saved 1.68 surfaces Cost: 6–80 cent per capita	C/B	15
Leverett (1983)	Fissure sealants in areas with water fluoride	Split mouth	Cohort	292	6–9 years	No data	70% less caries. Utility-cost ratio 0.3 for all, 1 for high caries active	C/B	6
Blinkhorn (1981)	Education Diet advice Fluoride tablets		CCT	242	12 years	27%, 26%	8% less caries in test group. Resource index +235%	C/C	3
Downer (1981)	Water fluoridation	Compares two towns	Cross-sectional	129/101 147/141	4–5 years 9–10 years	No data	4–5 yr: −1.91 dmft Cost in GBP–4.22/child 9–10 yr: −1.69 DMFT Cost in GBP–2.70/child	C/C	19
Klock (1980)	Preventive program		Cohort	645	9–12 years	7%	Prevention costs more than filling Ratio: 3.7	C/B	16
Stephen & Campbell (1978)	Fluoride tablets		RCT	61/55	5.5 years	11/13%	79% caries reduction 53.4% lower cost	B/C	12

RCT = Randomized controlled trials, CCT = Controlled clinical trials, DMFT = Decayed, missed filled permanent teeth, dmft = decayed missed filled primary teeth, GBP = UK pounds, SEK = Swedish kronor, AUD = Australian dollar.

with questionable cost-effectiveness unless only caries-active patients are to be treated (inconclusive evidence).

Fluoride rinsing

The three fluoride rinsing studies (9–11) had a low or medium evidence value. One study was a RCT (10), but with a low evidence value. Kobayashi (9) made no real economic analysis, only a total cost estimation for fluoride rinsing in schools. Vehamanen (11) stated a negative cost-utility ratio compared to fillings, while Strohmenger (10) stated a positive cost-utility ratio. The difference may perhaps be attributed to the much higher caries prevalence in the Italian children that Strohmenger studied. The 3 studies with estimated low (9–10) and medium (11) evidence thus gave contradictory results on the cost-effectiveness of fluoride rinsing (Inconclusive evidence).

Fluoride tablets and lozenges

A RCT from England (12), based on a small number of patients, showed 53% lower costs when fluoride tablets were used compared to fillings. Another English study (4), with a low evidence value due to the randomization being on schools rather than on pupils, showed a cost-utility ratio of 1.35, implying higher costs when fluoride tablets were used. The contradictory results from the 2 studies of low evidence may be due to differences in periods of trials, indicating differences of caries prevalence (inconclusive evidence).

Fluoride varnish

Two of the studies on fluoride varnish were performed during the same period in Finland (11) and in Sweden (13) and they both had 4 years of follow-up. In the Swedish study, the same cost was found for the fluoride varnish group and the group given a normal preventive program, while the cost-effect ratio in the Finnish study was 1.8 in favor of the fluoride varnish. None of the studies was a RCT and the Finnish study had a 30% loss to follow-up. The 2 studies with a moderate evidence value gave contradictory results regarding the cost-effectiveness of using fluoride varnish (inconclusive evidence).

Preventive programs

All five studies of preventive programs had a low evidence value; one of them a RCT with unclear randomization. A study from the USA (15) found that water fluoridation had the best cost-benefit ratio and that fissure sealants were second best. All other methods produced only marginal effects. An English study (3) found only an 8% better outcome in the test group than in the control group, at an unreasonably high cost. A Scottish study (14) demonstrated a 70% better outcome but at a higher cost per avoided dmfs/DMFS compared to fillings. The programs differed as the Scottish program included fissure sealants, and the target groups differed as the English program aimed at 12-year-olds and the Scottish program at 0–6-year-olds. Klock's cohort study (16) showed that the cost of preventing a caries lesion was 3.7 times higher than the cost of a filling. The individuals' subjective values of avoiding a caries lesion, however, were not taken into account.

In a multicenter RCT on 4 different strategies of caries prevention for a high-risk group of children, Oscarson et al. found (17) no significant effects on DMFS, but on D_eMFS (e = enamel) the fluoride varnish group had 1 surface less enamel caries increment compared to the toothbrushing group. The incremental cost (including treatment costs and patient-/family-related costs) per averted D_eMFS was SEK 2,043 (at a 3% discount rate of effects and of costs). A problem with this study relates to the use of D_eMFS rather than DMFS (or DMFT) as the outcome, since D_eMFS was not used in any of the other studies included in this chapter on economic analysis, and thus difficult to compare. If calculated as a cost-benefit analysis (CBA) instead of cost-effectiveness analysis (CEA), the incremental cost of fluoride varnish would exceed that of toothbrushing by more than a calculated actual cost of filling, i.e. a result similar to the one presented by Klock (16).

The 5 studies on preventive programs were of low evidence value, giving contradictory results (2 negative, 2 positive, and 1 using another outcome effect). Thus, nothing could be stated concerning evidence from caries-prevention programs and in total the evidence is inconclusive.

Chlorhexidine

Chlorhexidine was tested in 4-year-olds in a Swedish RCT (18), assessed to have a moderate odontological evidence value, but a low health-economic evidence value and thus a low total evidence value. Lower costs were found for the test group compared to the control group from a dental management perspective. The study was on primary teeth, which makes comparisons with studies on permanent teeth difficult and the evidence is inconclusive.

Water fluoridation

Water fluoridation was evaluated for 4–5-year-olds and 9–10-year-olds in 2 towns in a British study (19) assessed to have a low evidence value. The cost needed in order to reduce on average 1.91 DMFT and 1.69 DMFT varied between GBP 4.22 and GBP 2.70, respectively, for the 2 age groups. This original study on water fluoridation was the only one identified that evaluated the cost-effectiveness of water fluoridation and therefore the evidence is inconclusive.

Discussion

This systematic review on the economic aspects of caries

prevention showed that no conclusion could be inferred because of studies of low evidence values and with contradictory results. However, reviewed model studies (1) i.e. studies using earlier presented data from studies on caries-preventive measures in order to make cost analyses, showed better utility of caries prevention compared to costs than what could be assessed from original studies. Also, reviews published on cost evaluations of caries prevention showed that all preventive measures, except fluoride gels, gave lower costs compared to fillings and that water fluoridation was the most cost-effective preventive measure.

The contradictory results from the review of original studies, model and review studies, prompted us to make a calculation of cost-effectiveness using the present caries prevalence in Sweden, effects of the preventive measures according to the literature and costs approximated from the charges used in Swedish dental care. The cost-effectiveness of fluoridated toothpaste—presently 80–90% of the child population brush their teeth daily using fluoridated toothpaste (32)—is extremely good (i.e. cost per prevented DMFT very low) since the marginal cost for adding fluoride to the toothpaste is almost zero, and the utility of caries reduction from fluoride toothpaste has been well documented in RCT studies of high quality (1).

Since the prevalence of a disease to a high degree determines whether preventive measures are cost-effective or not, the reduced prevalence of caries has rendered earlier model calculations of cost-effectiveness outdated. However, adjusted to the present prevalence and present per item costs, earlier calculations of water fluoridation in Sweden by Jonsson (33) can still be considered valid; from a societal perspective, the cost per avoided DMFT by water fluoridation could be calculated at SEK 199, and when cost for parents' and children's time-consumption was included, it would actually give a benefit exceeding costs of SEK 2.

The reviewed studies, as summarized in Table 2, show that there are contradictory results from studies on fissure sealants (low evidence values), fluoride rinsing (low and moderate evidence values), fluoride tablets (low evidence values), fluoride varnish (low evidence values), and from preventive programs (low evidence values).

There was only one study of chlorhexidine in caries prevention on primary teeth, which makes it impossible to draw conclusions.

Thus, to conclude, there is presently no proof in published economic evaluations of caries-preventive measures for the benefit of caries prevention according to the criteria used in this systematic review.

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