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NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Literature Review of Economic Evaluations on Oral Health Improvement Programmes and Interventions

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Contents

		Page No.
Executive Summary		
Section 1:	**Background and Objective**	**1**
1.1	Background	1
1.2	Objective	2
Section 2:	**Methods**	**3**
2.1	Searching	3
2.2	Screening and Selection of Full Papers	5
2.3	Applicability and Quality Appraisal of Studies	9
2.4	Data Extraction	10
2.5	Data Synthesis and Presentation of Results	10
Section 3:	**Summary of Included Studies**	**11**
3.1	Results of the Record Selection Processes	11
3.2	Summary of the Included Studies	12
3.3	Quality of the Included Studies	19
3.4	Applicability	25
Section 4:	**Results of the Systematic Review**	**26**
4.1	Interpretation of the Results from Economic Evaluations	26
4.2	Fluoride Interventions	27
4.3	Dental Sealants	45
4.4	Dental Sealants & Fluoridated Mouth-Rinse	47
4.5	Intensified Check-Ups, Screening and Treatment	51
4.6	Other Interventions	54
4.7	Interventions Aimed at Disadvantaged Populations at High Risk of Poor Oral Health	56
Section 5:	**Discussion and Summary**	**57**
5.1	Research Question 1	57
5.2	Research Question 2	59
5.3	Strengths and Weaknesses of the Review	59
5.4	Gaps in the Evidence	60
5.5	Conclusions	61
References		**62**
Tables:		
Table 2.1	Resources Searched	4
Table 2.2	Literature Search Results	5
Table 3.1	Summary of Included Studies	14

Table 3.2	Details of Oral Health Interventions Assessed	17
Table 3.3	Summary of the Quality of the Included Studies by Intervention (not mutually exclusive)	19
Table 3.4	Summary of the Quality of the Included Studies by Setting	19
Table 3.5	Quality of the Included Studies	21
Table 4.1	Characteristics of 5 Studies of Fluoride Toothpaste	27
Table 4.2	Characteristics of 5 Studies of Fluoride Varnish	31
Table 4.3	Characteristics of 2 Studies of Fluoride Gel	37
Table 4.4	Characteristics of 2 Studies of Fluoride Mouth-Rinse	39
Table 4.5	Characteristics of 2 Studies of Fluoride Salt	40
Table 4.6	Characteristics of 2 Studies of Fluoride Milk Programmes	42
Table 4.7	Characteristics of 2 Studies of Fluoride Water Programmes	44
Table 4.8	Characteristics of Study of Dental Sealants	46
Table 4.9	Characteristics of Studies of Dental Sealants plus FMR	48
Table 4.10	Characteristics of Studies Assessing Intensified Check-ups, Screening and Treatment Programmes	52

Figures:

Figure 3.1	PRISMA Flow Diagram	12

Appendices:

Appendix A:	Search Strategies
Appendix B:	Citation and Named Author Searches
Appendix C:	Evidence Tables
Appendix D:	Studies Excluded Following Selection of Full Papers

Executive Summary

1.1 INTRODUCTION

This report summarises the literature on the cost-effectiveness of community based interventions aimed to prevent and reduce dental and periodontal disease, oral cancer or other oral disease, and promote oral health. This report is targeted to the general population, with a particular interest in those at greater risk of poor oral health and those less able to access dental services.

More specifically, the aim of this review was to answer the following questions:

1. Which community-based programmes and interventions to promote, improve, and maintain the oral health of a local community are cost effective?
2. Which methods and settings to deliver community-based programmes for disadvantaged populations at high risk of poor oral health are cost effective?

1.2 BACKGROUND

The Department of Health has requested the National Institute for Health and Care Excellence (NICE) to develop public health guidance for local authorities on oral health needs assessments and community oral health promotion programmes. The guidance will apply to local populations, with a particular focus on vulnerable groups at risk of poor oral health. The guidance will provide recommendations which are informed by effectiveness and cost-effectiveness evidence to promote, improve and maintain the oral health of local communities.

There are three components associated with the guidance development:

1. A review of oral health improvement programmes and interventions assessing evidence of effectiveness, barriers and facilitators;
2. A review and practice survey of oral health needs assessments;
3. An economic analysis.

The Newcastle and York External Assessment Centre is undertaking the third component only. The first component has been commissioned from Bazian and the second from Cardiff University. The economic analysis mirrors the Bazian approach in their review of the effectiveness of oral health programmes and interventions.

The first step in the economic analysis was to undertake a focused systematic review of published economic studies to establish if there are any high-quality economic studies that address the research questions and are relevant to current practice. If no studies are identified, then economic modelling of effective interventions might be necessary. This document reports on the literature review and its findings.

1.3 METHODS

The review was conducted in accordance with the methodology laid out in the third edition of Methods for the development of NICE public health guidance ('NICE Methods Manual').[1]

At project commencement a protocol was developed describing the proposed methodology, which was quality assured by NICE as meeting the standards of transparency and quality set out in the NICE methods Manual.[1] This has been followed throughout the process and its core components are now summarised.

The search strategy incorporated the population and intervention components of the strategy used by Bazian in searching for clinical effectiveness evidence. This strategy was adapted as appropriate for a search on cost-effectiveness research and was quality assured by NICE information specialists. Search dates ran from 1993 to the present date, reflecting the date limits applied in the clinical effectiveness review. Search sources were chosen which were not included in the clinical effectiveness review, and which were appropriate to retrieving research on cost-effectiveness. Databases searched included the Cost-effectiveness Analysis (CEA) Registry, EconLit, Embase, the Health Economic Evaluations Database (HEED), the Health Technology Assessment database (HTA), MEDLINE, the NHS Economic Evaluations Database (NHS EED) and the Research Papers in Economics (RePEC) database. In addition to searching these sources, reference lists of reviews and studies selected for inclusion in the review were scanned to identify further relevant studies. Citation searches were also conducted in the Science Citation Index database and named author searches were carried out in MEDLINE and Embase to identify other publications by authors of studies selected for inclusion. The search results were downloaded into bibliographic management software and records were de-duplicated.

Inclusion and exclusion criteria, consistent with the Bazian methodology, were developed and quality assured by NICE.

The titles and abstracts were screened independently by two researchers, applying the agreed eligibility criteria, with differences resolved by discussion. Full copies of potentially eligible papers were obtained and the 2 reviewers independently applied the eligibility criteria to them, with differences solved by discussion.

The applicability and quality of each included study was assessed using the template checklist for economic studies from the NICE Methods Manual.[1] One reviewer completed the checklist and this was checked by the second reviewer, with differences marked up and discussed. Papers judged 'not applicable' were excluded from further consideration.

Data from each remaining included paper were extracted and presented in an evidence table, following the format set out in the NICE Methods Manual[1] and finalised with NICE project team.

Costs were reported in papers in local currencies and at publication date or earlier price dates. These were adjusted to pounds sterling at 2013 prices by adjusting for exchange rates and intervening inflation.

The results were synthesised using a qualitative methodology by intervention, by risk group and by setting. No quantitative synthesis was possible because of the heterogeneity of the

studies

1.4 FINDINGS

The searches returned 4,162 unique records. Sixty-three papers were included following title/abstract screening, with 61 retrieved. Following application of the eligibility criteria to the full papers, 19 papers met the inclusion criteria. Three of these 19 papers reported on the same study, of which only 1 was included in this review, bringing the total to 17. Two papers reported results at 3 and 10 years using data from the same clinical study but applied to different populations; both papers are included and are referred to as two separate studies. Hence 17 papers from 17 studies were included.

The applicability of each study to the current English context and its quality were assessed by two reviewers using the template checklist for economic studies (see Appendix I in NICE Methods Manual'[1]). Applicability was judged from responses to a series of questions (1.1 to 1.8) in the Quality Appraisal Checklist for economic evaluations[1] and rated 'not applicable', 'partially applicable' or 'directly applicable'. The questions considered the study population, intervention, comparator, setting, perspective, benefits and costs.

The overall assessment of methodology was informed by responses to questions 2.1 to 2.11 in the Quality Appraisal Checklist.[1] The assessment indicated whether the economic evaluation provided evidence from a methodologically robust study and hence whether its conclusions about cost-effectiveness were potentially useful to inform the Public Health Advisory Committee's (PHAC's) decision-making. Studies were rated as having 'minor methodological limitations' (++), 'potentially serious limitations' (+) or 'very serious limitations' (-).

Of the 17 papers, 16 were judged partially applicable; the 'not applicable' paper described a supplemental food programme set in Carolina, USA in 1992 and is not described further. Ten studies assessed an intervention aimed at increasing exposure to fluoride. Some studies included more than 1 intervention. Of the 10:

- 4 appraised the use of dental sealant in addition to fluoride mouth-rinse;
- 2 appraised the use of dental sealants;
- 2 appraised an intensified check-up, screening and treatment programme and the check-up study included several other interventions, including xylitol, a naturally occurring sugar substitute, oral health education and motivational interview / behaviour modification programmes;
- 5 appraised using fluoride varnish;
- 2 appraised fluoride gel;
- 5 appraised adding fluoride to toothpaste; and
- 5 appraised adding fluoride to water, salt or milk.

Eight studies were set in a school, 8 in a community setting (one of the studies included a school and community setting and is reported twice) and one in the work place.

Of the 16 studies, 2 were judged to have minor methodological limitations, (++), 11 to have potentially serious limitations (+) and 3 to have very serious limitations (-). No study adopted the appropriate perspective for public health studies.

The findings are presented as evidence statements for each intervention.

Evidence Statement 1: Cost-effectiveness of fluoride toothpaste programmes

Evidence was found from 5 cost-effectiveness analysis (CEA) studies, one judged as having minor limitations (++)[2], and 4 having potentially serious limitations (+).[3-6] A fluoride toothpaste regime, with or without an additional oral health education component, reduced caries relative to a control group in community-based studies[2, 5, 6] set England, Germany and Sweden, and in one primary school-based study set in Australia.[3] The Chilean school-based study did not report changes in caries incidence.[4]

The UK community-based study[2] of pre-school aged children, found that the cost per child, per tooth saved, over the 4 years was £80.83 [£107.16 at 2013 prices] compared with a 'do nothing' approach. Savings from treatment costs avoided were not included. Sensitivity analysis was not carried out.

The Chilean study[4] found that the cost per child, per averted decayed, missing or filled tooth (DMFT), over the 6 years was $8.55 [£6.27 at 2013 prices] compared with a non-intervention group.

The Australian study[3] found that the cost per child, per averted caries was A$40.00 [£37.62 at 2013 prices] per year, compared with selective fissure sealing and topical fluoride use, which were delivered in a water-fluoridated area.

The Swedish study[6] found that the cost per child, per avoided filling, was €67.15 [£65.41 at 2013 prices] over the 3 years compared to a non-intervention group.

The German study[5] did not report cost analysis data separately for the fluoridated toothpaste regimen.

Only one study was directly applicable[2], being set in England, but the epidemiological, clinical and cost data are over 10 years old and thus of limited relevance to the current setting.

In the absence of agreed willingness to pay thresholds for caries avoided, combined with concerns about applicability, the findings from these 5 CEA studies provide little evidence to inform on the economic value of providing fluoride toothpaste interventions compared to standard care in England.

[2] Davies et al. (2003) [++]
[3] Arrow, P. (2000) [+]
[4] Marino et al (2012) [+]
[5] Splieth et al. (2008) [+]
[6] Wennhall et al. (2010) [+]

Evidence Statement 2: Cost-effectiveness of fluoride varnish programmes

Evidence from 1 CEA[7] and 4 cost-benefit analyses (CBAs)[5, 8-10] found that fluoride varnish regimes, with or without an additional oral health education component, reduced caries relative to a control group in all studies. These studies were set in Germany, Sweden and the USA.

The Swedish study (++)[10] was conducted with adolescents, aged 13-16 years, and was the only fluoride varnish programme set in a school. The cost per child, per avoided filling, over the 10 years was Swedish Krona (SEK) 315 [£37.85 at 2013 prices] compared with a no intervention group. The ratio of expected benefits from avoided fillings to costs was 1.8:1. The fluoride varnish programme produced a positive net value under most sensitivity analyses.

A second Swedish study[9] (+) was also conducted on adolescents (aged 11-17 years), but set in a community. The CBA determined total costs at SEK 3,880 [£1,065 at 2013 prices] per child and total benefits (from avoided fillings) at SEK 5,000 [£1,372 at 2013 prices] per child, a positive cost benefit ratio over 10 years.

The German study[5], (+), was set in a community with a hypothetical cohort of 1 million (m) individuals aged 6-100 years. It adopted a lifetime horizon. The total cost of the fluoride varnish programme per individual ranged from €457 [£461.54 at 2013 prices] to €579 [£584.75 at 2013 prices] over a lifetime, according to the age at which treatment started and efficacy curve. This was cost saving from reduced caries treatment compared to the no fluoride scenario, which was at per person cost of €932 [£941.25 at 2013 prices].

The two studies judged with very serious limitations[7, 8] (-), were set in communities in the USA. The study of a cohort of high-risk one-year-olds[7], reported a range of costs from $72.69 [£72.22 at 2013 prices] to $66.28 [£65.84 at 2013 prices] per carious surface averted over a 5-year period (range based on level of preventive intervention, all interventions included dental varnish, with or without counselling and outreach).

The second USA study[8] found that the net cost of fluoride varnish over 10 years was $22 to 58 million (m) [£16- £42 m at 2013 prices].

The results from all of the studies were judged partially applicable. None was set in England. Studies set in other countries may not generalise to England due to differences in underlying caries prevalence, different utilisation of fluoride products in communities, different standard dental care regimes and costs. Some of the cost data are old, dating back to 1996[7] and 1983[9]. The costs associated with these programmes will differ substantially from the current English context.

There is weak evidence from 3 higher quality studies[10, 9, 5] that adding fluoride varnish to standard care, with delivery in a school or community setting, results in financial savings from avoided caries treatment which exceeds the programme costs in their settings.

[10] Skold et al. (2008) [++]
[9] Petersson et al. (1994) [+]
[5] Splieth et al. (2008) [+]
[8] Hirsch et al. (2012) [-]
[7] Ramos-Gomez et al. (1999) [-]

Evidence Statement 3: Cost-effectiveness of fluoride gel programmes

Evidence from 2 CEAs[4, 5] found that fluoride varnish gel reduced caries relative to a control group, based on published literature.

The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a school setting in Chile. Using a 21% effectiveness rate for caries reduction, which was based on one published study, the cost per child, per averted DMFT, over the 6 years, was $21.30 [£15.61 at 2013 prices] compared with a non-intervention group.

No separate cost-effectiveness analysis was conducted for fluoride gel alone in the Germany study[5].

Both studies had potentially serious methodological weaknesses and applicability to England was limited by setting, date, different dental epidemiology, use of fluorides, cost structures and treatment pathways.

The evidence base is limited to the results from 1 poorly conducted study[4], with limited applicability to England and was insufficient to inform decisions on using fluoride gel in England.

[4] Marino et al (2012) [+]
[5] Splith et al. (2008) [+]

Evidence Statement 4: Cost-effectiveness of fluoride mouth-rinse programmes

Evidence from 1 CEA set in Chile[4] and 1 Swedish CBA[10] found that fluoride mouth-rinse (FMR) reduced caries relative to a control group. Both studies were set in schools.

The Swedish study[10] (++) was conducted on a simulated population of 300 adolescents aged 13-16 over 3 years. Compared to the control group, the FMR programme resulted in costs of SEK 63 [£7.57 at 2013 prices] per avoided filling, over 8 years. The ratio of expected benefits from avoided fillings to costs was 0.9:1. Under sensitivity analyses, the FMR resulted in a positive net value only at the upper limit of the 95% confidence interval of efficacy or if programme costs were reduced by 20%.

The Chilean study (+)[4] was conducted on a simulated population of 86,000 6-year old children, in a school setting. Based on a 26% effectiveness rate for caries reduction, the savings per averted DMFT, over a 6-year period, was $8.63 [£6.32 at 2013 prices] compared with a non-intervention group.

The results from both studies were judged partially applicable to England. Neither was set in the England.

Overall, there is inadequate evidence to inform decisions on using fluoride mouth-rinse in schools. The direction of benefit is inconsistent across the two studies, with one showing a small net cost[10] and the other a small benefit[4]. However, the net savings and net costs are each less than £1 per decayed tooth per year and so small changes in assumptions could switch the direction of results.

[10] Skold et al. (2008) [++]

[4] Marino et al (2012) [+]

Evidence Statement 5: Cost-effectiveness of fluoride salt programmes

Evidence from 1 CEA[4] and 1 CBA[5] found that fluoridated salt programmes, delivered in a community setting, reduced caries relative to a control group: these were set in Chile and Germany.

The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a community setting. Based on a 44% effectiveness rate for caries reduction, the savings per child, per averted DMFT, over the 6 years, was $16.21 [£11.88 at 2013 prices] compared with a non-intervention group.

The German study[5] (+), was set in a community, for a hypothetical cohort of 1 m individuals aged 6-100 years, over a lifetime. The intervention was assumed to reduce caries by 50%. The total cost of the fluoride salt programme ranged from €246 [£248 at 2013 prices] to €305 [£308 at 2013 prices] per person over a lifetime, according to the age when consumption started and the efficacy curve: in comparison, the no fluoride, restorative approach cost €932 [£941.25 in 2013 prices] per person. Thus fluoridated salt was cost saving to society.

The results from both studies were judged partially applicable to England. Neither was set in England; nether setting had fluoridated water.

The 2 studies provide weak evidence that the addition of salt fluoridation to standard care, delivered in a community setting, results in financial savings from avoided caries treatment, which exceed programme costs. The savings are driven by the high rate of caries reduction (44% and 50%); the key question is whether the introduction of salt fluoridation in England would realise such efficacy rates. If so, then the published economic evaluations suggest the intervention merits further consideration.

[4] Marino et al (2012) [+]
[5] Splieth et al. (2008) [+]

Evidence Statement 6: Cost-effectiveness of fluoride milk programmes

Evidence from 2 CEAs[4, 11], conducted by the same author, found that fluoride milk programmes, delivered via a nationally funded programme to provide milk to schools in Chile, reduced caries relative to a control group in both studies.

The first study[11] (+) assessed the addition of fluoride to milk, compared to a non-fluoridated milk control group, on a simulated population of 2,000 3-6-year old children, in a school setting. Incremental savings per DMFT avoided, over 4 years, was $5.10 (£4.60 at 2013 prices] and the incremental savings per child over 4 years was $7.20 (£6.50 at 2013 prices) compared with a non-intervention group.

The second study[4] (+), conducted on a simulated population of 86,000 6-year old children, used more robust modelling techniques and a slightly longer time horizon. Based on a 53% effectiveness rate for caries reduction, the savings per child, per averted DMFT, over 6 years, was $14.78 [£10.83 at 2013 prices] compared with a non-intervention group.

The results from both studies were judged partially applicable to England; however, the intervention is unlikely to be delivered in an English setting.

Both studies showed that milk fluoridation programmes have lower costs and reduce caries and hence are cost effective in their setting. However, they do not provide evidence that can be generalised to England because of the absence of school milk provision.

[11] Marino et al. (2007) [+]
[4] Marino et al (2012) [+]

Evidence Statement 7: Cost-effectiveness of fluoride water programmes

Evidence from 1 CEA[4] and 1 CBA[8] found that fluoridated water programmes, delivered in a community setting, reduced caries relative to a control group. The studies were set in Chile and the USA.

The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a community setting. Based on a 40% effectiveness rate for caries reduction, the savings per child, per averted DMFT, per 6 years, was $14.89 [£10.91 at 2013 prices] compared with a non-intervention group.

The USA community-based fluoridated water programme[8] was estimated to produce net savings of $8 m [£5.86 m at 2013 prices] over 10 years (25% of Colorado's population), compared to no intervention, with an associated decrease of 1.2% in the prevalence of cavities, after 10 years.

The results from these studies were judged partially applicable to England. Neither was set in England.

Both studies reported cost savings but the assumed rates of caries reduction were very different and were not transparent in either study. At best they provide weak evidence in support of the cost-effectiveness of community-based water fluoridation programmes.

[4] Marino et al (2012) [+]
[8] Hirsch et al. (2012) [-]

Evidence Statement 8: Cost-effectiveness of dental sealant programmes

Evidence from 2 CEAs[4, 12] found that a dental sealant (DS) programme, delivered in a community setting, reduced caries relative to a control group. Studies were set in Chile[4] and the USA[12].

The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a community setting. Based on a 50% effectiveness rate for caries reduction, the cost per child, per averted DMFT, over 6 years, was $11.56 [£8.47 at 2013 prices], representing a cost to society, compared with a non-intervention group.

The 1993 USA study[12] was judged to have very serious limitations (-), despite being one of the few lifetime studies identified in this review. This study was conducted on a cohort of 278, 7-year old children, in a low-income area of the USA, with fluoridated water supply.

Applying sealants to the first four molars resulted in an ICER of $4.06 [£4.37 at 2013 prices] per additional restoration-free tooth over a mean of 5.8 years, compared to a standard care control group, which did not receive dental sealants. Cost savings over 4 to 6 years were achieved with a strategy of identifying children with prior restorations and sealing remaining molars.

The results from these studies were judged to be partially applicable to England. Neither was set in England.

There is inconsistent evidence that a dental sealant programme represents a cost to society[8] and evidence from a methodologically poor study[12] that in some circumstances sealants can be cost saving. Overall, given the paucity of studies, their poor quality and poor applicability to England, no conclusions can be made on the cost-effectiveness of dental sealants applied in the community in England.

[4] Marino et al (2012) [+]
[12] Weintraub et al (1993) [-]

Evidence Statement 9: Cost-effectiveness of dental sealant and fluoridated mouth-rinse programmes

Evidence from 2 CEAs[13, 14] and 2 CBAs[15, 16] (3 studies) found that a dental sealant plus FMR programme, delivered in a school setting, reduced caries relative to a control. Studies were set in Australia, Japan and the USA.

The Australian papers[13, 15] (+), were for the same study with the same lead author, with one paper presenting results at 3 years[13] and the other at 10 years.[15] The original clinical trial was conducted on a cohort of Year 7 students from schools in Australia. The first economic evaluation[13], based on 522, 12-year old students from 5 low socioeconomic status (SES) districts, reported a net incremental cost for the dental sealant and FMR programme of $A11.80 [£11.10 at 2013 prices] per averted DMFS over 3 years, compared to routine dental care. The incremental cost-effectiveness ratio became more favourable with time, with a net cost of $A99.80 [£93.8922 at 2013 prices per DMFS averted in year 1, the year of sealant application, falling to a net cost of $A8.80 [£8.28 at 2013 prices] per DMFS averted in year 2, and a net savings of $A12.60 [£11.85 at 2013 prices] per DMFS prevented in year 3. The authors anticipated savings would continue beyond year 3.

The second economic evaluation[15] extrapolated the results of the 3-year study to a wider geographical area (n=3,500), adopted a 10-year time frame and provided a cost-benefit analysis. Estimated net savings ranged from $7,000 to $1.73 m, [£6,586 to £1.63 m at 2013 prices) with benefit to cost ratios of 1.0 to 1.7 respectively. Sensitivity analyses showed that under all scenarios the programme was cost saving over a 10-year period.

The Japanese study[16] (+) was conducted on 8 and 11 year old children in a school-based setting (n=221). It compared FMR and targeted fissure sealant to a control group who received standard dental treatment, including sealant placement. The incremental cost per child avoiding decayed and filled teeth (DFT) per year was 493 yen [£4.34 in 2013 prices] in the 8-year old group and 202 yen [£1.78 in 2013 prices] in the 11-year old group. Comparing programme and treatment costs and benefits (based on reduced treatment costs) resulted in cost benefit ratios of 1 to 1.84 for the group of eight year olds and 1 to 2.42 for the group

aged 11, over a 7-year period.

The USA study[14](+) was conducted on 1st and 6th graders (n=60) in a high caries prevalence area. The discounted costs for the sealant group (programme and dental expenses) was $1,720 [£1,897.54 at 2013 prices] compared to $2,100 [£2,316.77 at 2013 prices] for the control group, giving savings of $380, over 5 years, in favour of the sealant group with FMR (£419 at 2013 process). The number of teeth not missing, not decayed and not filled was 3,565 for the sealant group and 3,460 for the control group. The sealant programme was thus cost effective compared to ordinary practice.

The results from these studies were judged partially applicable to England. None were set in England.

There is moderate evidence from 4 studies of over 800 children[1] that using dental sealants plus FMR, delivered in a school setting, results in financial savings from avoided caries treatment, which exceed programme costs, over the long run. Cost-effectiveness increases over time as benefits associated with reduced treatment costs from fewer caries accrue; the majority of costs are incurred in the first year.

Despite concerns about methodological weaknesses, the quantity, quality and consistency of the evidence suggest dental sealant and FMR programmes merit further consideration, particularly whether the intervention could be adopted in England.

[13] Crowley et al. (1996) [+]
[15] Crowley et al. (2000) [+]
[16] Sakuma et al. (2010) [+]
[14] Zabos et al. (2002) [+]

Evidence Statement 10: Cost-effectiveness of intensified check-up, screening and treatment programmes

Evidence from 2 CBAs[8, 17] found that an intensified check-up, screening and treatment programme, delivered in a community and work place setting, reduced caries relative to a control group. Studies were set in Japan and the USA.

The Japanese study[17] in 1992 (+) consisted of oral-health checkups and calculus scaling in the work place, offered once a year, over 7 years (n= 357). Groups were classified by frequency of visits during the 7-year study. The programme delivered at medium frequency (2- 4 visits over 7 years) saved the employer $38.75 [£42.75 in 2013 prices] per person over the 7 years from reduced treatment costs. The light and heavy frequency groups incurred costs of $104.18 [-£114.93 at 2013 prices] and $42.62 [£47.02 in 2013 prices] respectively for the employer.

The USA hypothetical study[8] was set in a community (n=431,070). The study found that the net cost of a low intensified screening and treatment regime was $2 m [£1.47 m in 2013 prices] and $9 m [£6.60 m in 2013 prices] for high intensity treatment, per 10 years, for a decrease of 4 to 5.4% in the prevalence of cavities.

[1] Excluding the 3,500 from the Crowley 2000, which was an extrapolation of the smaller study.

The net savings associated with an intensified follow-up regime to reduce recurrence of caries was $22 m [£16.12 m in 2013 prices] for a 50% reduction of recurrence and $39 m [£28.58 m in 2013 prices] for a 75% reduction in recurrence over 10 years. There was no change in the prevalence of primary cavities and the programme was assumed to have no associated costs.

Neither study generalises to the current English setting because of aspects such as the prevalence of caries, cost structures, dental treatment pathways and the extent of fluoridation (nil in the Japanese study and about 75% in Colorado). Moreover, the private insurance system in Japan differs materially from that in England.

There is inconsistent evidence from the 2 CBAs that the use of intensified check-ups, screening and treatment delivered in a workplace or community setting, is cost effective compared to standard of care. Neither provides useful evidence to inform decisions on the cost-effectiveness of intensified check-up, screening and treatment programmes in England.

[17] Ichihashi et al. (2007) [+]
[8] Hirsch et al. (2012) [-]

Evidence Statement 11: Cost-effectiveness of other intervention programmes

Evidence from 1 CBA set in the USA[8] assessed interventions aimed at reducing transmission of bacteria from mother to children; use of xylitol, a naturally occurring sugar substitute, interventions in children; and motivational interviewing for families. All interventions were delivered in a community setting and assumed to reduce caries relative to a control group. Evidence came from published literature.

ES 11.1: The study found that the 10-year net cost associated with interventions aimed at reducing transmission of bacteria from mother to child was $23 m [£16.8 m at 2013 prices] when provided to all mothers in Colorado and a saving of $3 m [£2.2 m at 2013 prices] when provided to mothers of high-risk children only, in Colorado. The associated reductions in caries prevalence were 7.4% and 3.2%, respectively.

ES 11.2: Ten-year net savings of $3 m [£2.2 m at 2013 prices] were associated with the xylitol intervention for the high-risk and high efficacy group; and $24 m [£17.6 m at 2013 prices] for the group of all children over 6 months in the high efficacy group, with an associated reduction in caries of 2.2% and 12.6%, respectively. The net cost ranged from $10 m to $57 m [£7.3 m and £41.7 m at 2013 prices] for the other age and efficacy groups. Associated reductions in prevalence ranging from 1.3 to 4.9%.

ES 11.3: The motivational interviewing programme, resulted in a 10-year net savings of $29 m [£21.2 m at 2013 prices] when used with high-risk families and $11 m [£8.0 m at 2013 prices], when adopted for all families. The associated reductions in caries were 5.3% and 11.7%, respectively.

This study was judged as having very serious limitations, thus reducing confidence in the results. Applicability was also limited because of differences in epidemiology of caries, use of fluoride products in the community and dental treatment pathways and associated costs

The absence of corroboration from other studies of effect size and direction, concerns about

methodological quality and limited applicability suggest the findings from this study alone are insufficient to use as robust evidence to inform decisions on these interventions.

[8] Hirsch et al. (2012) [-]

1.5 DISCUSSION

Sixteen papers were identified that provided evidence to inform the research questions. The included studies assessed the following interventions:

- Programmes aimed to increase exposure to fluoride;
- Use of dental sealants, with and without FMR;
- Intensified check-up, screening and treatment programmes;
- Programmes aimed at reducing transmission of bacteria from mother to child;
- Use of xylitol inventions in children;
- Motivational interviewing for families.

All studies found that the intervention was more effective than a control at reducing incidence of caries.

All papers had methodological weaknesses and limited applicability to the current English context. Two were judged to have minor methodological limitations (++), 11 had potentially serious limitations (+) and 3 had very serious limitations (-). The applicability to England was assessed as partial in all of studies. The main reasons for the limited applicability were country, year of study, setting and cost sources. All studies except 1 were conducted outside of England. Differences in programme costs, dental treatment pathways and expenses, use of fluoride products and water fluoridation and funding and the organisation of dental services were evident, limiting the generalisability of the studies to the current English context.

Moreover, the clinical efficacy rates underpinning the older economic evaluations are unlikely to be generalisable to the current English context because of improved oral heath achieved over the last decade and a greater emphasis on prevention within English dental contracts and consequently delivered to patients.

Studies of the addition of fluoride to toothpaste, varnish, salt, water, gel and mouth-rinse, in a school or community-based setting, provided no evidence (toothpaste), or insufficient evidence (fluoride gel, fluoridated mouth-rinse) to inform on the economic value of these programmes. Weak evidence was found supporting fluoridated varnish, salt and community water. Evidence on the addition of fluoride to milk through a government funded school milk programme suggested that the intervention was cost effective; however, the applicability of this programme is very low.

There was inconsistent evidence that the use of dental sealants alone is cost saving. However, studies of dental sealants combined with FMR provided some evidence that, over a 10-year time horizon, such programmes could be cost effective, delivered in a school setting in England. There was insufficient evidence to draw conclusions on the economic impact of the intensified check-up, screening and treatment programme, programmes aimed at reducing transmission of bacteria from mother to child, use of xylitol inventions in children

or motivational interviewing for families.

Six studies assessed interventions among high-risk populations; however, there was considerable heterogeneity across the studies, varying by intervention and setting. The quality and applicability of these studies were limited as outlined above. Thus, there was insufficient evidence to inform conclusions on cost effective interventions among populations at high-risk of poor oral health.

1.5.1 Gaps in evidence

There is no robust evidence of the economic value of community-based programmes and interventions to promote, improve, and maintain the oral health of children or adults in England. The analyses by risk groups were also inadequate. No study addressed endpoints other than dental health; thus there was no evidence on the impact of prevention on diseases such as peritonitis and oral cancer. Future economic evaluations should be informed by the evidence of clinical effectiveness; such studies are likely to be available in a greater quantity, be of better quality, conducted more recently, set in England and include more population sub-groups.

The literature on the cost-effectiveness of oral health programmes was of insufficient quantity, quality and applicability to draw conclusions; therefore, we recommend *de novo* economic modelling to address remaining uncertainties.

1.5.2 Conclusions

Based on the included 16 papers, there was insufficient evidence to answer the research questions. All studies had methodological weaknesses and limited applicability to the current English context. Two had minor limitations (++), 11 had potentially serious limitations (+) and 3 had very serious limitations (-). The evidence was weak, inconsistent or not available for most interventions, with the exception of the dental sealant plus FMR programme, which was considered cost effective. Except for 1 study conducted in England, all studies were conducted in other countries, and many were conducted during the 1990s-early 2000s, thus limiting the generalisability to the current English context. In addition, half of the studies were conducted in a school-based setting, which is also not applicable to the current English context, as dental services are not provided through the schools in the current English system.

Based on the very limited evidence, a *de novo* economic model is recommended to answer the research questions.

Abbreviations

CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis
CRD	Centre for Reviews and Dissemination
CI	Confidence interval
CPH	Centre for Public Health
DEFS	Decayed, extracted and filled surfaces
DFT	Decayed and filled teeth
DMFT	Decayed, missing, filled teeth
DMFS	Decayed, missing, filled surfaces
DS	Dental sealant(s)
EAC	External Assessment Centre
EPPI	Evidence for Policy and Practice Information
F	Fluoride
FMR	Fluoride rinsing/ fluoride mouth-rinsing/fluoride mouth-rinses/fluoridated mouth-rinses/fluoride mouth-rinsing
FV	Fluoride varnish
FVT	Fluoride varnish treatment
G	Gel
HEED	Health Economic Evaluations Database
HTA	HTA Health Technology Assessment
ICER	Incremental cost-effectiveness ratio
m	million
MEPS	Medical Panel Expenditure Survey
MR	Mouth-rinse
NaF	Sodium fluoride
NHS EED	NHS Economic Evaluation Database
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NR	Not reported
OECD	Organization for Economic Co-operation and Development
PHAC	Public Health Advisory Committee
PSS	Personal Social Services
QALY	Quality Adjusted Life Years
RCH	Chilean Peso
RCT	Randomised controlled trial
RePEc	Research Papers in Economics
SD	Standard deviation
SEK	Swedish Krona
SES	Socio-economic status
TS	Targeted sealant

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Section 1: Background and Objective

1.1 BACKGROUND

The National Institute for Health and Care Excellence (NICE) was asked by the Department of Health to develop public health guidance for local authorities on oral health needs assessments and community oral health promotion programmes.

The guidance applies to local populations, with a particular focus on vulnerable groups at risk of poor oral health. These vulnerable groups include:

- Children aged 5 years and under;
- Adults aged over 65 years;
- People on low incomes;
- People who are homeless or who frequently change the location where they live (for example, traveller communities);
- People from some black and minority ethnic groups (for example, those of South Asian origin);
- People who chew tobacco;
- People with mobility difficulties or a learning disability and who live independently in the community.

The guidance provides recommendations, which are informed by clinical and cost-effectiveness evidence to promote positive oral health behaviour.

There are three components associated with the guidance development:

1. A review of oral health improvement programmes and interventions assessing evidence of clinical effectiveness, barriers and facilitators;
2. A review and practice survey of oral health needs assessments;
3. An economic analysis.

The Newcastle and York External Assessment Centre (EAC) has undertaken the third component only. The first component was commissioned from Bazian and the second from Cardiff University. The economic analysis complements the approach taken by Bazian in their review of the clinical effectiveness of oral health programmes and interventions. The literature search strategy adopted consistent population and interventions terms to those used by Bazian. This strategy was adapted as appropriate to a search on cost-effectiveness. Search sources were chosen which were not included in the clinical effectiveness review, and which were appropriate to retrieving research on cost-effectiveness.

The first step in the economic analysis was to undertake a focused systematic review of published economic studies to establish if there are any high-quality economic studies that

address the research questions and are relevant to current practice. In the absence of such studies, economic modelling of that intervention might be necessary. This document reports on the literature review and its findings.

1.2 OBJECTIVE

The objective of the literature review was to identify evidence to answer the following questions:

1. Which community-based programmes and interventions to promote, improve, and maintain the oral health of a local community are cost effective?
2. Which methods and settings to deliver community-based programmes for disadvantaged populations at high risk of poor oral health are cost effective?

Section 2: Methods

This review was conducted in accordance with the methodology laid out in the third edition of *Methods for the development of NICE public health guidance* ('NICE Methods Manual').[1]

At the outset of the project a protocol was developed and quality assured by the NICE team. This contained the proposed methodology to search databases, select studies, evaluate their quality, summarise studies and synthesise relevant studies. These methods are now described.

2.1 SEARCHING

2.1.1 Search strategy development

To ensure that the clinical and economic evidence bases were consistent, and that the overall search approach taken across the two reviews was consistent, it was agreed that the population and intervention component of the search strategies for the cost-effectiveness evidence review would reflect as far as possible the strategies developed for the clinical effectiveness component by Bazian. The strategies were supplied through the Centre for Public Health (CPH) team. These strategies were to be adapted as appropriate for a review of cost-effectiveness, for example through the use of search filters designed to retrieve cost-effectiveness research, and through the choice of specific search sources appropriate to searches on cost-effectiveness.

For the single database which was searched for both the clinical effectiveness and cost-effectiveness reviews (MEDLINE), the Bazian population and intervention component of the strategy was used almost without amendment. Two minor changes were made. Firstly, the use of the * (asterisk) as a truncation symbol was replaced by the use of the $ (dollar sign). Secondly, in response to a suggestion by the Centre for Public Health team, subject headings in line 19 were no longer searched as major descriptors (focussed).

For those databases for which Bazian had not prepared a clinical effectiveness search, the Bazian strategies were translated appropriately. For example, the Bazian title and abstract search strings used in Ovid MEDLINE were copied directly for use in Ovid Embase. Subject headings in the Bazian search were 'translated' as appropriate to indexing used in other databases searched (for example, the Emtree thesaurus used in Embase). For other databases, where indexing terms were not available or the interface was not sophisticated, the strategies were adapted. Sometimes this resulted in a more sensitive search approach than that used for MEDLINE and Embase.

Population and intervention strategies were adapted as appropriate to the context of an economic search: for example they were combined with an economic search filter when searching large biomedical databases such as MEDLINE and Embase.

The subject strategies provided by CPH were developed and quality assured for another part of this project by Bazian. The CPH team confirmed that the overall approach used by Bazian for the strategy was discussed with NICE and strategies were peer-reviewed within Bazian. It was also confirmed that NICE quality assured the strategy. To ensure the quality of the YHEC additions to these searches and the new search strategies developed by YHEC, search strategies were peer reviewed by an independent information specialist within YHEC. The proposed strategy was also discussed with, and quality assured by, NICE information specialists and included in the protocol.

Resources searched

The resources searched to identify relevant studies are listed in Table 2.1.

Table 2.1: Resources searched

Resource	Interface / url
Cost-effectiveness Analysis (CEA) Registry	https://research.tufts-nemc.org/cear4
EconLit	OvidSP
Embase	OvidSP
Health Economic Evaluations Database (HEED)	Wiley Interscience
Health Technology Assessment database (HTA)	Cochrane Library/Wiley Interscience
MEDLINE and MEDLINE in Process	OvidSP
NHS Economic Evaluation Database (NHS EED)	Cochrane Library/Wiley Interscience
RePEc (Research Papers in Economics)	EconomistsOnline - http://www.economistsonline.org/home

The strategy used to search all the databases is provided in Appendix A.

In addition to searching the resources listed in Table 2.1 for relevant records, reference lists of reviews and studies selected for inclusion in the review were scanned to identify further relevant studies, using title only to inform the decision. Citation searches were also conducted in Science Citation Index to identify publications which cited the studies selected for inclusion and which may have been missed in the database searches. Named author searches in MEDLINE and EMBASE were also undertaken to identify other publications by authors of studies selected for inclusion.

Details of the citation search and the strategies used for named author searches in MEDLINE and Embase (including date of search) are provided in Appendix B.

Search results were downloaded to EndNote bibliographic management software and de-duplicated using several algorithms.

Table **2**.2 shows the number of results identified from each resource by the literature searches, the total number of results identified by the literature searches and the number of results assessed for relevance following EndNote de-duplication.

Table 2.2: Literature search results

Resource	Number of results
Cost-effectiveness Analysis (CEA) Registry	28
EconLit	283
Embase	2,174
Health Economic Evaluations Database (HEED)	502
Health Technology Assessment database (HTA)	208
MEDLINE and MEDLINE in Process	1,192
NHS Economic Evaluation Database (NHS EED)	490
RePEc (Research Papers in Economics)	301
Web of Science – citation search	94
MEDLINE and MEDLINE in Process – named author search	282
Embase – named author search	375
Hand search of references of selected studies	1
Total literature search results	**5,930**
Total literature search results after Endnote de-duplication	**4,162**

2.2 SCREENING AND SELECTION OF FULL PAPERS

2.2.1 Inclusion and exclusion criteria

Inclusion and exclusion criteria, quality assured by NICE, to select relevant studies for the systematic review were agreed in the protocol and are described below.

2.2.1.1 Study design

Studies were eligible for inclusion if they reported full economic evaluations or both costs and health consequences of an interventions and comparator.

The following study types were included:

- Cost-consequences analysis;
- Cost-benefit analysis;
- Cost-utility analysis;
- Cost-effectiveness;
- Cost-minimisation.

Costing studies, 'burden of disease' studies and 'cost of illness' studies, which did not report data to inform a model, were not eligible for inclusion.

Systematic reviews of economic evaluations were eligible for inclusion and were used as a

source of further primary studies.
Studies that monitored and evaluated community based oral health programmes and interventions were also included.

2.2.1.2 Population

Studies were eligible for inclusion if they were carried out on the general population with a particular interest in those groups at greater risk of poor oral health and those groups who are less able to access dental services, including:

- Children aged 5 and under;
- Adults aged over 65;
- People on a low income;
- People who were homeless or who frequently changed the location where they lived (for example, traveler communities);
- People from some black and minority ethnic groups (for example, those of South Asian origin);
- People who chew tobacco;
- People with mobility difficulties or a learning disability and who live independently in the community;
- Children and young people who were looked after, or who are given support to live independently in the community.

Studies of children, young people and adults living in residential care or other non-community dwelling populations (e.g. prisoners, hospitalised patients) were not included in this review.

2.2.1.3 Intervention

Eligible interventions were those that aimed to reduce and prevent dental and periodontal disease, oral cancer or other oral disease, and promoted oral health through activities targeting:

- Increasing access to fluoride;
- Improving oral hygiene;
- Improving diet;
- Increasing access to dentists.

Eligible oral health promotion and oral disease prevention programmes and interventions included those integrated into existing services delivered in a range of settings, including but not limited to:

- Preschools/nurseries;
- Primary schools;
- Secondary schools;

- Special education (and dental services);
- Workplaces (for vulnerable adults);
- Homeless shelters and food banks;
- Smoking cessation and drug and alcohol services.

The following interventions were excluded from this review:

- Population-level programmes/ interventions:
  - Water fluoridation (unless it was one component of a series of interventions being assessed in the same study);
  - National media campaigns or websites and screening programmes;
  - Preventative information, advice and treatment provided by dental health practitioners to their patients.
- Community-based programmes/interventions that:
  - Do not have a targeted oral health component (smoking cessation, alcohol or drug treatment programmes that do not also explicitly address oral health);
  - Look solely at dental trauma preventing injuries (e.g. providing mouth guards). Programmes in schools that include education about this alongside other interventions to promote oral health were eligible but trauma/injury outcomes were not assessed.
- Individual-level interventions:
  - Preventative information/advice and treatment provided by dental health practitioners to their patients;
  - Oral health interventions for people with orthodontic and fixed appliances.
- Oral health promotion and access to dental treatment in residential care or as part of clinical services:
  - Nursing and residential care homes for children, young people and adults;
  - Interventions provided in dentists' surgeries or prisons;
  - In-patient drug or alcohol treatment programmes.

2.2.1.4 Comparators

Eligible comparators were control groups as follows:

- A group which received no programme or no intervention;
- A group which received a minimal programme or intervention group;
- A group which received usual care.

2.2.1.5 Settings

Interventions or programmes that were set in a community or school-based setting were eligible for inclusion in the systematic review.

2.2.1.6 Outcomes

Studies had to report the following outcomes to be eligible for inclusion in the systematic:

- Oral health outcomes, including changes in incidence and prevalence in:
  - Dental caries;
  - Decayed, missing, filled teeth (DMFT) or decayed, missing, filled surfaces (DMFS);
  - Periodontal disease scores (e.g. bleeding gums, number of pockets);
  - Oral cancer.
- Modifiable risk factor outcomes, including changes in:
  - Fluoride use;
  - Oral hygiene behaviours;
  - Brushing/flossing;
  - Dietary behaviour (sugar consumption);
  - Dental practice attendance.
- Determinant outcomes, including changes in:
  - Knowledge, attitudes, intentions;
  - Length and quality of life, including utility values;
  - Health and non-health related costs and/or benefits.

2.2.1.7 Country of study

Studies conducted in any Organisation for Economic Co-operation and Development (OECD) country or countries were eligible for inclusion[2], with priority given to studies from England or settings that are thought to be similar to the UK NHS.

2.2.1.8 Date of publication

Studies published in 1993 or later were eligible for inclusion.

2.2.1.9 Language of study

Only studies published in the English language were eligible for inclusion.

2.2.2 Selection of papers

The records were screened using the information available in the title and abstract (where provided). Citations with a title but no abstract were assessed for relevance based on the title only. To ensure a high degree of inter-rater reliability when assessing relevance, the 2 reviewers independently screened a sample of 20 studies against the inclusion criteria and discussed any relevant issues before screening the rest of the studies independently. Disagreements were resolved by discussion. A third reviewer was available should

[2] Members of the OECD in 2013 were as follows: Australia; Austria; Belgium; Canada; Chile; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Israel; Italy; Japan; Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States of America.

resolution not be possible, but was not required.
Full copies of the papers selected at the screening search were requested. On receipt, the selection criteria were applied to each full paper by the 2 reviewers independently. Again the 2 reviewers piloted the process using a sample of papers, discussing relevant issues before selecting from the remaining papers.

2.3 APPLICABILITY AND QUALITY APPRAISAL OF STUDIES

The applicability (of the study to the current English context) and quality of each included paper was assessed using the template checklist for economic studies (see Appendix I in NICE (2012)[1]). One reviewer completed the checklist and this was checked by the second reviewer, with differences marked up and discussed. Disagreements were small and resolved by discussion. The applicability and quality appraisal process required judging each study for:

- Its applicability to the current English context;
- The robustness of the methodology adopted to derive results.

2.3.1 Applicability of economic evaluation to the public health guidance

The applicability of each study to the English public sector was judged from responses to a series of questions (1.1 to 1.8) in the Quality Appraisal Checklist for economic evaluations[1]. The questions are reproduced in Section 3 Table 3.5. The questions considered aspects of applicability related to the study population, intervention, comparator, setting, perspective, benefits and costs. An overall judgment on the applicability of each economic evaluation to the current English public sector was made using the following definitions:

- *Not applicable*: The study fails to meet 1 or more of the applicability criteria, and this is **likely to** change the conclusions about cost-effectiveness;
- *Partially applicable*: The study fails to meet 1 or more of the applicability criteria, and this **could** change the conclusions about cost-effectiveness;
- *Directly applicable*: The study meets all of the applicability criteria or fails to meet 1 or more applicability criteria but this is unlikely to change the conclusions about cost-effectiveness.

2.3.2 Overall assessment of study quality informed by study limitations

The overall assessment of study quality indicates whether an economic evaluation provides evidence from a methodologically robust study and hence whether its conclusions about cost-effectiveness are potentially useful to inform the Public Health Advisory Committee's (PHAC) decision-making.

The overall assessment was informed by responses to questions 2.1 to 2.11 on study limitations in the Quality Appraisal Checklist for economic evaluations[1] (see Section 3 Table 3.5). Studies were classified using the following definitions:

- *Very serious limitations* (-): The study fails to meet 1 or more quality criteria and this is highly likely to change the conclusions about cost-effectiveness. Such studies should usually be excluded from further consideration;
- *Potentially serious limitations* (+): The study fails to meet 1 or more quality criteria and this could change the conclusions about cost-effectiveness;
- *Minor limitations* (++): The study meets all quality criteria, or the study fails to meet 1 or more quality criteria but this is unlikely to change the conclusions about cost-effectiveness.

2.4 DATA EXTRACTION

Data were extracted from each included study using cost-effectiveness evidence tables quality assured by NICE and drawing on the template provided at Appendix K in NICE (2012)[1]). The data extracted included study design, setting, population, intervention, control group cost sources, outcomes and modelling methods. Two reviewers independently extracted data from 100% of studies. Disagreements were resolved through discussion. In the event of an unresolved issue, a third reviewer could have been consulted for consensus, but was not required. Data for each included study were extracted and are presented in the evidence tables in Appendix C.

2.5 DATA SYNTHESIS AND PRESENTATION OF RESULTS

The economic evaluations were too heterogeneous to support meta-analysis and are reported as a narrative. Study characteristics, applicability and methodological quality are summarised and the results discussed. Studies are grouped by intervention and summarised individually, with focus on study setting and country. The results are synthesised using the term adopted in the NICE Methods Manual[1] into evidence statements grouped by intervention, reflecting the balance of the evidence, its strength (quality, quantity and consistency) and applicability. The categories used to describe the strength (quality, quantity and consistency) of evidence as recommended by NICE Methods Manual[1] are:

- **No evidence** – no evidence or clear conclusions from any studies;
- **Weak evidence** – no clear or strong evidence/conclusions from high quality studies and only tentative evidence/conclusions from moderate quality studies or clear evidence/conclusions from low quality studies;
- **Moderate evidence** – tentative evidence/conclusions from multiple high quality studies, or clear evidence/conclusions from one high quality study or multiple medium quality studies, with minimal inconsistencies across all studies;
- **Strong evidence** – clear conclusions from multiple high quality studies that are not contradicted by other high quality or moderate quality studies;
- **Inconsistent evidence** – mixed or contradictory evidence/conclusions across studies.

Section 3: Summary of Included Studies

This section reports the results of the literature search, provides a PRISMA diagram and reports details of the included studies.

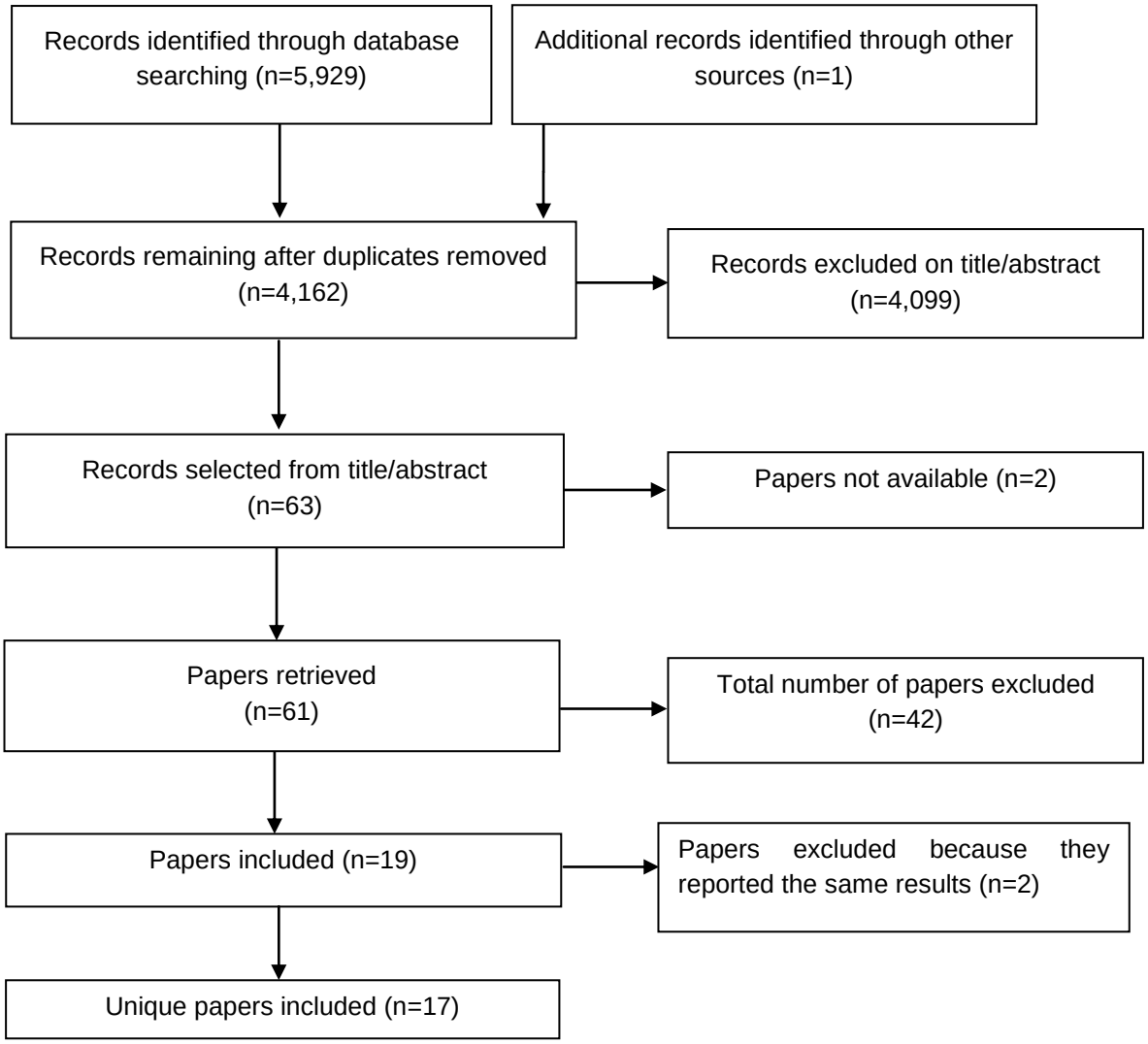
3.1 RESULTS OF THE RECORD SELECTION PROCESSES

Sixty-three papers were selected to be assessed from full text following the title/abstract screening. Two papers were not available, and 61 full papers were obtained. Nineteen of the 61 papers were selected for inclusion following an assessment of the full papers. Three papers reported the same study; the study with the greatest information content was selected[13] and hence 17 studies were included in the review.

The reasons why full papers were excluded, details of the studies which could not be obtained and details of the duplicate papers reporting the same study are provided in Appendix D.

Figure 3.1 provides a PRISMA flow diagram of the records identified by the searches, those records selected from the initial screen using abstracts/titles and those studies selected following review of the full papers.

Figure 3.1: PRISMA flow diagram



3.2 SUMMARY OF THE INCLUDED STUDIES

Based on the Quality Appraisal Checklist, one paper[18] was judged 'not applicable' and was dropped from further analysis. This study reported the effects of a supplemental nutrition programme for women and children on dental-related Medicaid expenditure. The assumed savings were modelled, with no validation of the modelled outputs and were not obtained from patient records.

Thus 16 studies were included in the evidence synthesis. Two papers seemed to report the same clinical study: on closer investigation it became clear that 1 reported a small-scale study over a 3-year period[13] and the second extrapolated the results to an enlarged hypothetical cohort over a longer time frame[15]. As each study conducted a separate and unique analysis on 2 different populations, they are counted and referred to as 2 separate studies in the remainder of this report; hence the synthesis is based on 16 papers reporting 16 studies.

The 16 studies were conducted in the following countries:

- England, n=1;
- Australia, n=3;
- Chile, n=2;
- Germany, n=1;
- Japan, n=2;
- Sweden, n=3;
- USA, n=4.

Interventions assessed for improving oral health included the following:

- Fluoride intervention, n=10;
- Dental sealants, n=2;
- Dental sealants and fluoride mouth-rinse, n=4;
- Intensified check-ups, screening and treatments, n=2;
- Xylitol products, n=1;
- Oral health education alone, n=1;
- Motivational interview / behaviour modification, n=1.

Study settings consisted of the following (one study included both a school and community, therefore the numbers add up to 17 rather than 16):

- School, n=8
    - Unspecified risk school district, n=6;
    - High-risk school district, n=2.
- Community, n=8
    - Unspecified risk communities, n=4;
    - High-risk communities, n=4.
- Employer, n=1.

The types of studies were as follows:

- Cost-effectiveness analysis, n=9;
- Cost-benefit analysis, n=7.

A summary of the included studies is provided in Table 3.1 and Table 3.2 provides details of the oral health interventions assessed.

Table 3:1: Summary of Included Studies

Study	Aim	Study design	Setting	Fluoridated water supply	Population	Location	Quality score
Arrow, P. (2000)	To assess the cost-effectiveness of a school-based occlusal caries prevention programme comprising selective fissure sealing and use of topical fluorides.	Cost-effectiveness	School, primary	Yes	6-year old children	Australia	+
Crowley et al. (1996)	To assess the cost-effectiveness of a 3-year school-based dental sealant and FMR programme in Year 7 students from 5 schools in Geelong and Ballarat, Australia.	Cost-effectiveness	School, high prevalence of caries in area	No	Year 7 (age 12) students	Australia	+
Crowley et al. (2000)	A hypothetical extrapolation of the results of the small-scale programme employing dental sealant and FMR to all year 7 students from 32 schools in Geelong and Ballarat, over a 10-year period.	Cost benefit	School	No	Year 7 (age 12) students	Australia	+
Davies et al. (2003)	To assess the cost-effectiveness of a postal toothpaste programme to prevent caries.	Cost-effectiveness	Community, high-risk area based on high prevalence of caries in area	No	Pre-school aged children (12-60 months)	England	++
Hirsch et al. (2012)	Use a system dynamics model to assess and compare early childhood caries interventions for benefits and costs among young children in Colorado.	Cost benefit	Community	In 75% of area	Pre-school children, under 72 months	USA	-
Ichihashi et al. (2007)	Examine whether oral-health promotion programmes provided as an occupational health service for employees are cost-beneficial for employers.	Cost benefit	Employer	NR	Male employees of household product company	Japan	+

Study	Aim	Study design	Setting	Fluoridated water supply	Population	Location	Quality score
Marino et al (2012)	Establish the cost-effectiveness of 7 dental caries prevention programmes among school children in Chile.	Cost- effectiveness	School and community	Cities use fluoridated water but rural areas do not	School age children (age 6)	Chile	+
Marino et al. (2007)	Estimate the cost-effectiveness of a programme to add fluoride to milk products, to prevent dental caries in school-aged children.	Cost-effectiveness	Nursery and school, primary	Yes	Children aged 3 to 6 years	Chile	+
Petersson et al. (1994)	Assess the long-term effects of an intensive fluoride varnish programme.	Cost benefit	Community	NR	Adolescents, aged 11-14-years old	Sweden	+
Ramos-Gomez et al. (1999)	Assess the cost-effectiveness of 3 different intensities of dental caries prevention programmes.	Cost-effectiveness	Community, low SES area	No	One-year old children	USA	-
Sakuma et al. (2010)	Estimate the cost-effectiveness ratio and cost benefit ratio of a school-based programme combining FMR and targeted sealant.	Cost benefit	School, primary	No	School aged children (age 8 and 11)	Japan	+
Skold et al. (2008)	Examine the cost-effectiveness of a dental caries prevention programme of fluoride varnish treatment or FMR, in an extended period of follow-up.	Cost benefit	School	NR	School age children (aged 13-16)	Sweden	++
Splieth et al. (2008)	Develop an economic prognostic model for the lifetime costs associated with caries treatment and to estimate the effect of caries prevention with fluorides.	Cost benefit	Community	No	Individuals, aged 6 to 100 years	Germany	+
Weintraub et al. (1993)	Compare the cost-effectiveness of dental treatment with and without the inclusion of sealants among low-income children.	Cost-effectiveness	Community, low income area	Yes	Children, aged 3-11 years	USA	-

Study	Aim	Study design	Setting	Fluoridated water supply	Population	Location	Quality score
Wennhall et al. (2010)	Calculate the costs of a 3-year programme to provide toothpaste, training on brushing, fluoride tablets and diet information on children up to the age of 5 years.	Cost-effectiveness	Community, low SES area	NR	Pre-school children, aged 2 years	Sweden	+
Zabos et al. (2002)	Evaluate clinical outcomes and cost-effectiveness of a school-based programme on the use of dental sealants in 1st and 6th graders.	Cost-effectiveness	School, high prevalence of dental caries in area	No	School-age children in grades 1 and 6	USA	+

NR: Not reported

Table 3.2: Details of the oral health interventions assessed

Study	Fluoride Interventions							DS	DS & FMR	Intensified check-ups / screening / treatment	Reduce transmission of bacteria	Xylitol in children	Motivational interview / education
	TP	V	G	MR	Salt	Milk	Water						
Arrow, P. (2000)	X*												
Crowley et al. (1996)									X				
Crowley et al. (2000)									X				
Davies et al. (2003)	X**												
Hirsch et al. (2012)		X					X			X	X	X	X
Ichihashi et al. (2007)										X			
Marino et al (2012)	X		X	X	X	X	X	X					
Marino et al. (2007)						X							
Petersson et al. (1994)		X											
Ramos-Gomez et al. (1999)		X‡‡											
Sakuma et al. (2010)									X				
Skold et al. (2008)		X		X									

Study	Fluoride Interventions							DS	DS & FMR	Intensified check-ups / screening / treatment	Reduce transmission of bacteria	Xylitol in children	Motivational interview / education
Splieth et al. (2008)	X	X	X		X								
Weintraub et al. (1993)								X					
Wennhall et al. (2010)	X‡												
Zabos et al. (2002)									X				

DS = dental sealant; F = fluoride; G = gel; FMR = fluoride mouth-rinse; FV = fluoride varnish; MR = mouth-rinse; OHE = oral health education; TP = toothpaste; V = varnish;

*preventive programme of professional cleaning with fluoride toothpaste and oral health education

**preventive postal programme of free fluoride toothpaste, a leaflet encouraging brushing and a toothbrush

‡ preventive programme of fluoride toothpaste, fluoride tablets and oral health education

‡‡ 3 levels of intervention: FV plus annual risk assessment; FV, annual risk assessment plus oral health education; FV, risk assessment, oral health education plus outreach programme to encourage attendance at dental appointments.

3.3 QUALITY OF THE INCLUDED STUDIES

The results of the quality assessment are presented by intervention in Table 3.3 and by setting in Table 3.4. Two studies were judged to have minor limitations (++), 11 to have potentially serious limitations (+) and 3 to have very serious limitations (-). Table 3.5 presents the responses to each question in the quality assessment checklist, by study.

Table 3.3: Summary of the quality of the included studies by intervention (not mutually exclusive)

Intervention	Minor limitations only [++]	Potentially serious limitations [+]	Very serious limitations [-]
Fluoride interventions	Davies et al. (2003) Skold et al. (2008)	Arrow, P. (2000) Marino et al (2012) Petersson et al. (1994) Marino et al. (2007) Splieth et al. (2008) Wennhall et al. (2010)	Hirsch et al. (2012) Ramos-Gomez et al. (1999)
Dental sealant alone		Marino et al (2012)	Weintraub et al (1993)
Dental sealants + FMR		Crowley et al. (1996) Crowley et al. (2000) Sakuma et al. (2010) Zabos et al. (2002)	
Intensified check-ups / screening / treatment		Ichihashi et al. (2007)	Hirsch et al. (2012)
Xylitol interventions in children			Hirsch et al. (2012)
Reducing transmission of bacteria			Hirsch et al. (2012)
Motivational interview / education			Hirsch et al. (2012)

Table 3.4: Summary of the quality of the included studies by setting

Setting/ population	Minor limitations only [++]	Potentially serious limitations [+]	Very serious limitations [-]
School, unspecified risk area	Skold et al. (2008)	Arrow, P. (2000) Crowley et al. (2000) Marino et al (2012)* Sakuma et al. (2010) Marino et al. (2007)	
School, high risk area		Crowley et al. (1996) Zabos et al. (2002)	
Community, unspecified risk area		Petersson et al. (1994) Splieth et al. (2008)	Hirsch et al. (2012)
Community, high risk area	Davies et al. (2003)	Wennhall et al. (2010)	Ramos-Gomez et al. (1999) Weintraub et al. (1993)

Employer		Ichihashi et al. (2007)	
* Marino et al (2012) included both a school and community setting.			

High-risk settings were defined by the authors as areas with low socio-economic status (SES)[6, 7, 12] or areas with a known high caries prevalence[2, 13, 14].

Table 3.5 provides for each paper, responses to the questions in the Quality Appraisal Checklist. These inform assessment of applicability and quality of each included paper. Abbreviations are provided in the footer of the Table and the questions are written in full immediately after the Table.

Table 3.5: Quality of the included studies

Study	Applicability (relevance to the specific topic) dimensions									Study limitation (level of methodological quality) dimensions											
	1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**2.10**	**2.11**	**2.12**
Arrow (2000)	PA	Y	UC	Y	UC	N	N	N	PA	NA	PA	PA	PA	PA	N	PA	PA	Y	Y	UC	Potentially serious limitations [+]
Crowley et al. (1996)	PA	PA	UC	PA	PA	N	N	N	PA	NA	PA	PA	PA	PA	PA	N	PA	Y	Y	UC	Potentially serious limitations [+]
Crowley (2000)	PA	PA	UC	PA	PA	N	N	N	PA	Y	PA	PA	PA	PA	PA	N	PA	Y	Y	UC	Potentially serious limitations [+]
Davies (2003)	Y	PA	PA	N	UC	N	N	N	PA	NA	PA	PA	PA	N	PA	PA	PA	Y	N	UC	Minor Limitations [++}
Hirsh (2012)	Y	PA	UC	N	UC	N	N	N	PA	Y	PA	PA	N	UC	Y	N	N	Y	N	UC	Very serious limitations [-]
Ichihashi (2007)	PA	PA	UC	N	UC	N	N	N	PA	NA	PA	PA	N	PA	PA	PA	N	N	N	UC	Potentially serious limitations [+]
Lee* (2004)	PA	PA	UC	N	N	N	N	N	NA												

Study	Applicability (relevance to the specific topic) dimensions									Study limitation (level of methodological quality) dimensions											
	1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**2.10**	**2.11**	**2.12**
Marino (2007)	Y	PA	UC	Y	UC	N	N	N	PA	NA	PA	PA	Y	Y	PA	PA	Y	Y	N	UC	Potentially serious limitations [+]
Marino (2012)	UC	PA	UC	N	UC	N	N	PA	PA	Y	PA	PA	NA	PA	Y	PA	N	Y	Y	UC	Potentially serious limitations [+]
Petersson (1994)	Y	PA	UC	N	UC	N	N	N	PA	PA	PA	PA	PA	PA	PA	UC	N	N	N	UC	Potentially serious limitations [+]
Ramos-Gomez (1999)	Y	PA	PA	N	UC	N	N	N	PA	PA	PA	PA	PA	N	PA	N	PA	N	N	UC	Very serious limitations [-]
Sakuma (2010)	Y	PA	UC	N	UC	N	N	N	PA	NA	PA	PA	NA	PA	PA	UC	N	Y	N	UC	Potentially serious limitations [+]
Skold (2008)	Y	PA	UC	N	UC	N	N	N	PA	NA	PA	PA	PA	PA	PA	PA	N	Y	Y	UC	Minor Limitations [++}
Splieth (2008)	PA	PA	UC	N	UC	N	N	N	PA	Y	Y	PA	PA	Y	PA	PA	N	N	Y	UC	Potentially serious limitations [+]

Study	Applicability (relevance to the specific topic) dimensions									Study limitation (level of methodological quality) dimensions											
	1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**2.10**	**2.11**	**2.12**
Weintraub (1993)	Y	PA	UC	N	UC	N	N	N	PA	NA	PA	PA	PA	N	PA	PA	PA	Y	N	UC	Very serious limitations [-]
Wennhall (2010)	Y	PA	UC	N	UC	N	N	N	PA	NA	N	N	N	UC	PA	PA	N	Y	PA	N	Potentially serious limitations [+]
Zabos (2002)	Y	PA	UC	N	UC	N	N	N	PA	NA	PA	PA	PA	PA	PA	PA	N	Y	PA	UC	Potentially serious limitations [+]

Y = Yes; N = No; PA = Partially Applicable; UC = Unclear; DA = Directly Applicable; NA = Not Applicable
*Lee was excluded after review of quality checklist as it was not applicable.

Key to Questions:

1.1. Is the study population appropriate for the topic being evaluated?
1.2. Are the interventions appropriate for the topic being evaluated?
1.3. Is the system in which the study was conducted sufficiently similar to the current English context?
1.4. Was/were the perspective(s) clearly stated and what were they?
1.5. Are all direct health effects on individuals included, and are all other effects included where they are material?
1.6. Are all future costs and outcomes discounted appropriately?
1.7. Is the value of health effects expressed in terms of quality-adjusted life years (QALYs)?
1.8. Are costs and outcomes from other sectors fully and appropriately measured and valued?
1.9. Overall judgement (no need to continue if NA).
2.1. Does the model structure adequately reflect the nature of the topic under evaluation?
2.2. Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?
2.3. Are all important and relevant outcomes included?
2.4. Are the estimates of baseline outcomes from the best available source?

2.5. Are the estimates of relative 'treatment' effects from the best available source?
2.6. Are all important and relevant costs included?
2.7. Are the estimates of resource use from the best available source?
2.8. Are the unit costs of resources from the best available source?
2.9. Is an appropriate incremental analysis presented or can it be calculated from the data?
2.10. Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?
2.11. Is there any potential conflict of interest?
2.12. Overall assessment.

3.4 APPLICABILITY

Only one study (Davies et al., 2003 [++])[2] was set in England, using data from a randomised controlled trial (RCT) conducted in the late 1990s. The applicability of its resource and cost data to current English costs and services is limited; the clinical effect size may however generalize to England.

All remaining studies were considered partially applicable, with the exception of Lee et al. (2004)[18] which was not applicable. These studies were based in Australia, Chile, Germany, Japan, Sweden and USA. The programme costs, dental treatment expenses, and provision of dental services used in other countries have limited applicability to the English population. The effect size of the clinical evidence may generalise to England depending on when and where the study was conducted. Many of the studies dated back to mid-1990s and early 2000s, which means that effect sizes are unlikely to generalise to the current English context due to improved overall dental health in England since that time.[19]

Most (n=12) of the studies had relatively short follow-up times of less than 7 years. Benefits tend to accrue over time as caries are avoided. Moreover, developing good oral habits in young children may promote less recurrent treatment and improve the care of secondary teeth. Most studies have not adopted a sufficiently long time horizon to fully measure the benefits associated with the programmes they investigated.

Many interventions assessed in the studies were similar to interventions available or potentially available in the England, with the exception of the fluoridated milk programme, which is unlikely to be delivered in an English setting. The other interventions involved attempts to increase exposure to fluoride through a variety of means, the use of dental sealants with and without additional fluoride, an intensified check-up, screening and treatment programme, programmes aimed at reducing the transmission of bacteria from mother to child, the use of xylitol inventions in children and motivational interviewing for families.

However, the settings in which the interventions were delivered are not always applicable to settings currently used to deliver oral health programmes in England. Interventions delivered in a school setting by dentists may not generalise to England, as dental services are not provided through the English school system. As noted, the milk interventions will not generalise because there is no public English health programme of free milk to children. Six studies delivered the oral health programme through the community and one through a place of employment, all of which may be applied to the English context.

The costs of the interventions varied and comparison is difficult due to differences in currency and units of measure used between studies. The denomination and year of value of reported costs and financial benefits were extracted from each study. These were converted to pounds sterling at 2013 prices by converting the currencies to sterling and indexing for intervening inflation using the retail price index. However, the resulting cost may not be a useful measure of the underlying resources used in either country.

Section 4: Results of the Systematic Review

This section provides an interpretation of the evidence for each intervention. Summaries of the individual studies which contributed evidence to each intervention are provided, followed by an evidence statement for each intervention. Full study characteristics are reported in evidence tables in Appendix C.

4.1 INTERPRETATION OF THE RESULTS FROM ECONOMIC EVALUATIONS

NICE has stated that its preferred form of economic evaluation is cost-utility analysis, whereby health effects are expressed in terms of quality-adjusted life years (QALY).[20] Decision aids are available to guide decision makers in interpreting the incremental cost/QALY. These consider factors such as the absolute level of the cost/QALY, the generalisability of the results to the decision setting and the level of uncertainty. However, none of the selected studies in this systematic review expressed outcomes in terms of QALYs. Therefore, the existing NICE guidance on cost-effectiveness cannot be applied to the results of those studies.

The selected studies reported cost-effectiveness and cost-benefit analyses.

Studies which reported a cost-effectiveness analysis measured effectiveness (benefits) in terms of disease avoided using surrogates for disease such as decayed or filled teeth. No study expressed a threshold at which point the intervention would be considered cost effective. Without such thresholds (which may or may not generalise to the English setting), it may not be possible to determine whether the results indicate interventions are cost effective relative to the comparator.

Interventions which are cost saving and have improved clinical outcomes relative to the comparator can be recommended; those which cost more and have poorer or equivalent efficacy are not recommended. The difficulty lies with those interventions which cost more but which prevent more disease and hence have a cost per decayed tooth or filling prevented. There is no accepted willingness to pay for such outcomes.

With cost-benefit analysis, benefits and costs are expressed in monetary terms and different interventions can be compared using the ratio of benefits to costs to determine which intervention offers the highest benefits relative to its costs.

For each form of economic evaluation the results are reported at the last follow-up period or longest time horizon adopted for a model; interim results are not presented. For economic evaluations using CBA a statement on the more cost-effective intervention is provided. For economic evaluations using cost-effectiveness analysis the cost per measure of effect is presented for each intervention; however, it is not possible to determine if the intervention

with the lowest cost-effectiveness measure is an effective use of public sector resources.

4.2 FLUORIDE INTERVENTIONS

Ten studies evaluated the cost-effectiveness of 7 different fluoride interventions: fluoride toothpaste (n=5)[2-6], fluoride varnish (n=5)[5, 7-10], fluoride gel (n=2)[4, 5], fluoride mouth-rinse (n=2)[4, 10], fluoride salt (n=2)[4, 5], fluoride milk (n=2)[4, 11] and fluoride water, as a component of a complex intervention (n=2)[4, 8]. Four of the studies evaluated a fluoride intervention programme, which included fluoride plus an oral health education component, either verbal or written.[2, 3, 6, 7] Three of the studies were set in a school setting (risk not specified)[3, 10, 11], 6 in a community setting (high risk area, n=3[2, 6, 7]; risk not specified n=3[5, 8, 9]) and one assessed several fluoride regimes in a school or community setting (risk not specified)[4]. One of the studies was conducted in England.[2] Two studies were classified as having minor limitations only (++)[2, 10], 6 as having potentially serious limitations (+)[3-6, 9, 11] and 2 as having serious limitations (-)[7, 8].

The evidence on each intervention is now reviewed.

4.2.1 Fluoride toothpaste (n=5)

Five studies evaluated the cost-effectiveness of fluoride toothpaste intervention delivered in a school-based setting[3, 4], or community based setting[2, 5, 6] (high risk n=2[2, 6]). Four of the studies were classified as having potentially serious limitations (+)[3-6] and one as having minor limitations (++)[2]. One of these studies was carried out in England (Davies) [++][2]. The characteristics are set out in Table 4.1.

Table 4.1: Characteristics of 5 studies of fluoride toothpaste

Study	Design	Country	Population
Davies et al. (2003) [++][2]	CEA	England	Community, high risk, Pre-school children, aged 12-60 months
Arrow, P. (2000) [+][3]	CEA	Australia	School-based, Children, aged 6 years
Marino et al (2012) [+][4]	CEA	Chile	School Children, age 6 years
Splieth et al. (2008) [+][5]	CBA	Germany	Community, Individuals, aged 6 to 100 years
Wennhall et al. (2010) [+][6]	CEA	Sweden	Community, high risk, Pre-school children, aged 2 years

A summary of the individual studies is provided below.

Davies (2003)

Davies et al. (2003)[2] [++] performed a cost-effectiveness analysis of a community-based, postal toothpaste programme, conducted over 4 years, among pre-school aged children (12-60 months) in England. The intervention included a quarterly mailing of free fluoridated toothpaste (1450 ppm fluoride), an information leaflet encouraging brushing, and the inclusion of a free toothbrush once a year. It was delivered to children in an area of high caries prevalence in North West England, without fluoridated water. The study included 6,781 children from the age of 12 months who were followed until 5 years of age (5,344 children completed the programme).

The study reported that the incremental cost of the programme was about £28 per child, compared to 'do-nothing'. The cost per tooth saved from DMFT was £80.83, the cost of preventing caries was £424.38 per child and the cost of preventing extraction was £679.01 per child. No savings from treatment costs avoided were included. Sensitivity analyses were not carried out.

This study set in England is relevant to the English context and setting, although the data were collected prior to 2002, which limits the applicability of the costs and results to current English practice. The efficacy was based on 1 RCT, which was not clearly described. Limited information on the modelling method and cost base was provided. The final outcome of DMFT reduction was assessed at 5.5 years; the longer-term benefits of the programme were, thus, not included.

Arrow (2000)

Arrow et al (2000)[3] [+], is a cost-effectiveness analysis of a school-based occlusal caries prevention programme for 6-year-old primary school children in Australia which is partially applicable to the English context.

Efficacy data were derived from a prevention programme delivered in a water-fluoridated area of Western Australia. The intervention comprised professional cleaning with a paste containing fluoride and individualised oral health education (n=207). The comparator comprised selective fissure sealing with topical fluorides (n=197).

At the end of the 24-month trial, there was no difference in caries incidence between the intervention and control groups: the mean (SD) DMFS of the intervention group was 2.2 (3.7) compared to 2.4 (4.2) for the control group ($p = 0.76$). In the cost-effectiveness analysis, efficacy data were applied to 2 cohorts of 100 children each. Cost data were estimated retrospectively and included programme costs only. The costs of dental treatment were not included.

The cost per patient of the 2-year programme (discounted at 5% and deflated to 1994 prices) was $A689 for the intervention group and $A369 for the control group. The incremental cost of the programme per averted caries on the first permanent molar was

$A40/child/year. Limited sensitivity analyses were conducted. The results were sensitive to the caries benefit assumed for the intervention.

The study was limited by the short duration of the field trial (2 years), which was insufficient to capture the full benefits of a caries prevention programme. In addition, it was assumed that the time allotted for fissure sealing in the control group was 3 minutes, shorter than that reported in the literature (11 minutes), thus underestimating the costs of the control group. Some children in the intervention group received sealants as well as the intervention because the clinician judged they were at high risk of caries. The exact number of children who received sealants was not reported. This may have introduced bias favouring the intervention in terms of caries incidence and the control by overestimating costs in the intervention group. Programme costs were estimated using 1994 Australian dollar values, and hence have little applicability to current NHS/PSS costs. The applicability of this oral health programme provided in a school setting is of limited value to the current English context which does not have school dentists.

Marino (2012)

Marino et al (2012)[4] [+] performed a cost-effectiveness analysis of 7 dental caries prevention programmes on a modelled population of 86,000 school-aged children in Chile. The 7 interventions included 3 community-based programmes (water-fluoridation, salt-fluoridation and dental sealants) and 4 school-based programmes (milk-fluoridation, fluoridated mouth-rinses (FMR), APF-Gel, and supervised tooth brushing with fluoride toothpaste). The interventions were compared to 2 non-intervention communities, 1 representative of a hypothetical city and another of a rural community, neither with fluoridated water. The study was judged to be partially applicable to the current English setting.

The fluoridated toothpaste intervention was supervised tooth brushing with fluoride toothpaste for children aged 6 years with a follow-up period of 6 years, in a school-based setting. Treatment effects were derived from published studies, mostly conducted in Chile. The costs were 2009 market costs in Chile, converted to 2009 US dollars and included the cost of supervision.

The incremental discounted cost per averted DMFT was $8.55. The supervised tooth brushing and fluoridated toothpaste programme was not cost saving under any sensitivity analyses.

This study was limited by the use of a public health fee structure for dental costs, which represents the lower end of dental treatment costs and may underestimate costs. The study also assumed 100% compliance with school programmes, favouring the programme. Limited information was provided on the clinical efficacy rates on which the cost-effectiveness analysis was based. The study was conducted in a school-based setting in Chile, which limits its generalisability to the current English context as England does not provide access to dentists through schools.

Splieth et al (2008)

No separate cost-effectiveness measures were provided for fluoridated toothpaste programme alone in Splieth et al. 2008[5] results. The authors presented the results of the cost-effective analysis of the fluoridated toothpaste programme in combination with the fluoridated salt and fluoridated gel programmes.

Wennhall (2010)

Wennhall et al. (2010)[6] [+] performed a cost-effectiveness analysis of a 3-year oral health outreach programme for pre-school children aged 2 years living in a low-socio-economic multi-cultural urban area in southern Sweden. The fluoridation status of the water supply was not reported. The programme provided free diet information, toothbrush training, fluoride tablets, fluoride toothpaste, toys and pamphlets at each visit. Outcomes were compared to a historical reference group. Treatment effects (number of caries avoided) were derived from a non-randomised prospective study which included approximately 800 children. At the age of 5 the decayed, extracted filled surfaces (DEFS) were 8.2 and 11.2 in the intervention and control groups respectively, giving a prevented DEFS risk reduction rate of 27% in the intervention group.

Programme costs were applied retrospectively and included labour costs (dentists, dental nurses, dental hygienists) and material costs. The total cost for 1 child to complete the 3-year programme was €310.11 compared to €96 in the control group; the net present revenue for an average of three avoided fillings per child was estimated to be €184. The net cost of the programme was estimated to be €30 per child. In sensitivity analysis, a net gain of €61 per child was achieved using the high limit of the CI of outcome; using the lower limit the net cost was €109 per child.

This study was partially applicable, as the interventions can be applied to the current English context. However, the health care system and costs associated with the programme in Sweden may not be entirely applicable to the current English context.

Evidence Statement 1: Cost-effectiveness of fluoride toothpaste programmes
Evidence was found from 5 cost-effectiveness analysis (CEA) studies, one judged as having minor limitations (++)[2], and 4 having potentially serious limitations (+).[3-6] A fluoride toothpaste regime, with or without an additional oral health education component, reduced caries relative to a control group in community-based studies[2, 5, 6] set England, Germany and Sweden, and in one primary school-based study set in Australia.[3] The Chilean school-based study did not report changes in caries incidence.[4] The UK community-based study[2] of pre-school aged children, found that the cost per child, per tooth saved, over the 4 years was £80.83 [£107.16 at 2013 prices] compared with a 'do nothing' approach. Savings from treatment costs avoided were not included. Sensitivity analysis was not carried out. The Chilean study[4] found that the cost per child, per averted decayed, missing or filled tooth (DMFT), over the 6 years was $8.55 [£6.27 at 2013 prices] compared with a non-

intervention group.

The Australian study[3] found that the cost per child, per averted caries was A$40.00 [£37.62 at 2013 prices] per year, compared with selective fissure sealing and topical fluoride use, which were delivered in a water-fluoridated area.

The Swedish study[6] found that the cost per child, per avoided filling, was €67.15 [£65.41 at 2013 prices] over the 3 years compared to a non-intervention group.

The German study[5] did not report cost analysis data separately for the fluoridated toothpaste regimen.

Only one study was directly applicable[2], being set in England, but the epidemiological, clinical and cost data are over 10 years old and thus of limited relevance to the current setting.

In the absence of agreed willingness to pay thresholds for caries avoided, combined with concerns about applicability, the findings from these 5 CEA studies provide little evidence to inform on the economic value of providing fluoride toothpaste interventions compared to standard care in England.

[2] Davies et al. (2003) [++]
[3] Arrow, P. (2000) [+]
[4] Marino et al (2012) [+]
[5] Splieth et al. (2008) [+]
[6] Wennhall et al. (2010) [+]

4.2.2 Fluoride varnish (n=5)

Five studies evaluated the cost-effectiveness or cost benefit of a fluoride varnish intervention delivered in a school-based setting (n=1)[10] or community based setting (n=4)[5, 7-9], 1 of which was a high-risk area[7]. One of the studies was classified as having minor limitations only (++)[10], 2 as having potentially serious limitations (+)[5, 9] and 2 as having very serious limitations (-)[7, 8]. None of the studies were conducted in England. The characteristics are set out in Table 4.2.

Table 4.2: Characteristics of 5 studies of fluoride varnish

Study	Design	Country	Population
Skold et al. (2008)[10] [++]	CBA	Sweden	School, Children, aged 13-16 years
Petersson et al. (1994)[9] [+]	CBA	Sweden	Community, Adolescents, aged 11-17-years
Splieth et al. (2008)[5] [+]	CBA	Germany	Community, Individuals, aged 6 to 100 years
Hirsch et al. (2012)[8] [-]	CBA	USA	Community, Pre-school children, aged under 72 months

Ramos-Gomez et al. (1999)[7] [-]	CEA	USA	Community, low SES area, Children, aged 1

A summary of the individual studies is provided below.

Skold (2008)

Skold et al. (2008)[10] [++] performed a cost-benefit analysis of a school-based fluoride varnish (FVT) and fluoride rinsing programme (FMR) in Sweden, in a medium risk caries area. The FVT was administered every 6 months for 3 years and the FMR was administered on the first and last 3 days of each school semester during the 3-year study period. Both interventions were performed at school by a dental nurse. The interventions were administered to school children aged 13-16 years and the children were followed-up 5 years later. The treatment effects of FVT were derived from the published results of 1 RCT.

The costs associated with the resources used in the programme were based on published studies. Dental treatment costs were based on the public fee structure in 2005. Costs were discounted at 3% and valued in 2006 SEK.

A hypothetical cohort of 100 students was modelled. The 'natural course' of caries development during the 3-year study and 5-year follow-up was based on the results of a longitudinal study of the development of caries in schoolchildren, which assumed 2.5% of restorations were replaced per year.

Compared to the control group, the FVT programme resulted in a saving of SEK 315 per avoided filling. The FVT was expected to be cost saving, with the ratio of expected benefits from avoided fillings to costs of 1.8 to 1. The FVT programme results showed positive net values in most sensitivity analyses.

This intervention could be delivered by a similar approach in England, however, the costs will not generalise to the English setting. The study was conducted in Sweden, which may limit the generalisability of the study to the current English context.

Petersson (1994)

Petersson et al. (1994)[9] [+] conducted a partially applicable cost-benefit analysis of a 3-year intensive fluoride varnish programme among Swedish adolescents. One hundred and sixty Swedish adolescents received 3 applications of varnish annually plus a basic preventive programme including oral hygiene and dietary information. The control group received standard fluoride varnish treatment twice a year plus a basic preventive programme. Regular use of fluoride toothpaste was recommended to both groups. Efficacy data were derived from a published RCT and assessed at the end of the programme and four years thereafter.

Costs included programme costs and restorative costs but not dental treatment costs. Costs and benefits were valued in 1983 SEK and discounted by 5% a year.

There was no significant difference in proximal caries incidence between treatment and control group at the end of the 3-year programme. The control group had significantly more proximal caries at the end of the 4-year follow-up (year 7).

The net benefit due to prevention of caries (SEK 1,800) and arrested progression of existing lesions (SEK 3,200) totaled SEK 5,000 per person. The net cost for the preventive programme was SEK 3,880, giving net savings of SEK 1,120 per person over 10 years.

The intervention could be delivered by a similar approach in England; however, the efficacy data were based on an RCT set in Sweden which may not generalise to the English setting. The applicability of these data is limited in that the standard of care for dentistry in Sweden may differ from that in England (for example, the control group received biannual fluoride varnish). The costs associated with this programme in Sweden in 1983, will also differ substantially from current UK NHS and PSS costs.

Splieth (2008)

Splieth et al. (2008)[5] [+] conducted a cost-benefit analysis of 4 dental caries prevention programmes in a hypothetical cohort of 1 million individuals aged 6 to 100 living in East Germany, which is partially applicable to England. East Germany had a non-fluoridated water supply.

Interventions included fluoridated salt, fluoride gel (weekly home application), fluoridated toothpaste and a professional biannual fluoride application. Interventions were compared to a restorative approach with no fluoride use over a lifetime horizon.

Data for the no fluoride control group were obtained from a heath survey. Treatment effectiveness rates were derived from published studies, including systematic reviews. The costs of the different fluoride prophylaxis regimes were modified from the literature and treatment costs were based on East German national health fees. Costs were discounted at 5% a year. The price year was not stated but estimated by the review authors to be 2007.

A system dynamics model was used applying monthly transitional probabilities, with 8 health states (healthy to failure of crown/replaced with bridge). Caries development was predicted over the lifetime of individuals.

The cost-effectiveness of each fluoride regime was calculated under 4 scenarios:

- Fluoride use from age 6 to age 18, constant effect;
- Fluoride use from age 6 to age 18, decreasing effect from the age of 18;
- Fluoride use from age 6 to age 18, linearly increasing effect to age 12 then decreasing after age 18;
- Lifelong use of fluoride, constant effect.

The discounted lifetime costs for the no fluoride control scenario was €932. The fluoride varnish application resulted in lower overall costs ranging from €457 to €579. Fluoride regimes were always cost effective compared to a restorative approach.

The combination of fluoride salt, fluoride toothpaste, and fluoride gel was most cost effective. This reduced the discounted costs for caries treatment and prophylaxis to €148, when applied from age 6 to age 18 and to €214 for lifelong use.

The applicability of this study is limited in that it was conducted in East Germany and the standard of care for dentistry, treatment pathways and assumptions used in the study may differ from the English context. The costs associated with this programme may differ substantially from current UK NHS and PSS costs.

Hirsch (2012)

Hirsch et al. (2012)[8] [-] performed a partially applicable cost-benefit analysis of 6 community based early childhood caries prevention interventions in pre-school aged children under 72 months, living in Colorado, USA. Seventy-five percent of Colorado's population is served by a fluoridated water supply. One intervention was to expand community water fluoridation to the entire population. Others were:

- Expanded use of fluoride varnish;
- Efforts to reduce *Streptococcus (s) mutans* transmission from parents to children using xylitol gum, chlorhexidine, or behavioural interventions;
- Use of xylitol products directly with older children;
- Aggressive screening for, and treatment of caries activity;
- Focused preventive care and education for children who already have cavities to reduce recurrence;
- Motivational interviewing; and
- Educational programmes that reduce consumption of sugary drinks, nocturnal bottle use, and other harmful behaviours.

The intervention was the expanded use of fluoride varnish to school-aged children under 72 months of age for a period of 10 years. Treatment efficacy was derived from published studies and personal communication. The authors assumed that fluoride varnish reduced decay of primary teeth by one-third at a cost of $16 per child, per application. No details were provided about the source of the costs of interventions or unit resources within each programme. The costs of restorative care and other treatment costs were obtained from the Medical Panel Expenditure Survey (MPES), Colorado Medicaid and the National Survey of Ambulatory Surgery.

A system dynamics model categorised children by age (0-6 months; 7-24 months, 25 to 72 months) and by caries risk categories (high, medium, low, based on family income). Varnish options were simulated in 3 scenarios: varnish given to all children aged over 6 months twice annually, varnish given to high-risk children aged over 6 months 3 times annually, and varnish given to all children aged over 24 months twice annually.

Cavity prevalence decreased from 18.2% in the no intervention group to 12.4% for children aged over 6 months, 14.7% for high-risk children aged over 6 months and 16% for children aged over 24 months, in the intervention group.

The net cost for the dental varnish programme was $118m for children aged over 6 months, $22m for high-risk children aged over 6 months and $58m for children aged over 24. Targeting the highest risk children aged over 6 months had a similar effect on reducing caries as providing fluoride varnish for all children aged over 24 months but at a lower programme cost.

The intervention is applicable to the current English context. The study, however, was judged to have serious limitations due to weaknesses related to the quality of efficacy and cost data used, which included proxies, estimates, expert's opinion, and extrapolations when data were not available. Insufficient information on efficacy and costs meant that a judgement on the appropriateness of findings for England could not be made. The study was conducted in the USA, which limits its generalisability to the English context.

Ramos-Gomez (1999)

Ramos-Gomez et al. (1999)[7] [-] conducted a cost-effectiveness analysis of 3 dental caries prevention programmes, in a hypothetical cohort of 1 year-old children in a low income (high risk) area in California, USA in 1996, which is partially applicable to the English context. The authors of the study assumed 84% of the participants lived in non-fluoridated areas and 16% in fluoridated areas.

Three successively more complete levels of preventive interventions were assessed:

- Fluoride varnish applied at 6-month intervals plus an annual risk assessment based on parental and sibling caries, feeding practices and risk behaviours (minimal intervention);
- Fluoride varnish plus an annual risk assessment plus oral hygiene counselling on age-specific topics (intermediate intervention);
- Fluoride varnish plus counselling plus outreach via telephone and personal prompts to encourage dental appointment attendance (comprehensive).

These 5-year interventions were compared to no intervention.

Treatment effects for the minimal intervention (40% reduction in caries) were obtained from one published study; treatment effects for the intermediate (70%) and comprehensive interventions (80%) were based on clinical observation at the UCSF Paediatric Dental Clinic. The programme costs for each intervention were based on 1996-97 California Dental Medicaid reimbursement rates and actual costs to provide the interventions. Treatment costs were based on 115 patients at a dental clinic at the University of California.

The cost of each intervention, per child, over 5 years was $314.00 (minimal), $497.00 (intermediate), and $570.00 (comprehensive). The number of carious surfaces averted per

child over 5 years (compared to the no intervention number of 10.80 carious surfaces) was 4.32 (minimal), 7.32 (intermediate) and 8.36 (comprehensive). The cost per carious surface averted was $72.69 (minimal), $65.74 (intermediate) and $66.28 (comprehensive).

The intervention could be delivered by a similar approach in England. This study was judged to have serious limitations due to the assumptions used in the model, including the treatment efficacy rates used, which were based on 1 study and clinical observation. The sources of the incidence rates and disease course were not provided, nor were details of the resource costs and interventions.

The lack of transparency about the choice and source of efficacy measures and programme costs limits confidence in the results of the study. The study was conducted in the USA in 1996, which limits the generalisability of the study to the current English context.

Evidence Statement 2: Cost-effectiveness of fluoride varnish programmes

Evidence from 1 CEA[7] and 4 cost-benefit analyses (CBAs)[5, 8-10] found that fluoride varnish regimes, with or without an additional oral health education component, reduced caries relative to a control group in all studies. These studies were set in Germany, Sweden and the USA.

The Swedish study (++)[10] was conducted with adolescents, aged 13-16 years, and was the only fluoride varnish programme set in a school. The cost per child, per avoided filling, over the 10 years was Swedish Krona (SEK) 315 [£37.85 at 2013 prices] compared with a no intervention group. The ratio of expected benefits from avoided fillings to costs was 1.8:1. The fluoride varnish programme produced a positive net value under most sensitivity analyses.

A second Swedish study[9] (+) was also conducted on adolescents (aged 11-17 years), but set in a community. The CBA determined total costs at SEK 3,880 [£1,065 at 2013 prices] per child and total benefits (from avoided fillings) at SEK 5,000 [£1,372 at 2013 prices] per child, a positive cost benefit ratio over 10 years.

The German study[5], (+), was set in a community with a hypothetical cohort of 1 million (m) individuals aged 6-100 years. It adopted a lifetime horizon. The total cost of the fluoride varnish programme per individual ranged from €457 [£461.54 at 2013 prices] to €579 [£584.75 at 2013 prices] over a lifetime, according to the age at which treatment started and efficacy curve. This was cost saving from reduced caries treatment compared to the no fluoride scenario, which was at per person cost of €932 [£941.25 at 2013 prices].

The two studies judged with very serious limitations[7, 8] (-), were set in communities in the USA. The study of a cohort of high-risk one-year-olds[7], reported a range of costs from $72.69 [£72.22 at 2013 prices] to $66.28 [£65.84 at 2013 prices] per carious surface averted over a 5-year period (range based on level of preventive intervention, all interventions included dental varnish, with or without counselling and outreach).

The second USA study[8] found that the net cost of fluoride varnish over 10 years was $22 to 58 million (m) [£16- £42 m at 2013 prices].

The results from all of the studies were judged partially applicable. None was set in England. Studies set in other countries may not generalise to England due to differences in underlying caries prevalence, different utilisation of fluoride products in communities, different standard dental care regimes and costs. Some of the cost data are old, dating back to 1996[7] and 1983[9]. The costs associated with these programmes will differ substantially from the current English context.

There is weak evidence from 3 higher quality studies[10, 9, 5] that adding fluoride varnish to standard care, with delivery in a school or community setting, results in financial savings from avoided caries treatment which exceeds the programme costs in their settings.

[10] Skold et al. (2008) [++]
[9] Petersson et al. (1994) [+]
[5] Splieth et al. (2008) [+]
[8] Hirsch et al. (2012) [-]
[7] Ramos-Gomez et al. (1999) [-]

4.2.3 Fluoride gel (n=2)

Two studies evaluated the cost-effectiveness of a fluoride gel intervention delivered in a school and community setting[4] and community based setting.[5] Both studies were classified as having potentially serious limitations (+). Neither was conducted in England. The characteristics are set out in Table 4.3.

Table 4.3: Characteristics of 2 studies of fluoride gel

Study	Design	Country	Population
Marino et al (2012)[4] [+]	CEA	Chile	School, children, aged 6 years
Splith et al. (2008)[5] [+]	CEA	Germany	Community, Individuals, aged 6 to 100 years

Marino (2012)

Marino et al (2012)[5] [+] performed a cost-effectiveness analysis of 7 dental caries prevention programmes in a simulated population of 86,000 school-aged children in Chile. See Section 4.2.1 for study details and applicability.

The relevant intervention was APF-Gel provided to school children of 6 years of age for a period of 6 years. Treatment effects were derived from 1 published study. Costs were 2009 market costs in Chile converted to US dollars.

The incremental discounted costs per averted DMFT were $21.30. The fluoridated APF-Gel programme remained a cost to society under most sensitivity analyses.

The applicability of these data to England is limited in that costs were priced using 2009 market costs in Chile, and are of little relevance to English NHS/PSS cost. Dental fees were based on the public health fee structure, which is at the lower end of dental treatment costs. The generalisability of costs to England is very poor.

Splieth (2008)

No separate cost-effectiveness measures were provided for fluoridated gel programme alone in Splieth et al. 2008[5] results. The authors presented the results of the cost-effective analysis of the fluoridated gel programme in combination with the fluoridated salt and fluoridated toothpaste programmes. Therefore this study is not part of the assessment of fluoridated toothpaste programme.

Evidence Statement 3: Cost-effectiveness of fluoride gel programmes
Evidence from 2 CEAs[4, 5] found that fluoride varnish gel reduced caries relative to a control group, based on published literature. The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a school setting in Chile. Using a 21% effectiveness rate for caries reduction, which was based on one published study, the cost per child, per averted DMFT, over the 6 years, was $21.30 [£15.61 at 2013 prices] compared with a non-intervention group. No separate cost-effectiveness analysis was conducted for fluoride gel alone in the Germany study[5]. Both studies had potentially serious methodological weaknesses and applicability to England was limited by setting, date, different dental epidemiology, use of fluorides, cost structures and treatment pathways. The evidence base is limited to the results from 1 poorly conducted study[4], with limited applicability to England and was insufficient to inform decisions on using fluoride gel in England. [4] Marino et al (2012) [+] [5] Splith et al. (2008) [+]

4.2.4 Fluoride mouth-rinse (n=2)

Two studies evaluated the cost-effectiveness of FMR. For both studies, the interventions were delivered in a school setting[10, 4]. One study was classified as having minor limitations only (++)[10] and the other as having potentially serious limitations (+)[4]. Neither of the studies was conducted in England. The characteristics are set out in Table 4.4.

Table 4.4: Characteristics of 2 studies of fluoride mouth-rinse

Study	Design	Country	Population
Skold et al. (2008)[10] [++]	CBA	Sweden	School Children, aged 13-16
Marino et al (2012)[4] [+]	CEA	Chile	School Children, aged 6

A summary of the individual studies is provided below.

Skold (2008)

Skold et al. (2008)[10] [++] performed a cost-benefit analysis of a school-based fluoride varnish (FVT) and FMR programme in Sweden, in a medium risk caries area. See Section 4.2.2 for study and intervention details and applicability.

The intervention was FMR administered 36 times during the 3-year study period to children aged 13-16. Follow-up was 5 years later.

Compared to the control group, the FMR programme resulted in costs of SEK 63 per avoided filling. The ratio of expected benefits to costs was 0.9 to 1. Under sensitivity analyses, the FMR resulted in a positive net value only at the upper limit of the 95% CI or if programme costs were reduced by 20%.

This intervention could be delivered by the same approach in England. However, the costs may not generalise to the English setting. The study was conducted in Sweden, which limits the generalisability of the study to the current English context.

Marino (2012)

Marino et al (2012)[4] [+] performed a cost-effectiveness analysis of 7 dental caries prevention programmes in a simulated population of 86,000 school-aged children, in Chile. See Section 4.2.1 for study details and applicability.

The intervention was FMR delivered in school, to children aged 6 for a period of 6 years. Treatment effects were derived from published studies, mostly conducted in Chile. Costs were 2009 market costs in Chile, converted to US dollars.

The incremental discounted savings per averted DMFT were $8.63. FMR was cost saving under all scenarios in the sensitivity analyses.

This intervention could be delivered in an English setting, but the generalisability of the results to England is unlikely as costs were priced using 2009 market costs in Chile and there are differences in access to dentists, epidemiology and use of fluoride products between Chile and England.

Evidence Statement 4: Cost-effectiveness of fluoride mouth-rinse programmes
Evidence from 1 CEA set in Chile[4] and 1 Swedish CBA[10] found that fluoride mouth-rinse (FMR) reduced caries relative to a control group. Both studies were set in schools. The Swedish study[10] (++) was conducted on a simulated population of 300 adolescents aged 13-16 over 3 years. Compared to the control group, the FMR programme resulted in costs of SEK 63 [£7.57 at 2013 prices] per avoided filling, over 8 years. The ratio of expected benefits from avoided fillings to costs was 0.9:1. Under sensitivity analyses, the FMR resulted in a positive net value only at the upper limit of the 95% confidence interval of efficacy or if programme costs were reduced by 20%. The Chilean study (+)[4] was conducted on a simulated population of 86,000 6-year old children, in a school setting. Based on a 26% effectiveness rate for caries reduction, the savings per averted DMFT, over a 6-year period, was $8.63 [£6.32 at 2013 prices] compared with a non-intervention group. The results from both studies were judged partially applicable to England. Neither was set in the England. Overall, there is inadequate evidence to inform decisions on using fluoride mouth-rinse in schools. The direction of benefit is inconsistent across the two studies, with one showing a small net cost[10] and the other a small benefit[4]. However, the net savings and net costs are each less than £1 per decayed tooth per year and so small changes in assumptions could switch the direction of results. [10] Skold et al. (2008) [++] [4] Marino et al (2012) [+]

4.2.5 Fluoride salt (n=2)

Two studies evaluated the cost-effectiveness of fluoride salt interventions. Both interventions were delivered in a community-based setting[4, 5]. Both studies were classified as having potentially serious limitations (+). Neither of the studies was conducted in England. The characteristics are set out in Table 4.5.

Table 4.5: Characteristics of 2 studies of fluoride salt

Study	Design	Country	Population
Marino et al (2012)[4] [+]	CEA	Chile	Community Children, aged 6
Splieth et al. (2008)[5] [+]	CBA	Germany	Community, Individuals, aged 6 to 100

A summary of the individual studies is provided below.

Marino (2012)

Marino et al (2012)[4] [+] performed a cost-effectiveness analysis of 7 dental caries prevention programmes in a simulated population of 86,000 school-aged children, in Chile. See section 4.2.1 for study details and applicability.

The intervention was salt fluoridation offered to children aged 6 years old for a period of 6 years with delivery in a community-based setting. Treatment effects were derived from published studies, mostly conducted in Chile. Costs were 2009 market costs in Chile converted to US dollars.

The incremental discounted saving per averted DMFT was $16.2. The fluoridated salt programme was cost saving under all scenarios in the sensitivity analyses.

The generalisability of the results to England is unlikely as costs were priced using 2009 market costs in Chile and there are differences in background fluoridation, epidemiology and dental treatment pathways between the two countries.

Splieth (2008)

Splieth et al. (2008)[5] [+] conducted a cost-benefit analysis of 4 dental caries prevention programmes in a hypothetical cohort of 1 million individuals aged from 6 to 100, living in East Germany without fluoride use, over a lifetime. This was partially applicable to England. See Section 4.2.2 for study details and applicability.

The intervention was salt fluoridation, which was compared to a restorative approach with no fluoride use over a lifetime.

The fluoride salt regime was always cost effective compared to a restorative approach. The discounted lifetime costs for the no fluoride control (restorative approach) was €932. The preventive professional fluoridated salt programme reduced the overall costs to between €246 and €305 depending on the assumed benefit.

The combination of fluoride salt, fluoride toothpaste, and fluoride gel was the most cost effective option. This programme reduced the discounted costs for caries treatment and prophylaxis to €148, when applied between the ages of 6 to 18 years and to €214 for lifelong use.

Evidence Statement 5: Cost-effectiveness of fluoride salt programmes
Evidence from 1 CEA[4] and 1 CBA[5] found that fluoridated salt programmes, delivered in a community setting, reduced caries relative to a control group: these were set in Chile and Germany. The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a community setting. Based on a 44% effectiveness rate for caries reduction, the savings per child, per averted DMFT, over the 6 years, was $16.21 [£11.88 at 2013 prices] compared with a non-intervention group.

The German study[5] (+), was set in a community, for a hypothetical cohort of 1 m individuals aged 6-100 years, over a lifetime. The intervention was assumed to reduce caries by 50%. The total cost of the fluoride salt programme ranged from €246 [£248 at 2013 prices] to €305 [£308 at 2013 prices] per person over a lifetime, according to the age when consumption started and the efficacy curve: in comparison, the no fluoride, restorative approach cost €932 [£941.25 in 2013 prices] per person. Thus fluoridated salt was cost saving to society.

The results from both studies were judged partially applicable to England. Neither was set in England; nether setting had fluoridated water.

The 2 studies provide weak evidence that the addition of salt fluoridation to standard care, delivered in a community setting, results in financial savings from avoided caries treatment, which exceed programme costs. The savings are driven by the high rate of caries reduction (44% and 50%); the key question is whether the introduction of salt fluoridation in England would realise such efficacy rates. If so, then the published economic evaluations suggest the intervention merits further consideration.

[4] Marino et al (2012) [+]
[5] Splieth et al. (2008) [+]

4.2.6 Fluoride milk (n=2)

Two studies evaluated the cost-effectiveness of a fluoride milk intervention. In both studies the intervention was delivered in a school setting.[11] [4] Both studies were classified as having potentially serious limitations (+)[4] [11]. Neither of the studies was conducted in England and they had the same lead author (Marino). The characteristics are set out in Table 4.6.

Table 4.6: Characteristics of 2 studies of fluoride milk programmes

Study	Design	Country	Population
Marino et al. (2007)[11] [+]	CEA	Chile	School Children, aged 3 to 6
Marino et al (2012)[4] [+]	CEA	Chile	School Children, aged 6

A summary of the individual studies is provided below.

Marino (2007)

Marino et al (2007)[11] [+] performed a cost-effectiveness analysis of a programme of added fluoride to milk products over a 4-year period, in a simulated population of 2,000 children aged 3 to 6 years old attending public kindergarten and primary schools in a rural community in Chile. Both communities had low levels of fluoride in the water. In Chile, milk is distributed to all children up to age of 6 years through a National Complementary Feeding Programme. The control community did not receive added fluoride.

Treatment effects were derived from a community trial with 2 non-randomised arms, conducted in 1999. Costs included programme costs, transportation costs and productivity losses. Dental expenses were from 1999 Ministry of Health fees. Costs were valued in 1999 Chilean pesos and discounted at 3%. Outcomes were not discounted.
The mean (SD) DMFT for the intervention group was 2.08 (2.85) and 3.49 (3.42) for the control group. Incremental savings per DMFT avoided, over 4 years were $5.1. The incremental savings per child over a 4-year period were $7.2.

In England children do not have milk provided by the State so implementation of this intervention would be much more difficult than in Chile. Programme and treatment costs were also not applicable to an English setting. Access to dentists and dental treatment pathways are also likely to be different between the two countries.

Marino (2012)

Marino et al (2012)[4] [+] performed a cost-effectiveness analysis of 7 dental caries prevention programmes in a simulated population of 86,000 school-aged children in Chile. See section on 4.2.1 for study details.

The intervention was the addition of fluoride to milk provided to school children aged 6 years old for a period of 6 years delivered in schools. Treatment effects were derived from published studies, most of which were conducted in Chile. Costs were 2009 market costs in Chile converted to US dollars.

The incremental discounted savings per averted DMFT were $14.78, which dominated the comparator. The fluoridated milk programme was cost saving under all sensitivity analyses.

The intervention is unlikely to be delivered in an English setting. Fluoride was provided through a nationally funded milk programme in Chile, which is not applicable to the current English system.

Evidence Statement 6: Cost-effectiveness of fluoride milk programmes
Evidence from 2 CEAs[4, 11], conducted by the same author, found that fluoride milk programmes, delivered via a nationally funded programme to provide milk to schools in Chile, reduced caries relative to a control group in both studies. The first study[11] (+) assessed the addition of fluoride to milk, compared to a non-fluoridated milk control group, on a simulated population of 2,000 3-6-year old children, in a school setting. Incremental savings per DMFT avoided, over 4 years, was $5.10 (£4.60 at 2013 prices] and the incremental savings per child over 4 years was $7.20 (£6.50 at 2013 prices) compared with a non-intervention group. The second study[4] (+), conducted on a simulated population of 86,000 6-year old children, used more robust modelling techniques and a slightly longer time horizon. Based on a 53% effectiveness rate for caries reduction, the savings per child, per averted DMFT, over 6 years, was $14.78 [£10.83 at 2013 prices] compared with a non-intervention group.

The results from both studies were judged partially applicable to England; however, the intervention is unlikely to be delivered in an English setting.

Both studies showed that milk fluoridation programmes have lower costs and reduce caries and hence are cost effective in their setting. However, they do not provide evidence that can be generalised to England because of the absence of school milk provision.

[11] Marino et al. (2007) [+]
[4] Marino et al (2012) [+]

4.2.7 Fluoride water (n=2)

Two studies evaluated the cost-effectiveness of added fluoride to water intervention delivered in a community based setting.[8, 4] One study was classified as having potentially serious limitations (+)[5] and the other as having very serious limitations (-)[9]. Neither study was conducted in England. The characteristics are set out in Table 4.7.

Table 4.7: Characteristics of 2 studies of fluoride water programmes

Study	Design	Country	Population
Marino et al (2012)[4] [+]	CEA	Chile	Community Children, aged 6
Hirsch et al. (2012) [8] [-]	CBA	USA	Community Pre-school children, aged under 72 months

A summary of the individual studies is provided below.

Marino (2012)

Marino et al (2012)[4] [+] performed a cost-effectiveness analysis of 7 dental caries prevention programmes in a simulated population of 86,000 school-aged children in Chile. See Section 4.2.1 for study details and applicability.

The intervention was fluoridated water provided in a community setting to 6 years old children for a period of 6 years. Treatment effects were derived from published studies, most of which were conducted in Chile. Costs were 2009 market costs in Chile converted to US dollars.

The incremental discounted savings per averted DMFT were $14.89.The fluoridated water programme was cost saving under all sensitivity analyses.

Hirsch (2012)

Hirsch et al. (2012)[8] [-] performed a cost-benefit analysis of 6 community based early childhood caries prevention interventions in pre-school children aged under 72 months, living

in Colorado, USA. This study was partially applicable to England. Colorado has a mostly fluoridated water supply. See Section 4.2.1 for study details.

The intervention was expanding community water fluoridation to 24.6% of Colorado's population, which was not currently served.
The 10-year net savings (cost of baseline restorative care minus care post intervention minus cost of intervention) were $8 m for the water fluoridation programme.

Evidence Statement 7: Cost-effectiveness of fluoride water programmes

Evidence from 1 CEA[4] and 1 CBA[8] found that fluoridated water programmes, delivered in a community setting, reduced caries relative to a control group. The studies were set in Chile and the USA.

The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a community setting. Based on a 40% effectiveness rate for caries reduction, the savings per child, per averted DMFT, per 6 years, was $14.89 [£10.91 at 2013 prices] compared with a non-intervention group.

The USA community-based fluoridated water programme[8] was estimated to produce net savings of $8 m [£5.86 m at 2013 prices] over 10 years (25% of Colorado's population), compared to no intervention, with an associated decrease of 1.2% in the prevalence of cavities, after 10 years.

The results from these studies were judged partially applicable to England. Neither was set in England.

Both studies reported cost savings but the assumed rates of caries reduction were very different and were not transparent in either study. At best they provide weak evidence in support of the cost-effectiveness of community-based water fluoridation programmes.

[4] Marino et al (2012) [+]
[8] Hirsch et al. (2012) [-]

4.3 DENTAL SEALANTS

Two studies evaluated the cost-effectiveness of dental sealants.[4, 12] One was a community-based study, set in Chile. It was classified as having potentially serious limitations. The second was set in a low-income area in Michigan, USA, with water fluoridation. This study was classified as having very serious limitations. The characteristics are set out in Table 4.8.

Table 4.8: Characteristics of study of dental sealants

Study	Design	Country	Population
Marino et al (2012) [4] [+]	CEA	Chile	Community Children, aged 6
Weintraub et al (1993)[12] [-]	CEA	USA	Community health centre Children, aged 7

Summaries of the studies are provided below.

Marino (2012)

Marino et al (2012)[4] [+] performed a cost-effectiveness analysis of 7 dental caries prevention programmes in a simulated population of 86,000 school-aged children in Chile. See Section 4.2.1 for study details and applicability.

The relevant intervention was DS for 6-year old children for a period of 6 years. Treatment effects were derived from published studies, mostly conducted in Chile. Costs were 2009 market costs in Chile converted to US dollars.

The incremental discounted costs per averted DMFT were $11.56. The DS programme was sensitive to changes in effectiveness and discount rate. The cost per DMFT averted ranged from $26.11 to a saving per DMFT of $4.01.

The intervention could be delivered by a similar approach in the current English context. The generalisability of the results to England is unlikely as costs were priced using 2009 market costs in Chile and there are differences in access to dentists, treatment pathways and epidemiology between England and Chile.

Weintraub (1993)

Weintraub et al[12] (1993) [-] undertook a retrospective patient analysis to evaluate the cost-effectiveness of dental sealants. Dental care was provided at a health clinic and dentists used their judgment to determine sealant placement or alternative treatment. The services were provided to 278 children with a mean age of 7 years, all of who had at least 3 years between their first and last dental visit.

The analysis compared the probability of survival of a healthy tooth (restoration–free) and costs for children who did not receive sealants, received any sealant or received sealants on all first molars. Costs included the cost of sealants and restorative treatments.

The results showed that adopting a strategy of identifying children with prior restorations and sealing the remaining molars was cost saving within 4-6 years. For other strategies cost-effectiveness ratios improved over time but were not cost saving. The 11-year discounted incremental cost-effectiveness ratio (ICER) for a sealant compared to no sealant was $81.96 per additional healthy tooth; applying sealants to the first four molars reduced the ICER to

$4.06 per additional healthy tooth. This study was limited by age, setting and the risk of bias regarding which patients received sealants. The two groups in the study were unmatched.

Evidence Statement 8: Cost-effectiveness of dental sealant programmes

Evidence from 2 CEAs[4, 12] found that a dental sealant (DS) programme, delivered in a community setting, reduced caries relative to a control group. Studies were set in Chile[4] and the USA[12].

The Chilean study[4] (+) was conducted on a simulated population of 86,000 6-year old children, in a community setting. Based on a 50% effectiveness rate for caries reduction, the cost per child, per averted DMFT, over 6 years, was $11.56 [£8.47 at 2013 prices], representing a cost to society, compared with a non-intervention group.

The 1993 USA study[12] was judged to have very serious limitations (-), despite being one of the few lifetime studies identified in this review. This study was conducted on a cohort of 278, 7-year old children, in a low-income area of the USA, with fluoridated water supply. Applying sealants to the first four molars resulted in an ICER of $4.06 [£4.37 at 2013 prices] per additional restoration-free tooth over a mean of 5.8 years, compared to a standard care control group, which did not receive dental sealants. Cost savings over 4 to 6 years were achieved with a strategy of identifying children with prior restorations and sealing remaining molars.

The results from these studies were judged to be partially applicable to England. Neither was set in England.

There is inconsistent evidence that a dental sealant programme represents a cost to society[8] and evidence from a methodologically poor study[12] that in some circumstances sealants can be cost saving. Overall, given the paucity of studies, their poor quality and poor applicability to England, no conclusions can be made on the cost-effectiveness of dental sealants applied in the community in England.

[4] Marino et al (2012) [+]
[12] Weintraub et al (1993) [-]

4.4 DENTAL SEALANTS & FLUORIDATED MOUTH-RINSE

Four studies evaluated the cost-effectiveness of a dental sealant and FMR combination programme.[13-16]

All 4 studies were in a school setting (high risk, n=2[13, 14]). None of the studies were conducted in England. The studies were all classified as having potentially serious limitations (+).The characteristics are set out in Table 4.9.

Table 4.9: Characteristics of studies of dental sealants plus FMR

Study	Design	Country	Population
Crowley et al. (1996)[13] [+]	CEA	Australia	School, high risk area Year 7 students, aged 12 years
Crowley et al. (2000)[15] [+]	CBA	Australia	School Year 7 students, aged 12 years
Sakuma et al. (2010)[16] [+]	CBA	Japan	School Children, aged between 8 and 11 years
Zabos et al. (2002)[14] [+]	CEA	USA	School, high risk area Children, grades 1 and 6

A summary of the individual studies is provided below.

Crowley (1996)

Crowley et al. (1996)[13] [+] performed a cost-effectiveness analysis of a 3-year school-based DS and FMR programme in Year 7 students from 5 low SES schools in two non-fluoridated regions of Australia. This study is partially applicable to England.

The intervention of DS and weekly FMR plus routine dental care was compared to routine dental care in a field study (n=522). Programme costs were applied retrospectively and were based on consultation with the Victoria School Dental Services. Dental treatment costs were based on 1994 average dental fees from private practice dentists and were also collected retrospectively. Costs and outcomes were discounted to present value using a 5% annual discount rate.

The mean DMFS increment at 3 years was 0.93 in the intervention group and 2.35 in the control group. This represented a gain of 1.42 DFMS ($p < 0.001$).

The net cost of combined programme and treatment costs resulted in an overall net cost of $3,400 ($13.60 per child). The ICER was $11.80 per DMFS averted over the three-year period. The cost-effectiveness ratio ranged from an overall saving of $7.00 to a cost of $35.60 per DMFS averted, based on varying frequency and cost of dental examinations.

The study was conducted in Australia between 1989 to 1991, which limits its generalisability to the current English context. The limitations of this small-scale study include the assumption that the intervention group received a dental examination once every 3 years and control group once every 2 years. The ICERs were highly sensitive to changes in this assumption and this may understate the intervention costs compared to assuming the same dental examination rates in both groups.

Crowley (2000)

Crowley et al (2000)[13] [+] conducted a cost-benefit analysis which extrapolated the results of the 3 year school-based dental sealant and FMR[13] intervention to all 32 school districts and to a 10 year period.

The model assumed 3,500 students received the intervention with dental examinations conducted at same rate in both groups with a 75% participation rate. Mean baseline DMFS and disease increment were based on the mean values in the 3-year study[13] and the model assumed that the mean effectiveness rate declined at a constant rate from years 4 to 10, varying between 0 and 60%.

The costs of the programme were $33.00 per child, per year, the same as small-scale study.

The incremental benefits-to-cost ratios improved with each successive year of the programme. The benefit- to-cost ratio was 1.0 or above for all scenarios at year 10.

Sakuma (2010)

Sakuma et al. (2010)[16] [+] conducted a cost-benefit analysis of a school-based programme combining FMR and targeted sealant (TS) in primary school children in Japan in 1999. This study is partially applicable to England. Japan has a non-fluoridated water supply.

The programme provided TS and FMR to 8 and 11-year old children attending 2 nursery/primary schools in 1999 in Japan. Children were assessed annually in nursery school (for 2 years) and twice a year in primary school (for 5 years). Sealant application was performed by a school-based dentist. Children used a daily mouth-rinse with 0.05% sodium fluoride (NaF) in nursery school and 0.2% NaF solution weekly in primary school. The control group received usual dental treatment, including sealant placement.

Caries prevalence (decayed and filled surfaces) was obtained from a primary research study. The cost of sealant placement and treatment fees were taken from the Japanese dental insurance scheme in 2002.

At the end of the programme the rate of DFT was 96% higher among aged 8 control group children compared to the aged 8 intervention group (1.49 vs. 0.05) ($p<0.001$) and 91% higher in the aged 11 group (3.48 vs.0.31) ($p<0.001$).

The cost per DFT avoided per child per year was 493 yen (aged 8 group) and 202 yen (aged 11 group). The cost benefit ratio (intervention to control group) was 1 to 1.84 (aged 8) and 1: 2.42 (aged 11).

The applicability of the study results to an English setting is limited by differences in health care system resources and cost data in Japan. Access to dentists is also likely to be different, as dentists are not provided through the school system in England.

Zabos (2002)

Zabos et al. (2002)[14] [+] conducted a cost-effectiveness analysis of a school-based programme on the use of dental sealants in first and sixth grade school children (n=60), which is partially applicable to England. Two elementary schools in a low SES area in New York, USA, with poor access to dentists received the intervention. The intervention involved dental sealants, targeting first and second molars with weekly sodium fluoride rinses, oral

hygiene instructions and referrals to family dentists or a local health centre. The comparator group was children from a no treatment school. Children had high caries prevalence in these non-fluoridated areas, mostly untreated because of poor access to dentists.

Treatment effect data were obtained from a comparative cohort study. The mean (SD) increase in caries incidence, per child, at the end of the 5-year programme was 6.8 (7.0) for the control group and 2.2 (6.0) for the intervention group (p = 0.003). The programme costs included personnel, equipment and supplies. Dental treatment costs were based on private practice. Costs were valued in 1992 US dollars and discounted at 3%.

The discounted costs of the programme and dental expenses were $380 less for the sealant group ($2,100 (control) and $1,720 (sealant)). There were 105 healthy teeth more in the sealant group (control: 3,460; sealant: 3,565) compared to the control group. The sealant programme was thus cost-effective compared to ordinary practice.

The cost of administering sealants used in this study ($9.20) was less than private practice ($30.00). If the cost was increased to private practice rates, it was no longer cost saving.

The results are limited by the cost-effectiveness analysis being based on a small sample size with high dropout rate. Other limitations included a lack of transparency about the programme sources used and the approach to estimating treatment-related savings. Dental access and costs are likely to be very different to NHS/PSS in England. The study was conducted in the USA in 1987, which limits the generalisability of the study to the current English context.

Evidence Statement 9: Cost-effectiveness of dental sealant and fluoridated mouth-rinse programmes
Evidence from 2 CEAs[13, 14] and 2 CBAs[15, 16] (3 studies) found that a dental sealant plus FMR programme, delivered in a school setting, reduced caries relative to a control. Studies were set in Australia, Japan and the USA. The Australian papers[13, 15] (+), were for the same study with the same lead author, with one paper presenting results at 3 years[13] and the other at 10 years.[15] The original clinical trial was conducted on a cohort of Year 7 students from schools in Australia. The first economic evaluation[13], based on 522, 12-year old students from 5 low socioeconomic status (SES) districts, reported a net incremental cost for the dental sealant and FMR programme of $A11.80 [£11.10 at 2013 prices] per averted DMFS over 3 years, compared to routine dental care. The incremental cost-effectiveness ratio became more favourable with time, with a net cost of $A99.80 [£93.89 at 2013 prices per DMFS averted in year 1, the year of sealant application, falling to a net cost of $A8.80 [£8.28 at 2013 prices] per DMFS averted in year 2, and a net savings of $A12.60 [£11.85 at 2013 prices] per DMFS prevented in year 3. The authors anticipated savings would continue beyond year 3. The second economic evaluation[15] extrapolated the results of the 3-year study to a wider geographical area (n=3,500), adopted a 10-year time frame and provided a cost-benefit analysis. Estimated net savings ranged from $7,000 to $1.73 m, [£6,586 to £1.63 m at

2013 prices) with benefit to cost ratios of 1.0 to 1.7 respectively. Sensitivity analyses showed that under all scenarios the programme was cost saving over a 10-year period.

The Japanese study[16] (+) was conducted on 8 and 11 year old children in a school-based setting (n=221). It compared FMR and targeted fissure sealant to a control group who received standard dental treatment, including sealant placement. The incremental cost per child avoiding decayed and filled teeth (DFT) per year was 493 yen [£4.34 in 2013 prices] in the 8-year old group and 202 yen [£1.78 in 2013 prices] in the 11-year old group. Comparing programme and treatment costs and benefits (based on reduced treatment costs) resulted in cost benefit ratios of 1 to 1.84 for the group of eight year olds and 1 to 2.42 for the group aged 11, over a 7-year period.

The USA study[14](+) was conducted on 1st and 6th graders (n=60) in a high caries prevalence area. The discounted costs for the sealant group (programme and dental expenses) was $1,720 [£1,897.54 at 2013 prices] compared to $2,100 [£2,316.77 at 2013 prices] for the control group, giving savings of $380, over 5 years, in favour of the sealant group with FMR (£419 at 2013 process). The number of teeth not missing, not decayed and not filled was 3,565 for the sealant group and 3,460 for the control group. The sealant programme was thus cost effective compared to ordinary practice.

The results from these studies were judged partially applicable to England. None were set in England.

There is moderate evidence from 4 studies of over 800 children[iii] that using dental sealants plus FMR, delivered in a school setting, results in financial savings from avoided caries treatment, which exceed programme costs, over the long run. Cost-effectiveness increases over time as benefits associated with reduced treatment costs from fewer caries accrue; the majority of costs are incurred in the first year.

Despite concerns about methodological weaknesses, the quantity, quality and consistency of the evidence suggest dental sealant and FMR programmes merit further consideration, particularly whether the intervention could be adopted in England.

[13] Crowley et al. (1996) [+]
[15] Crowley et al. (2000) [+]
[16] Sakuma et al. (2010) [+]
[14] Zabos et al. (2002) [+]

4.5 INTENSIFIED CHECK-UPS, SCREENING AND TREATMENT

Two studies were identified that evaluated an intensified check-up and screening programme.[8, 17]

One study was set in a community[8] and the other at a place of employment[17]. Neither of the studies was conducted in England. One study was classified as having potentially serious

[iii] Excluding the 3,500 from the Crowley 2000 which was an extrapolation of the smaller study.

limitations (+)[17] and the other as having very serious limitations (-)[8]. The characteristics are set out in Table 4.10.

Table 4.10: Characteristics of studies assessing intensified check-ups, screening and treatment programmes

Study	Design	Country	Population
Ichihashi et al. (2007)[17] [+]	CBA	Japan	Employer Employees of a household product company
Hirsch et al. (2012)[8] [-]	CBA	USA	Community Pre-school children, aged under 72 months

A summary of the individual studies is provided below.

Ichihashi (2007)

Ichihashi et al. (2007)[17] [+] conducted a cost-benefit analysis to examine an oral health programme provided as an occupational health service for male employees of a household plant in Tokyo, Japan. This study was partially applicable to England. Female employees, retired employees, employees who were admitted to hospital and those with high medical treatment costs were excluded from the study. The water fluoridation status was not reported. However, most of Japan did not have fluoride applied as a public health measure. The programme consisted of check-ups by dentists and oral health instruction, in addition to calculus scaling by dental hygienists. It was offered at the workplace between 1992 and 1997 inclusive. Users were categorised by the number of visits they attended: light frequency users (once per seven years; n=103); medium frequency users (2 to 4 visits per 7 years; n=160); heavy frequency users (5 and 6 visits per 7 years; n=59). The no-visit group (n=35) was the control group.

Treatment data were derived from a cohort study. The benefits were determined by the difference in accumulated dental expenses for the 7 years. Direct and indirect costs were included in total programme costs. Costs were discounted at 3% annually.

The net benefit (benefits minus costs) was $-104.18, $38.75 and $-42.61 for the light, medium and heavy programmes respectively. The medium frequency programme was net cost saving for employers.

The cost of the programme reflects labour costs for dental staff in Japan 20 years ago. Dental expenses were from a nationally agreed set of treatment fees from a similar period. Both the costs and expenses have little relevance to UK NHS/PSS costs.

Hirsch (2012)

Hirsch et al. (2012)[8] [-] performed a cost-benefit analysis of 6 community based early childhood caries prevention interventions in pre-school children aged under 72 months living in Colorado, USA. This study was partially applicable to England. Colorado has a mostly fluoridated water supply. See Section '4.2.1 for study details and applicability.

The intervention was secondary prevention through intensified screening and treatment of caries activity to reduce progression to cavities in children aged over 6 months.

Intensified treatment assumed white-spot lesions were identified and treated before they become cavities. A low intensity treatment programme assumed the fraction of untreated caries that was treated per month was equal to the model's rates for treating cavities (unspecified), and the high treatment intensity programme assumed a more aggressive programme of screening and treatment.

Hirsch also examined an intensified programme of follow-up care for children who had prior restorative care to limit the recurrence of caries by 50% and 75%.

The 10-year net cost (cost of baseline restorative care minus care post intervention minus cost of intervention) was $2 m and $9 m for the low and high-intensified screening and treatment programmes, respectively. The prevention of recurrence by 50% and 75% through an intensified programme of follow up care resulted in 10-year net savings of $22 m and $39 m, respectively. The 10-year programme costs were assumed to be 0%.

The intervention is applicable to the current English context. However, the study was judged to have serious limitations due to weaknesses related to the quality of the efficacy and cost data used, which included proxies, estimates, expert's opinion, and extrapolations which were used when data were not available. Insufficient information on efficacy and costs meant that a judgement on the appropriateness of the findings for England could not be reached. The study was conducted in the USA, which may limit the generalisability of the study to the English context.

Evidence Statement 10: Cost-effectiveness of intensified check-up, screening and treatment programmes
Evidence from 2 CBAs[8, 17] found that an intensified check-up, screening and treatment programme, delivered in a community and work place setting, reduced caries relative to a control group. Studies were set in Japan and the USA. The Japanese study[17] in 1992 (+) consisted of oral-health checkups and calculus scaling in the work place, offered once a year, over 7 years (n= 357). Groups were classified by frequency of visits during the 7-year study. The programme delivered at medium frequency (2- 4 visits over 7 years) saved the employer $38.75 [£42.75 in 2013 prices] per person over the 7 years from reduced treatment costs. The light and heavy frequency groups incurred costs of $104.18 [-£114.93 at 2013 prices] and $42.62 [£47.02 in 2013 prices] respectively for the employer.

The USA hypothetical study[8] was set in a community (n=431,070). The study found that the net cost of a low intensified screening and treatment regime was $2 m [£1.47 m in 2013 prices] and $9 m [£6.60 m in 2013 prices] for high intensity treatment, per 10 years, for a decrease of 4 to 5.4% in the prevalence of cavities.

The net savings associated with an intensified follow-up regime to reduce recurrence of caries was $22 m [£16.12 m in 2013 prices] for a 50% reduction of recurrence and $39 m [£28.58 m in 2013 prices] for a 75% reduction in recurrence over 10 years. There was no change in the prevalence of primary cavities and the programme was assumed to have no associated costs.

Neither study generalises to the current English setting because of aspects such as the prevalence of caries, cost structures, dental treatment pathways and the extent of fluoridation (nil in the Japanese study and about 75% in Colorado). Moreover, the private insurance system in Japan differs materially from that

There is inconsistent evidence from the 2 CBAs that the use of intensified check-ups, screening and treatment delivered in a workplace or community setting, is cost effective compared to standard of care. Neither provides useful evidence to inform decisions on the cost-effectiveness of intensified check-up, screening and treatment programmes in England.

[17] Ichihashi et al. (2007) [+]
[8] Hirsch et al. (2012) [-]

4.6 OTHER INTERVENTIONS

Hirsch (2012)

Hirsch et al. (2012)[8] [-] performed a cost-benefit analysis of 6 community-based early childhood caries prevention interventions in pre-school children aged under 72 months, living in Colorado, USA. Three of the programmes have been discussed (varnish, water fluoridation and intensify screening) earlier in this review. The remaining interventions were aimed at reducing the transmission of bacteria from mother to children, evaluating the use of xylitol interventions (xylitol is a naturally occurring sugar substitute) in children and evaluating the impact of motivational interviewing for families.

Transmission prevention interventions among mothers were assumed to reduce caries by 73% at a cost of $100 per mother.

Xylitol use was assessed for children over 2 years old at high and low risk of caries and for high and low efficacy rates as assumed by the authors and for all children aged over 6 months. The assumed cost of xylitol interventions was $100 per child.

Motivational interviewing was defined as a brief interactive approach to counselling and educating parents that focused on skills that move patients to action, and was assessed in all families and high-risk families.
The 10-year net cost was $23 m for xylitol given to all mothers to prevent transmission of bacteria and a $3 m savings when xylitol was given to mothers of high-risk children only, with an accompanying 7.4% and 3.2% improvement in caries incidence, respectively.

Xylitol interventions were cost saving for the high-risk and high efficacy group ($3 m) and for all children aged over 6 months for the high efficacy group ($24 m). The net cost ranged from $10 m to $57 m for the other groups.

The motivational interviewing programme across Colorado resulted in a 10-year net savings of $29 m when used with high-risk families and $11 m when adopted for all families.

Evidence Statement 11: Cost-effectiveness of other intervention programmes

Evidence from 1 CBA set in the USA[8] assessed interventions aimed at reducing transmission of bacteria from mother to children; use of xylitol, a naturally occurring sugar substitute, interventions in children; and motivational interviewing for families. All interventions were delivered in a community setting and assumed to reduce caries relative to a control group. Evidence came from published literature.

ES 11.1: The study found that the 10-year net cost associated with interventions aimed at reducing transmission of bacteria from mother to child was $23 m [£16.8 m at 2013 prices] when provided to all mothers in Colorado and a saving of $3 m [£2.2 m at 2013 prices] when provided to mothers of high-risk children only, in Colorado. The associated reductions in caries prevalence were 7.4% and 3.2%, respectively.

ES 11.2: Ten-year net savings of $3 m [£2.2 m at 2013 prices] were associated with the xylitol intervention for the high-risk and high efficacy group; and $24 m [£17.6 m at 2013 prices] for the group of all children over 6 months in the high efficacy group, with an associated reduction in caries of 2.2% and 12.6%, respectively. The net cost ranged from $10 m to $57 m [£7.3 m and £41.7 m at 2013 prices] for the other age and efficacy groups. Associated reductions in prevalence ranging from 1.3 to 4.9%.

ES 11.3: The motivational interviewing programme, resulted in a 10-year net savings of $29 m [£21.2 m at 2013 prices] when used with high-risk families and $11 m [£8.0 m at 2013 prices], when adopted for all families. The associated reductions in caries were 5.3% and 11.7%, respectively.

This study was judged as having very serious limitations and limited applicability due to differences in epidemiology of caries, use of fluoride products in the community and dental treatment pathways and associated costs.

The absence of corroboration from other studies of effect size and direction, concerns about methodological quality and limited applicability suggest the findings from this study alone are insufficient to use as robust evidence to inform decisions on these interventions.

[8] Hirsch et al. (2012) [-]

4.7 INTERVENTIONS AIMED AT DISADVANTAGED POPULATIONS AT HIGH RISK OF POOR ORAL HEALTH

Six studies assessed interventions specifically in high-risk populations, 2 in a school setting[13, 14] and 4 in a community setting.[2, 6, 7, 12] One study was judged to have minor limitations[2], one to have potentially serious limitations[6] and 2 to have very serious limitations.[7, 12] Interventions included providing fluoridated toothpaste[2, 6], fluoride varnish[7], dental sealant alone[12] dental sealant and fluoride mouth-rinse.[13, 14] Based on the limited number of studies on high-risk populations, the considerable heterogeneity across studies varying by intervention and setting, and the low quality of 2 studies [-] and their limited applicability, there was insufficient evidence to inform conclusions on cost effective interventions among populations at high-risk of poor oral health.

Section 5: Discussion and Summary

The primary research questions for this review are:

Question 1: Which community-based programmes and interventions to promote, improve, and maintain the oral health of a local community are cost effective?

Question 2: Which methods and settings to deliver community-based programmes for disadvantaged populations at high risk of poor oral health are cost effective?

The quantity, quality and consistency of the evidence found to answer each question are discussed below.

5.1 RESEARCH QUESTION 1

Sixteen studies were identified that provided evidence for this question. Interventions involved increased exposure to fluoride, the use of dental sealants with and without FMR, an intensified check-up, screening and treatment programme, programmes to reduce the transmission of bacteria from mother to child, the use of xylitol inventions in children and motivational interviewing for families. All studies found that the intervention was more effective than a control at reducing incidence of caries. There were no published studies demonstrating a lack of effect on incidence of caries, suggesting possible publication bias.

All studies had methodological weaknesses and limited applicability to the current English context. Two studies were judged to have minor methodological limitations (++), 11 had potentially serious limitations (+) and 3 had very serious limitations (-). Evidence from the 3 studies with very serious limitations was discounted in informing judgments of cost-effectiveness.

The applicability of the studies to England was assessed as partial in all studies. The main reasons for the limited applicability were that the majority of studies were carried out in countries other than England, the studies were too old, the setting was not applicable to the English system, treatment pathways were different to England and the cost sources were not English sources. All studies except 1 were conducted outside England. Differences in programme costs, dental treatment pathways and expenses, use of fluoride products and water fluoridation and the funding and organisation of dental services between the study countries and England were evident.

Half of the studies were set in a school where dental services were provided by a dentist or dental hygienist, limiting their generalisability to the current English context, where there are no school-based dental services. Studies of milk fluoridation were set in communities where milk was provided free to children, unlike in England, which limits the applicability of those studies. Such programmes could be implemented in the English school system but would entail large organisational change and funding, so their implementation is judged to be

unlikely.

In addition, many of the studies, including the English clinical study, were conducted in the late 1990s to early 2000s and were therefore unlikely to be generalisable to the current English context. Over time, overall dental health in England has improved.[19] There has been an increased use of fluoride in toothpaste and related products, as well as a stronger focus on dentists providing preventive care, including the use of varnish and sealants.[19] Thus the effect size measured in earlier studies is unlikely to apply to today's cohorts.

None of the selected studies expressed outcomes in terms of QALYs. The included studies used cost-benefit analysis and cost-effectiveness analysis. Cost-benefit analyses which value benefits as avoided costs to treat caries and compare the savings to the programme costs provide results which directly inform whether the intervention or comparator provides the better use of resources. This is also true in some cost-effectiveness analyses where the intervention dominates the comparator, being more effective and cheaper. However, where an intervention was more effective but more expensive it is not possible to determine if it is value for money. There is no generally accepted willingness to pay threshold for measures such as caries avoided.

There was no evidence linking poor oral health to periodontal disease or related diseases such as oral cancer.

All of the studies except one were conducted on children or adolescents limiting the generalisability of the results to adults.

Some of the studies had relatively short follow-up times, the majority being between 2 and 7 years. Benefits accrue over time but programme costs remain stable; therefore the time horizon for studies may be insufficient to quantify all benefits. For example, benefits to secondary teeth from improved quality of primary teeth were never quantified and few studies considered avoided recurrent tooth decay associated with preventing the first occurrence. No study measured the improved quality of life to the child of avoided dental treatment, including surgery in some cases, and few measured the benefits to families.

Dentists also find treating children more difficult than adults so applying a unit cost per filling may understate the cost of some treatments. Hospitalisation is more common in children, some of whom require to be managed using a general anesthetic.

Studies of the addition of fluoride to toothpaste, varnish, salt, water, gel and mouth-rinse, in a school or community-based setting provided no evidence (toothpaste), or insufficient evidence (fluoride gel, fluoridated mouth-rinse) to inform on the economic value of these programmes. Weak evidence was found supporting fluoridated varnish, fluoridated salt and fluoridated water. Evidence on the benefits of adding fluoride to school milk through a government funded school milk programme suggested that the intervention was cost effective; however, the applicability of this programme is very low.

Overall, there is an absence of robust evidence of the cost-effectiveness of programmes to increase exposure to fluoride in England.

There was inconsistent evidence that the use of dental sealants alone is cost saving. However, studies of dental sealants combined with FMR provided some evidence that over a 10-year time horizon such programmes could be cost effective when delivered in a school setting in England. The cost-effectiveness of this programme increases over time as benefits from reduced treatment due to fewer caries accrue but the majority of costs are incurred in the first year.

There was insufficient evidence to draw conclusions on the economic impact of the intensified check-up, screening and treatment programme, programmes aimed at reducing transmission of bacteria from mother to child, use of xylitol inventions in children or motivational interviewing for families.

5.2 RESEARCH QUESTION 2

Six studies assessed interventions among high-risk populations; however there was considerable heterogeneity across the studies which varied by intervention and setting. The quality and applicability of these studies were limited. There was insufficient evidence to inform conclusions on which might be cost effective interventions among populations at high-risk of poor oral health.

5.3 STRENGTHS AND WEAKNESSES OF THE REVIEW

This review was carried out in accordance with the NICE Methods Manual[1], which fosters a robust systematic review approach. The reporting of this review's methods, results and conclusions conforms to NICE's requirements for transparency and also meets the PRISMA checklist for reporting systematic reviews.

Bias has been minimised by:

- Developing and agreeing with NICE a systematic review protocol with clear questions;
- Adopting detailed eligibility criteria and checking uncertainties with NICE staff;
- Adopting wide geographic and temporal filters which do not limit scope, undertaking an extensive literature search;
- Deploying 2 independent reviewers to select studies, using a 2-stage selection process and resolving differences by discussion;
- Undertaking quality assessment and applicability assessment using independent checklists; and
- Producing detailed evidence tables.

Studies rejected from an assessment of the full text of papers have been listed with reasons for exclusion, to enhance transparency.

The poor quality and applicability of the 16 studies identified has already been discussed. There is a high probability of publication bias indicated by the positive efficacy data reported in all studies. One tool often suggested to mitigate this bias is by wider searching of grey

literature. Hence further searching of grey literature may have identified studies reporting negative results. Publication bias is therefore a limitation.

Efforts were made to minimize source selection bias by searching a range of databases, scanning reference lists of reviews and included studies, citation searches and named author searches.

The population and intervention aspects of the search strategies for the cost-effectiveness evidence review were required to reflect the strategy developed by Bazian for the clinical effectiveness component. There are some potential limitations to the Bazian strategy in the range of textword terms and subject headings used – a wider choice of terms could potentially have enriched the strategy and increased search sensitivity. As the authors were not involved in the development of this strategy, it is not possible to know the extent to which individual terms were explored and included or excluded for specific reasons. As with any search strategy, the developers will have sought to balance sensitivity and specificity as appropriate. The Bazian strategy was extensively tested in development (for example by comparing material captured by alternative draft strategies), and the final strategy was quality assured by NICE.

Costs were reported in different currencies and time periods. The methodology adopted to convert these to pounds sterling at 2013 prices uses currency rates and the retail price index. However, the resulting cost may not be a useful measure of the underlying resources used in either country.

None adopted an appropriate perspective for public health evidence.

No study identified a conflict of interest. However, this aspect was not reported in all studies and hence may exist but is undetectable.

5.4 GAPS IN THE EVIDENCE

There is no robust evidence of the economic value of community-based programmes and interventions to promote, improve, and maintain the oral health of children or adults in England.

Future economic evaluations should be informed by the evidence of clinical effectiveness; such studies are likely to be available in a greater quantity, be of better quality, conducted more recently, set in England and include more population sub-groups. Economic research should prioritise the most clinically effective interventions.

Evidence is also required of the impact of poor oral health on related diseases including stroke and other vascular diseases, arthritis and those associated with cognitive impairment.

The literature on the cost-effectiveness of oral health programmes was of insufficient quantity, quality and applicability to draw conclusions. Therefore we recommend *de novo* economic modelling to address remaining uncertainties.

5.5 CONCLUSIONS

Based on the 16 studies included in this review, there was insufficient evidence to answer the research questions. All of the studies had methodological weaknesses and limited applicability to the current English context. Two had minor limitations (++), 11 had potentially serious limitations (+) and 3 had very serious limitations (-). The evidence was weak, inconsistent or not available for most interventions, with the exception of the dental sealant plus FMR programme, which was considered cost effective. Except for 1 study conducted in England, all of the studies were conducted in other countries, and many were old thus limiting the generalisability to the current English context. Half of the studies were conducted in a school setting, which is not applicable to England as dental services are not provided at schools in the current English system.

Based on the very limited evidence identified by this systematic review, a *de novo* economic model is recommended to answer the research questions.

References

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3. Arrow P. Cost minimisation analysis of two occlusal caries preventive programmes. *Community Dental Health.* 2000;17:85-91.
4. Marino R, Fajardo J, Morgan M. Cost-effectiveness models for dental caries prevention programmes among Chilean schoolchildren. *Community Dental Health.* 2012;29:302-308
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APPENDIX A

Search Strategies

A.1: Source: MEDLINE In-Process & Other Non-Indexed Citations and MEDLINE

Interface / URL: OvidSP
Database coverage dates: 1946 to present
Search date: 03/07/13
Retrieved records: 1192

Search strategy:

1 (oral care or oral health or oral hygiene or dental care or dental health or dental hygiene or school dentist$ or community dentist$ or public health dentist$).ti,ab. 34659
2 (promot$ or improv$ or advis$ or advic$ or program$ or campaign$ or scheme$ or initiative$ or prevent$ strateg$ or prevent$ measure$).ti,ab. 2490625
3 ((oral care or oral health or oral hygiene or dental care or dental health or dental hygiene or school dentist$ or community dentist$ or public health dentist$) adj2 (promot$ or improv$ or advis$ or advic$ or program$ or campaign$ or scheme$ or initiative$ or prevent$ strateg$ or prevent$ measure$)).ti,ab. 4076
4 (oral disease$ or oral neoplasm$ or oral cancer$ or dental disease$ or mouth disease$ or dental decay or mouth neoplasm$ or mouth cancer$ or gum disease$ or DMF or caries or ((tooth or teeth) adj2 (decay$ or loss)) or gingivitis or periodontal disease$ or periodontitis or ((dental or oral) adj plaque)).ti,ab. 83735
5 (prevent$ or control$ or reduc$).ti,ab. 4669495
6 ((oral disease$ or oral neoplasm$ or oral cancer$ or dental disease$ or mouth disease$ or dental decay or mouth neoplasm$ or mouth cancer$ or gum disease$ or DMF or caries or ((tooth or teeth) adj2 (decay$ or loss)) or gingivitis or periodontal disease$ or periodontitis or ((dental or oral) adj plaque)) adj2 (prevent$ or control$ or reduc$)).ti,ab. 6735
7 (public health or school$ or communit$ or food bank$ or shelter$ or neighbourhood$ or neighborhood$ or region$ or area$ or population$).ti,ab. or Child Day Care Centers/ or Schools, Nursery/ or community health centers/ or substance abuse treatment centers/ or community mental health centers/ or child guidance clinics/ or maternal-child health centers/ or Sheltered Workshops/ 3184517
8 6 and 7 2286
9 (access$ or inaccess$ or obtain$ or unobtain$ or utili?ation or (service$ adj4 (uptake or take?up)) or attend$ or non-attend$).ti,ab. 1784605
10 ((oral care or oral health or oral hygiene or dental care or dental health or dental hygiene or school dentist$ or community dentist$ or public health dentist$) adj2 (access$ or inaccess$ or obtain$ or unobtain$ or utili?ation or (service$ adj4 (uptake or take?up)) or attend$ or non-attend$)).ti,ab. 1291
11 3 or 8 or 10 7116
12 toothbrushing/ or toothpastes/ or fluorides, topical/ or Mouthwashes/ 14689
13 "Pit and Fissure Sealants"/tu [Therapeutic Use] 1192
14 ((fluorid$ adj2 (varnish$ or topical or milk)) or toothpast$ or toothbrush$ or fissure sealant$ or mouthwash$ or flossing or dental floss).ti,ab. 10270
15 12 or 13 or 14 19449
16 15 and (2 or 7) 6171
17 (diet$ or food$ or nutrition$ or smok$ or tobacco$ or alcohol$).ti,ab. 1076147
18 17 and 1 and 2 1596

19 Oral Health/ or exp Dental Care/ or exp Mouth Diseases/pc or Periodontal diseases/pc or Oral Hygiene/ or school dentistry/ or public health dentistry/ or community dentistry/ 52636
20 Health Promotion/ or Health Education, Dental/ 56023
21 preventive health services/ or Primary Prevention/ or Secondary Prevention/ or Cariostatic Agents/tu 27032
22 exp health services accessibility/ or healthcare disparities/ or vulnerable populations/ 90205
23 Food habits/ or food preferences/ or Diet/ or diet therapy/ or exp Smoking Cessation/ or exp Alcohol Drinking/ 201739
24 19 and 20 3879
25 19 and 21 784
26 19 and 22 2628
27 19 and 23 1670
28 24 or 25 or 26 or 27 7989
29 (Brushathon or smile month or smile4life or smile 4 life or smile for life or brushing for life or designed to smile or national oral health plan or child-smile or child smile or childsmile or smile with a prophet or winning smiles or (smokefree adj2 smiling) or smileathon or creative smiles or city smiles or smile sack or bright smiles).ti,ab. 36
30 11 or 16 or 18 or 28 or 29 18250
31 case report.tw. or letter/ or historical article/ or comment/ or editorial/ or (animal/ not (animal/ and human/))5501269
32 30 not 31 17055
33 limit 32 to english language 14664
34 limit 33 to yr="1993 -Current" 10821
35 economics/ 26735
36 exp "costs and cost analysis"/ 176208
37 economics, dental/ 1862
38 exp "economics, hospital"/ 18920
39 economics, medical/ 8520
40 economics, nursing/ 3872
41 economics, pharmaceutical/ 2529
42 (economic$ or cost or costs or costly or costing or price or prices or pricing or pharmacoeconomic$).ti,ab. 442702
43 (expenditure$ not energy).ti,ab. 17739
44 value for money.ti,ab. 917
45 budget$.ti,ab. 18406
46 or/35-45 566052
47 ((energy or oxygen) adj cost).ti,ab. 2787
48 (metabolic adj cost).ti,ab. 787
49 ((energy or oxygen) adj expenditure).ti,ab. 16431
50 or/47-49 19307
51 46 not 50 561678
52 34 and 51 1192

A.2: Source: Embase

Interface / URL: OvidSP
Database coverage dates: 1974 to 2013 July 03
Search date: 04/07/13
Retrieved records: 2174

Search strategy:

1 (oral care or oral health or oral hygiene or dental care or dental health or dental hygiene or school dentist$ or community dentist$ or public health dentist$).ti,ab. 34276
2 (promot$ or improv$ or advis$ or advic$ or program$ or campaign$ or scheme$ or initiative$ or prevent$ strateg$ or prevent$ measure$).ti,ab. 3021294
3 ((oral care or oral health or oral hygiene or dental care or dental health or dental hygiene or school dentist$ or community dentist$ or public health dentist$) adj2 (promot$ or improv$ or advis$ or advic$ or program$ or campaign$ or scheme$ or initiative$ or prevent$ strateg$ or prevent$ measure$)).ti,ab. 4007
4 ((oral disease$ or oral neoplasm$ or oral cancer$ or dental disease$ or mouth disease$ or dental decay or mouth neoplasm$ or mouth cancer$ or gum disease$ or DMF or caries or ((tooth or teeth) adj2 (decay$ or loss)) or gingivitis or periodontal disease$ or periodontitis or ((dental or oral) adj plaque)) adj2 (prevent$ or control$ or reduc$)).ti,ab. 6714
5 (public health or school$ or communit$ or food bank$ or shelter$ or neighbourhood$ or neighborhood$ or region$ or area$ or population$).ti,ab. or day care/ or nursery school/ or health center/ or drug dependence treatment/ or community mental health center/ or sheltered workshop/ 3743488
6 4 and 5 2266
7 ((oral care or oral health or oral hygiene or dental care or dental health or dental hygiene or school dentist$ or community dentist$ or public health dentist$) adj2 (access$ or inaccess$ or obtain$ or unobtain$ or utili?ation or (service$ adj4 (uptake or take?up)) or attend$ or non-attend$)).ti,ab. 1236
8 3 or 6 or 7 6966
9 tooth brushing/ or toothpaste/ or fluoride varnish/ or mouthwash/ 16632
10 fissure sealant/ 2652
11 ((fluorid$ adj2 (varnish$ or topical or milk)) or toothpast$ or toothbrush$ or fissure sealant$ or mouthwash$ or flossing or dental floss).ti,ab. 10259
12 9 or 10 or 11 22190
13 12 and (2 or 5) 6667
14 (diet$ or food$ or nutrition$ or smok$ or tobacco$ or alcohol$).ti,ab. 1323990
15 14 and 1 and 2 1705
16 oral health$.ti,ab. or dental health/ or dental procedure/ or exp mouth disease/pc or mouth hygiene/ or school dentistry/ or (dentistry/ and public health service/) or (public health$ adj3 (dentist$ or dental)).ti,ab. 56763
17 health promotion/ or dental health education/ 69928
18 preventive health service/ or primary prevention/ or secondary prevention/ or anticaries agent/ 58267
19 health care delivery/ or health care organization/ or health care facility/ or financial management/ or health care disparity/ or vulnerable population/ or health care planning/ 415543

20 feeding behavior/ or eating habit/ or food preference/ or diet/ or diet therapy/ or smoking cessation/ or drinking behavior/ or alcohol consumption/ or binge drinking/ 361201
21 16 and 17 3782
22 16 and 18 2789
23 16 and 19 3142
24 16 and 20 2696
25 21 or 22 or 23 or 24 10885
26 (Brushathon or smile month or smile4life or smile 4 life or smile for life or brushing for life or designed to smile or national oral health plan or child-smile or child smile or childsmile or smile with a prophet or winning smiles or (smokefree adj2 smiling) or smileathon or creative smiles or city smiles or smile sack or bright smiles).ti,ab. 35
27 8 or 13 or 15 or 25 or 26 20773
28 case report.tw. or letter.pt. or editorial.pt. or ((animal experiment/ or animal model/ or animal tissue/ or nonhuman/) not exp human/) 5108007
29 27 not 28 19984
30 limit 29 to english language 16945
31 limit 30 to yr="1993 -Current" 12954
32 health-economics/ 32719
33 exp economic-evaluation/ 200064
34 exp health-care-cost/ 192262
35 exp pharmacoeconomics/ 163389
36 32 or 33 or 34 or 35 457168
37 (econom$ or cost or costs or costly or costing or price or prices or pricing or pharmacoeconomic$).ti,ab. 564099
38 (expenditure$ not energy).ti,ab. 22434
39 (value adj2 money).ti,ab. 1243
40 budget$.ti,ab. 22778
41 37 or 38 or 39 or 40 587006
42 36 or 41 850766
43 (metabolic adj cost).ti,ab. 826
44 ((energy or oxygen) adj cost).ti,ab. 3059
45 ((energy or oxygen) adj expenditure).ti,ab. 19264
46 43 or 44 or 45 22361
47 42 not 46 845872
48 31 and 47 2174

A.3: Source: NHS Economic Evaluation Database (NHS EED) - Issue 2 of 4, April 2013

Interface / URL: Cochrane Library/Wiley Interscience (online)
Database coverage dates: Information not found
Search date: 05/07/13
Retrieved records: 490

Search strategy:

#1 oral:ti,ab,kw 67731

#2 (dental or dentist* or mouth* or gum or gums or DMF or caries or tooth* or teeth* or gingiv* or periodont* or fluorid* or fissure* or sealant* or floss*) 35203
#3 ("oral care" or "oral health" or "oral hygiene" or "oral disease" or "oral diseases" or "oral neoplasm" or "oral neoplasms" or "oral cancer" or "oral cancers" or "oral plaque") 3300
#4 (Brushathon or "smile month" or smile4life or "smile 4 life" or "smile for life" or "brushing for life" or "designed to smile" or "national oral health plan" or child-smile or "child smile" or childsmile or "smile with a prophet" or "winning smiles" or "smokefree and smiling" or "smiling and smokefree" or smileathon or "creative smiles" or "city smiles" or "smile sack" or "bright smiles") 1
#5 ("public health" or school* or communit* or "food bank" or "food banks" or shelter* or neighbourhood* or neighborhood* or region* or area* or population*):ti,ab near/3 (access* or inaccess* or obtain* or unobtain* or utilisation or utilization or "service uptake" or "service takeup" or "service take-up" or attend* or non-attend* or nonattend*):ti,ab 889
#6 MeSH descriptor: [Dental Devices, Home Care] explode all trees 300
#7 MeSH descriptor: [Toothpastes] explode all trees 536
#8 MeSH descriptor: [Fluorides, Topical] explode all trees 368
#9 MeSH descriptor: [Mouthwashes] explode all trees 1166
#10 MeSH descriptor: [Pit and Fissure Sealants] explode all trees 268
#11 MeSH descriptor: [Oral Health] explode all trees 152
#12 MeSH descriptor: [Dental Care] explode all trees 458
#13 MeSH descriptor: [Mouth Diseases] explode all trees and with qualifiers: [Prevention & control - PC]1311
#14 MeSH descriptor: [Periodontal Diseases] explode all trees and with qualifiers: [Prevention & control - PC] 795
#15 MeSH descriptor: [Oral Hygiene] explode all trees 1498
#16 MeSH descriptor: [School Dentistry] explode all trees 84
#17 MeSH descriptor: [Public Health Dentistry] explode all trees 2351
#18 MeSH descriptor: [Cariostatic Agents] explode all trees and with qualifiers: [Therapeutic use - TU] 894
#19 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 from 1993 to 2013, in Economic Evaluations 490

A.4: Source: Health Technology Assessment database (HTA) - Issue 2 of 4, April 2013

Interface / URL: Cochrane Library/Wiley Interscience (online)
Database coverage dates: Information not found
Search date: 05/07/13
Retrieved records: 208

Search strategy:

#1 oral:ti,ab,kw 67731
#2 (dental or dentist* or mouth* or gum or gums or DMF or caries or tooth* or teeth* or gingiv* or periodont* or fluorid* or fissure* or sealant* or floss*) 35203
#3 ("oral care" or "oral health" or "oral hygiene" or "oral disease" or "oral diseases" or "oral neoplasm" or "oral neoplasms" or "oral cancer" or "oral cancers" or "oral plaque") 3300

#4 (Brushathon or "smile month" or smile4life or "smile 4 life" or "smile for life" or "brushing for life" or "designed to smile" or "national oral health plan" or child-smile or "child smile" or childsmile or "smile with a prophet" or "winning smiles" or "smokefree and smiling" or "smiling and smokefree" or smileathon or "creative smiles" or "city smiles" or "smile sack" or "bright smiles") 1
#5 ("public health" or school* or communit* or "food bank" or "food banks" or shelter* or neighbourhood* or neighborhood* or region* or area* or population*):ti,ab near/3 (access* or inaccess* or obtain* or unobtain* or utilisation or utilization or "service uptake" or "service takeup" or "service take-up" or attend* or non-attend* or nonattend*):ti,ab 889
#6 MeSH descriptor: [Dental Devices, Home Care] explode all trees 300
#7 MeSH descriptor: [Toothpastes] explode all trees 536
#8 MeSH descriptor: [Fluorides, Topical] explode all trees 368
#9 MeSH descriptor: [Mouthwashes] explode all trees 1166
#10 MeSH descriptor: [Pit and Fissure Sealants] explode all trees 268
#11 MeSH descriptor: [Oral Health] explode all trees 152
#12 MeSH descriptor: [Dental Care] explode all trees 458
#13 MeSH descriptor: [Mouth Diseases] explode all trees and with qualifiers: [Prevention & control - PC]1311
#14 MeSH descriptor: [Periodontal Diseases] explode all trees and with qualifiers: [Prevention & control - PC] 795
#15 MeSH descriptor: [Oral Hygiene] explode all trees 1498
#16 MeSH descriptor: [School Dentistry] explode all trees 84
#17 MeSH descriptor: [Public Health Dentistry] explode all trees 2351
#18 MeSH descriptor: [Cariostatic Agents] explode all trees and with qualifiers: [Therapeutic use - TU] 894
#19 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 from 1993 to 2013, in Technology Assessments 208

A.5: Source: Econlit

Interface / URL: OvidSP
Database coverage dates: 1961 to June 2013
Search date: 08/07/13
Retrieved records: 283

Search strategy:

1 ((dental or oral or dentist$) adj5 (health$ or hygiene or care)).af. 117 Advanced
2 ((dental or oral or dentist$) adj5 (promot$ or improv$ or advis$ or advic$ or program$ or campaign$ or scheme$ or initiative$ or prevent$)).af. 24 Advanced
3 ((dental or oral or dentist$) adj5 (access$ or inaccess$ or availab$ or unavailab$ or obtain$ or unobtain$ or uptake or up-take or takeup or take-up or attend$ or utilisation or utilization)).af. 42 Advanced
4 ((dental or oral or dentist$) adj5 (school or community or public health)).af. 12 Advanced
5 ((mouth$ or oral) and (disease$ or cancer$ or neoplasm$)).af. 93 Advanced

6 (dental disease$ or dental decay or gum disease$ or periodont$ or DMF or caries or plaque or gingiv$).af. 27 Advanced
7 ((tooth$ or teeth$) adj5 (decay$ or loss)).af. 8 Advanced
8 (toothbrush$ or tooth-brush$ or toothpaste$ or tooth-paste$ or fluorid$ or fissure$ or sealant$ or floss$ or mouthwash$ or mouth-wash$ or mouthrinse$ or mouth-rinse$ or cariostatic).af. 95 Advanced
9 (Brushathon or smile month or smile4life or smile 4 life or smile for life or brushing for life or designed to smile or national oral health plan or child-smile or child smile or childsmile or smile with a prophet or winning smiles or (smokefree adj2 smiling) or smileathon or creative smiles or city smiles or smile sack or bright smiles).af. 0 Advanced
10 or/1-9 349 Advanced
11 limit 10 to (yr="1993 -Current" and english) 283

A.6: Source: Cost-effectiveness Analysis (CEA) Registry

Interface / URL: https://research.tufts-nemc.org/cear4
Database coverage dates: Information not found. Has been funded from 1976 to present, and website indicates database contains content published from 1976 to present (https://research.tufts-nemc.org/cear4/AboutUs/WhatistheCEARegistry.aspx)
Search date: 08/07/13
Retrieved records: 28 (40 results returned and saved as Word document – results handchecked – 10 excluded as duplicates, 2 excluded as pre-1993 results; 28 added to EndNote by hand)

Search strategy:

Note: Basic search interface used. ‘Search for articles’ selected. Search terms used in the Full Search Contents box. Each search run and any results downloaded separately.

brushathon = 0 results
brushing = 0 results
caries = 0 results
cariostatic = 0 results
childsmile = 0 results
child-smile = 0 results
dental = 20 results
dentist = 2 results
dentistry = 2 results
dentists = 0 results
dmf = 0 results
fissure = 0 results
fissures = 0 results
floss = 0 results
flossed = 0 results
flosses = 0 results
flossing = 0 results
fluoride = 1 result

fluorides = 0 results
gingivitis = 0 results
gum disease = 0 results
gum diseases = 0 results
mouth = 3 results
mouthrinse = 0 results
mouth-rinse = 0 results
mouthrinses = 0 results
mouth-rinses = 0 results
mouthwash = 0 results
mouth-wash = 0 results
mouthwashes = 0 results
mouth-washes = 0 results
oral cancer = 2 results
oral cancers = 0 results
oral care = 0 results
oral disease = 2 results
oral diseases = 0 results
oral health = 1 result
oral hygiene = 0 results
oral neoplasm = 0 results
oral neoplasms = 0 results
periodontal = 0 results
periodontitis = 0 results
plaque = 5 results
sealant = 0 results
sealants = 0 results
smile = 1 result
smile4life = 0 results
smileathon = 0 results
smiles = 0 results
smiling = 0 results
teeth = 0 results
tooth = 1 result
toothbrush = 0 results
tooth-brush = 0 results
toothbrushes = 0 results
tooth-brushes = 0 results
toothbrushing = 0 results
tooth-brushing = 0 results
toothpaste = 0 results
tooth-paste = 0 results
toothpastes = 0 results
tooth-pastes = 0 results

A.7: Source: RePEc (Research Papers in Economics)

Interface / URL: http://www.economistsonline.org/home
Database coverage dates: Information not found
Search date: 08/07/13
Retrieved records: 301

Search strategy:

Note: Each search run separately. All searches were limited to 'Partner – RePEc'. All results were added to EconomistsOnline folder, and downloaded as one file of 301 results.

1. ("oral care" OR "oral health" OR "oral hygiene" OR dental OR dentist* OR "gum disease*" OR DMF OR caries OR tooth OR teeth OR gingiv* OR periodont* OR plaque OR toothbrush* OR tooth-brush* OR toothpaste* OR tooth-paste* OR fluorid* OR fissure* OR sealant* OR floss* OR mouthwash* OR mouth-wash* OR mouthrinse* OR mouth-rinse* OR cariostatic) AND PYFROM=1993 AND PYTILL=2013 = 148 results

2. (oral OR mouth*) AND (promot* OR improv* OR advis* OR advic* OR program* OR campaign* OR scheme* OR initiative* OR prevent* OR disease* OR neoplasm* OR cancer) AND PYFROM=1993 AND PYTILL=2013 = 169 results

3. (brushathon OR "smile month" OR smile4life OR "smile 4 life" OR "smile for life" OR "brushing for life" OR "designed to smile" OR "child-smile" OR "child smile" OR childsmile OR "smile with a prophet" OR "winning smiles" OR smileathon OR "creative smiles" OR "city smiles" OR "smile sack" OR "bright smiles") AND PYFROM=1993 AND PYTILL=2013 = 0 results

4. smokefree AND smiling AND PYFROM=1993 AND PYTILL=2013 = 0 results

A.8: Source: Health Economic Evaluations Database (HEED)

Interface / URL: Wiley Interscience
Database coverage dates: Information not found
Search date: 10/07/13
Retrieved records: 502

Search strategy:

Note: expert search interface used. Maximum download of 350 results, therefore 2 searches carried out separately.

Search 1:

1. AX= dental or dentist* or mouth* or DMF or caries or tooth* or teeth* or gingiv* or periodont* or fluorid* or fissure* or sealant* or floss* or cariostatic = 488

2. AX=brushathon or 'smile month' or smile4life or 'smile 4 life' or 'smile for life' or 'brushing for life' or 'designed to smile' or 'child-smile' or 'child smile' or childsmile or 'smile with a prophet' or 'winning smiles' or smileathon or 'creative smiles' or 'city smiles' or 'smile sack' or 'bright smiles' = 0

3. AX=smokefree and smiling = 0

4. CS=1 or 2 or 3 = 488

5. JD=1993 or 1994 or 1995 or 1996 or 1997 or 1998 or 1999 or 2000 or 2001 or 2002 or 2003 or 2004 or 2005 or 2006 or 2007 or 2008 or 2009 or 2010 or 2011 or 2012 or 2013 = 41704

6. CS=4 and 5 = 339

Search 2:

1. AX='oral care' or 'oral health' or 'oral hygiene' or 'oral disease' or 'oral diseases' or 'oral neoplasm' or 'oral neoplasms' or 'oral cancer' or 'oral cancers' or 'oral plaque' or 'gum disease' or 'gum diseases' = 57
2. TI=oral = 493
3. TI=care or health* or hygiene or disease* or neoplasm* or cancer* or plaque or promot* or improv* or advis* or advic* or program* or campaign* or scheme* or initiative* or prevent* or access* or inaccess* or availab* or unavailab* or obtain* or unobtain* or uptake or up-take or takeup or take-up or attend* or utilisation or utilization or school* or communit* = 17816
4. CS=2 and 3 = 139
5. CS=1 or 4 = 171
6. JD=1993 or 1994 or 1995 or 1996 or 1997 or 1998 or 1999 or 2000 or 2001 or 2002 or 2003 or 2004 or 2005 or 2006 or 2007 or 2008 or 2009 or 2010 or 2011 or 2012 or 2013 = 41704

7. CS=5 and 6 = 163

APPENDIX B

Citation and Named Author Searches

A.9: Source: Web of Science

Interface / URL: Web of Knowledge
Search date: 12/08/13 – 13/08/13
Retrieved records: 94

Search strategy:

Cited reference search function - searched by title for references citing the following 18 studies:

1. Davies GM, Worthington HV, Ellwood RP, Blinkhorn AS, Taylor GO, Davies RM, et al. An assessment of the cost-effectiveness of a postal toothpaste programme to prevent caries among five-year-old children in the North West of England. Community Dent Health. 2003 Dec;20(4):207-10. PubMed PMID: 14696738. English.
2. Arrow P. Cost minimisation analysis of two occlusal caries preventive programmes. Community Dent Health. 2000 Jun;17(2):85-91. PubMed PMID: 11349992. English.
3. Wennhall I, Norlund A, Matsson L, Twetman S. Cost-analysis of an oral health outreach program for preschool children in a low socioeconomic multicultural area in Sweden. Swed Dent J. 2010;34(1):1-7. PubMed PMID: 20496851. English.
4. Ichihashi T, Muto T, Shibuya K. Cost-benefit analysis of a worksite oral-health promotion program. Ind Health. 2007 Jan;45(1):32-6. PubMed PMID: 17284871. English.
5. Marino R, Fajardo J, Morgan M. Cost-effectiveness models for dental caries prevention programmes among Chilean schoolchildren. Community Dent Health. 2012 Dec;29(4):302-8. PubMed PMID: 23488214. English.
6. Marino R, Morgan M, Weitz A, Villa A. The cost-effectiveness of adding fluorides to milk-products distributed by the National Food Supplement Programme (PNAC) in rural areas of Chile. Community Dent Health. 2007 Jun;24(2):75-81. PubMed PMID: 17615821. English.
7. Sakuma S, Yoshihara A, Miyazaki H, Kobayashi S. Economic Evaluation of a School-based Combined Program with a Targeted Pit and Fissure Sealant and Fluoride Mouth Rinse in Japan. Open Dent J. 2010;4:230-6. PubMed PMID: 21673833. Pubmed Central PMCID: PMC3111721. English.
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Named author searches

A.10: Source: MEDLINE In-Process & Other Non-Indexed Citations and MEDLINE

Interface / URL: OvidSP
Database coverage dates: 1946 to present
Search date: 13/08/13
Retrieved records: 282

Search strategy:

1	Arrow P$.au.	14
2	Crowley S$.au.	214
3	Davies G$.au.	2029
4	Hirsch G$.au.	322
5	Ichihashi T$.au.	88
6	Lee J$.au.	53415
7	Marino R$.au.	501
8	Moberg Skold U$.au.	3
9	Moberg U$.au.	7
10	Moberg S$.au.	50
11	Morgan M$.au.	3217
12	Petersson L$.au.	162

13 Ramos-Gomez F$.au. 47
14 Sakuma S$.au. 649
15 Skold U$.au. 10
16 Splieth C$.au. 61
17 Wennhall I$.au. 6
18 Zabos G$.au. 8
19 or/1-18 60694
20 Amato E$.au. 51
21 Anselmo T$.au. 6
22 Birkhed D$.au. 284
23 Blinkhorn A$.au. 265
24 Campain A$.au. 20
25 Considine J$.au. 83
26 Davies R$.au. 2699
27 Edelstein Burton L$.au. 0
28 Edelstein L$.au. 106
29 Edelstein B$.au. 115
30 Burton L$.au. 369
31 Ellwood R$.au. 135
32 Fajardo J$.au. 74
33 Flessa S$.au. 47
34 Frosh M$.au. 9
35 Glied S$.au. 110
36 Kobayashi S$.au. 6728
37 Kotch J$.au. 91
38 Matsson L$.au. 96
39 Miyazaki H$.au. 1370
40 Mootabar R$.au. 1
41 Muto T$.au. 1091
42 Nolon A$.au. 2
43 Norlund A$.au. 60
44 Norton E$.au. 277
45 Rozier R$.au. 150
46 Rozier G$.au. 4
47 Shepard D$.au. 266
48 Shibuya K$.au. 899
49 Taylor G$.au. 3950
50 Tobin J$.au. 686
51 Turgeon L$.au. 28
52 Twetman S$.au. 179
53 Vann W$.au. 193
54 Villa A$.au. 1067
55 Weitz A$.au. 26
56 Westerberg I$.au. 4
57 Worthington H$.au. 449
58 Wright C$.au. 3136
59 Wright F$.au. 900

60 Yoshihara A$.au. 135
61 or/20-60 25823
62 19 or 61 86222
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65 economics, dental/ 1865
66 exp "economics, hospital"/ 19249
67 economics, medical/ 8557
68 economics, nursing/ 3875
69 economics, pharmaceutical/ 2580
70 (economic$ or cost or costs or costly or costing or price or prices or pricing or pharmacoeconomic$).ti,ab. 459900
71 (expenditure$ not energy).ti,ab. 18471
72 value for money.ti,ab. 967
73 budget$.ti,ab. 18836
74 or/63-73 585425
75 ((energy or oxygen) adj cost).ti,ab. 2884
76 (metabolic adj cost).ti,ab. 817
77 ((energy or oxygen) adj expenditure).ti,ab. 17119
78 or/75-77 20103
79 74 not 78 580886
80 62 and 79 2187
81 Oral Health/ 10089
82 exp Dental Health Services/ 29710
83 exp Mouth Diseases/ 229175
84 exp dentistry/ 330880
85 exp public health dentistry/ 30892
86 exp Dental Materials/ 87407
87 exp Tooth Diseases/ 141447
88 (oral$ or dental or dentist$ or mouth$ or gum or gums or DMF or caries or tooth$ or teeth$ or gingiv$ or periodont$ or fluorid$ or fissure$ or sealant$ or floss$).ti,ab. 842887
89 or/81-88 1120297
90 80 and 89 336
91 case report.tw. or letter/ or historical article/ or comment/ or editorial/ or (animal/ not (animal/ and human/))5635548
92 90 not 91 322
93 limit 92 to (english language and yr="1993 -Current") 282

A.11: Source: Embase

Interface / URL: OvidSP
Database coverage dates: 1974 to 2013 August 12
Search date: 13/08/13
Retrieved records: 375

Search strategy:

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2	Crowley S$.au.	241
3	Davies G$.au.	2030
4	Hirsch G$.au.	388
5	Ichihashi T$.au.	93
6	Lee J$.au.	58746
7	Marino R$.au.	534
8	Moberg Skold U$.au.	1
9	Moberg U$.au.	8
10	Moberg S$.au.	56
11	Morgan M$.au.	3532
12	Petersson L$.au.	168
13	Ramos-Gomez F$.au.	43
14	Sakuma S$.au.	701
15	Skold U$.au.	11
16	Splieth C$.au.	64
17	Wennhall I$.au.	6
18	Zabos G$.au.	7
19	or/1-18	66590
20	Amato E$.au.	73
21	Anselmo T$.au.	5
22	Birkhed D$.au.	288
23	Blinkhorn A$.au.	318
24	Campain A$.au.	29
25	Considine J$.au.	88
26	Davies R$.au.	3039
27	Edelstein Burton L$.au.	0
28	Edelstein L$.au.	103
29	Edelstein B$.au.	127
30	Burton L$.au.	393
31	Ellwood R$.au.	126
32	Fajardo J$.au.	113
33	Flessa S$.au.	72
34	Frosh M$.au.	7
35	Glied S$.au.	107
36	Kobayashi S$.au.	8089
37	Kotch J$.au.	94
38	Matsson L$.au.	101
39	Miyazaki H$.au.	1516
40	Mootabar R$.au.	1
41	Muto T$.au.	1254
42	Nolon A$.au.	2
43	Norlund A$.au.	71
44	Norton E$.au.	264
45	Rozier R$.au.	133

46 Rozier G$.au. 4
47 Shepard D$.au. 331
48 Shibuya K$.au. 1014
49 Taylor G$.au. 4033
50 Tobin J$.au. 716
51 Turgeon L$.au. 36
52 Twetman S$.au. 164
53 Vann W$.au. 86
54 Villa A$.au. 1269
55 Weitz A$.au. 26
56 Westerberg I$.au. 5
57 Worthington H$.au. 398
58 Wright C$.au. 3369
59 Wright F$.au. 965
60 Yoshihara A$.au. 155
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62 19 or 61 95110
63 health-economics/ 33053
64 exp economic-evaluation/ 203385
65 exp health-care-cost/ 195035
66 exp pharmacoeconomics/ 168084
67 63 or 64 or 65 or 66 466636
68 (econom$ or cost or costs or costly or costing or price or prices or pricing or pharmacoeconomic$).ti,ab. 580597
69 (expenditure$ not energy).ti,ab. 23033
70 (value adj2 money).ti,ab. 1291
71 budget$.ti,ab. 23321
72 68 or 69 or 70 or 71 604113
73 67 or 72 873499
74 (metabolic adj cost).ti,ab. 852
75 ((energy or oxygen) adj cost).ti,ab. 3128
76 ((energy or oxygen) adj expenditure).ti,ab. 19655
77 74 or 75 or 76 22833
78 73 not 77 868481
79 62 and 78 2875
80 exp dental procedure/ 201341
81 dental health/ 2324
82 exp mouth disease/ 421659
83 exp dentistry/ 93770
84 exp dental material/ 96005
85 dental education/ 19614
86 (oral$ or dental or dentist$ or mouth$ or gum or gums or DMF or caries or tooth$ or teeth$ or gingiv$ or periodont$ or fluorid$ or fissure$ or sealant$ or floss$).ti,ab. 968854
87 or/80-86 1301750
88 79 and 87 442
89 case report.tw. or letter.pt. or editorial.pt. or ((animal experiment/ or animal model/ or animal tissue/ or nonhuman/) not exp human/) 5147652

90	88 not 89	429
91	limit 90 to (english language and yr="1993 -Current")	375

APPENDIX C

Evidence Tables

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Arrow, P. **Year:** 2000. **Citation:** Arrow, P. (2000). Cost minimisation analysis of two occlusal caries preventive programmes. *Community Dental Health*. 17; 85-91. **Aim of study:** To assess the cost-effectiveness analysis of a school-based occlusal caries prevention programme. **Type of economic analysis:** Cost-effectiveness and minimisation analyses. **Economic Perspective:** SDS perspective. **Quality score:** + (++,+,-)	**Source population(s):** A simulated cohort of 6-year-old children enrolled in primary schools. **Setting:** School Dental Services (SDS) in Western Australia. **Fluoridation:** Fluoridated water supply. **Follow-up**: 2 years. **Data sources:** Benefits: Treatment effect data collected as part of a field study.[4] Costs: Cost data applied retrospectively. Programme costs (labour costs and material costs): Labour costs estimated by dental therapist wages multiplied by the time taken to perform the preventive procedures. Time per	**Intervention(s):** A preventive care programme of professional cleaning with a fluoride-containing paste and individualised oral health education from school dental therapists; children recalled to dentist at individually tailored intervals; study examinations conducted at baseline, 12 months and 24 months. **Comparator(s):** Standard SDS preventive care from school dental therapists, comprising of selective fissure sealing and application of topical fluorides on first permanent molars, based on caries risk; done at 1 time only, with no re-sealing or re-application of topical fluorides on subsequent visits. Study examinations conducted at baseline, 12 months and 24 months. **Sample size:** **Total:** 100. **Intervention:** NR. **Control:** NR.	**Outcomes:** • Incidence of individuals with occlusal caries on first permanent molars – objective; • Frequency of preventive visits objective; • Costs of programme – subjective; • Incremental cost-effectiveness of the programme per averted caries – subjective. **Time horizon:** 2 years. **Discount rates:** Annual discount rate of 5%. **Perspective:** SDS perspective. **Measures of uncertainty:** 95% confidence intervals (CI) reported. **Modelling method:** • A decision tree was used to assign probabilities; probabilities at the chance nodes were based on probability values of field study; • The cost-effectiveness analysis was based on the point estimate of the risk difference for effectiveness; because the field trial did not find a significant difference between the treatment and control groups in caries incidence, this

[4] Arrow P. Control of occlusal caries in the first permanent molars by oral hygiene. Community Dent Oral Epidemiol. 1997 Aug;25(4):278-83.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Applicability: Partially applicable.	procedure was based on clinician report. Cost of materials was obtained from SDS supply division and amount used was based on a 'typical' patient. Costs of dental treatment not included.		analysis was more properly termed a cost minimisation analysis; • Costs of dental treatment not included; • Indirect costs to patients and parents (travelling time, loss of wages, time away from school, pain and discomfort) were not included in the analysis; • Costs set at 1994 Australian dollar value.

Results

Primary results:

- The field study on which this was based, found no difference in caries incidence between treatment and control group at month 24; (DMFS (test) = 2.2 ± 3.7; DMFS (control) = 2.4 ± 4.2, p = 0.76).

Also reported:

- Risk ratio (RR) = 0.82, 95% CI (0.53, 1.28);
- Risk difference (RD) = 0.04, 95% CI (- 0.05, 0.13);
- Number need to treat (NNT) = 25;
- Number needed to harm (NNTH) = 20;
- Number needed to benefit (NNTB) = 8.

Frequency of visits**:** In year 1, test group had more frequent visits; in 2nd year frequency of attendance was similar between test and control group.

Cost of 2-year programme (discounted and deflated):

- Test: A$689;
- Control: A$369.

Incremental cost-effectiveness of the programme per averted caries:

It cost an addition $40.00/child/year, above the cost of the control programme, to prevent 1 child from having an occlusal carie on the first permanent molar.

Secondary results: NR.

Sensitivity analysis:

Applying the lower 95% CI of the risk difference indicated test programme was more expensive and produced fewer benefits. Minor changes to cost-effectiveness ratio changes were seen with changes in wage level and discount rate.

Notes

Limitations identified by author:

- Duration of the field trial was short for testing a caries preventive programme; the time allotted for fissure sealing in this study (3 minutes) was different than that seen in the literature (11 minutes), thus underestimating the costs of the control group;
- Labour costs comprised a major portion of the total costs and were based on the time taken to perform each preventive measure. Time was estimated by clinician report; however, reporting of time was not calculated in the same manner by clinicians in the test vs. control group: test clinicians calculated using 5 minute intervals, control clinicians calculated using 1-minute intervals; this may have led to some measurement error in the test clinicians.

Limitations identified by review team:

- Some children in the test group received sealants as well as profession cleaning and oral health education because the clinician felt they were at high risk of caries; the exact number of children who received both is not reported, but may result in risk of bias in terms of caries incidence, frequency of visits and programme costs; bias would favor the test group in terms of caries incidence and favor the control group (overestimate costs in test group) in terms of frequency of visits and programme costs;
- Children in the test group were recalled to dentist at individually tailored intervals, which was not further defined. This was not stated for control group. Number of visits fed into total costs, therefore, is at risk of bias;
- Programme costs were estimated using 1994 Australian dollar value, and hence of little relevance to current NHS/PSS cost. Access to dentists also likely to be different.

Evidence gaps and/or recommendations for future research:

- Longer term benefit not measured.

Funding source: Not reported.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Crowley S, Morgan M, Wright C. **Year:** 1996. **Citation:** Crowley S, Morgan M, Wright C. (1996). Economic Evaluation of Dental Sealant and Fluoride Mouth-rinsing Programme in Two Non-Fluoridated Regions of Victoria. Working paper 57, CHPE. **Aim of study**: <u>Small Scale Programme:</u> To assess the cost-effectiveness of a 3-year school-based dental sealant and fluoride mouth-rinsing (DS and FMR) programme in Year 7 students from 5 schools in Geelong and Ballarat, Australia. <u>Large Scale Programme:</u> A hypothetical extrapolation of the results of the small-scale programme to all year 7 students from all 32 schools in Geelong and Ballarat, over a 10-year period.	**Source population(s):** <u>Small Scale Programme:</u> Year 7 students attending one of 5 low SES schools in Ballarat or Geelong, Australia. <u>Large Scale Programme:</u> Year 7 students attending one of 32 schools in Ballarat or Geelong, Australia. **Setting:** Schools in Ballarat and Geelong, Australia. **Fluoridation:** <u>Small & Large Scale Programme:</u> Non-fluoridated water supply. **Follow-up:** <u>Small Scale Programme:</u> Three years. <u>Large Scale Programme:</u> Extrapolation to 10-years. **Data sources:** <u>Small Scale Programme:</u> <u>Benefits</u>: DFMS data based on field study outcomes. <u>Costs:</u> Programme: costs of	**Intervention(s):** <u>Small & Large Scale Programme:</u> Dental sealant and fluoride mouth-rinsing (DS and FMR) plus routine dental care from private dental practitioner. **Comparator(s):** Routine dental care. **Sample size:** <u>Small Scale Programme:</u> **Total:** 522. **Intervention:** 256. **Control:** 266. <u>Large Scale Programme:</u> Assumed an average of 3,500 students enter Year 7 annually for 10 years. **Intervention:** NR. **Control**: NR.	**Primary outcomes:** <u>Small Scale Programme:</u> • Incremental DMFS per child over 3 years – objective; • Incremental cost-effectiveness ratio – subjective. <u>Large Scale Programme:</u> • Value of reduced dental care utilisation due to intervention **–** subjective; • Benefit-to-cost ratio: – subjective. **Time horizon:** <u>Small Scale Programme:</u> 3 years. <u>Large Scale Programme:</u> 10 years. **Discount rates:** <u>Small Scale Programme</u>: Costs inflated to 1994 dollars; year 2 and 3 costs and outcomes were discounted at an annual rate of 5%. **Perspective**: Societal. **Measures of uncertainty:** 95% standard deviation (SD) and CI reported. **Modelling method:** <u>Small Scale Programme:</u> • Assumed a cohort of 250 students entered both groups; • Year 2 & 3 costs and outcomes

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Type of economic analysis: Small Scale Programme: Cost-effectiveness analysis. Large Scale Programme: Cost-benefit analysis. **Economic Perspective:** Societal. **Quality score:** + (++,+,-) **Applicability:** Partially applicable.	programme applied retrospectively; based on consultation with the Victoria School Dental Services; indirect costs not included. Dental treatment: based on 1994 average dental fees from private practice dentists, collected retrospectively. Large Scale Programme: Benefits: Mean baseline DMFS rates and disease increment based on study outcomes from 3-year study. Costs: Programme and dental treatments costs extrapolated from the small scale programme, expanded to 32 schools. Study assumed cost of purchasing a mobile dental van.		discounted to present value using annual discount rate of 5%; • Assumed decay restored in year of increment; • Assumed intervention group received a dental exam once every 3 years and control group once every 2 years; • Sealants could be placed, repaired or replaced annually; • FMR done weekly with 0.2% sodium fluoride. Large Scale Programme: • Outcomes from small-scale programme were projected for a hypothetical cohort of all Year 7 students in Ballarat or Geelong, Australia, over 10 years; • Costs extrapolated from small scale study, expanded to 32 schools; • Assumed dental exams conducted at same rate in both groups; • Assumed 75% participation rate; • Mean baseline DMFS and disease increment during the first 3 years was based on the mean values in the 3-year study; • Assumed the mean effectiveness rate declined at a constant rate from year 4 - 10, varying between 0 - 60%; • Sensitivity analyses conducted for varying levels of effectiveness (0% - 60%) and lower and upper extremes of

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
			benefits.

Primary outcomes

Small Scale Study:

Mean DMFS increment at 3 years:

- DMFS (intervention) = 0.93 (+/ -2.5);
- DMFS (control) = 2.35 (+/- 4.05);
- Gain of 1.42 DFMS in control group (95% CI 0.79, 2.03) ($p < 0.001$); (1.33 DFMS discounted).

Cost of programme:

- $24,750 discounted cost over 3 years, (~ $33.00 per child, per year). [FMR was 35% of costs].

Dental treatment costs over 3 years (discounted at 5%):

- Intervention group: $25,400;
- Control group: $46,750.

Net Cost:

Combining programme and treatment costs resulted in a overall net cost of $3,400 ($13.60 per child).

ICER:

The incremental cost-effectiveness ratio was $11.80 per DMFS averted over the three-year period.

Large Scale Study:

Costs of programme:

- ~ $33.00 per child, per year – same as small scale study.

Benefit-to-cost ratio:

- Assuming lower estimate of benefit and 0% effectiveness rate, benefit-to-cost ratio = 1.0;
- Assuming upper estimate of benefit and 60% effectiveness rate, benefit-to-cost ratio = 1.7.

Incremental benefits-to-cost ratio improved with each successive year of programme; lower estimate at 0% effectiveness had a benefit-to-cost ratio of 0.2 in year 1, which increased to 1.4 in year 10.

Dropouts:

Small Scale Study:

- 19.1% withdrawal rate in intervention group; 10.9% withdrawal rate in the control group.

Large Scale Study:

- NR.

Secondary analysis: NR.

Sensitivity analysis:

Small Scale Programme:

- Cost-effectiveness ratio was sensitive to varying effectiveness rate (i.e. using the lower and upper boundary of the 95% CI) and frequency of dental examinations (i.e. control group receiving 2 exams per 3 years and intervention group receiving 1 exam per 3 years); less sensitive to the use of 0% and 10% discount rates;
- ICER ranged from an overall savings of $7.00 to a cost of $35.60 per DMFS averted, based on varying frequency/cost of dental exams.

Large Scale Programme:

- Benefit-to-cost ratios were analysed at varying levels of effectiveness and lower and upper estimates of benefits; range 1.0 to 1.7.

Notes

Limitations identified by author:

Effectiveness rates based on a single prospective community study; care in trial may not represent usual practice; assumed decay restored in year of increment, which may or may not be true; the population in the clinical study were high-risk so benefits may not generalise to lower-risk groups. If level of dental caries continues to fall in non-fluoridated areas, the potential benefit as estimated in this study may be overstated.

Limitations identified by review team:

Small & Large Scale Programme

- The programme costs were applied retrospectively and are thus at risk of bias;
- In the small scale study, it was assumed intervention group received a dental exam once every 3 years and control group once every 2 years: the ICERs were highly sensitive to changes in this assumption; may have led to underestimation of intervention costs compared to using same dental exam rates in both groups; the large scale programme assumed each group had the same dental exam rate;
- Preventative intervention delivered by a dental auxiliary not a dentist to save money; not known if this acceptable in E&W;
- The study was conducted in Australia in 1989-1991, which may limit the generalisability of the study to the current English context.

Large Scale Programme:

- Assumed same baseline mean caries experience as in the small scale programme, but in the wider setting, adolescents may have a lower mean baseline DFMS than the higher risk children targeted in the small scale programme;
- Retention rates and effectiveness rates over the 10 years were based on published studies and may not have been applicable to the current setting and year;
- Sources of costs not clearly defined;
- Residual effectiveness rate in years 4-10 were based on the literature and varied form 0-60%.

Evidence gaps and/or recommendations for future research:

Small Scale Study:

- Limiting the time frame of the analysis to 3 years undervalues the potential economic benefits of the intervention.

Funding source: NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Crowley S, Campain AL, Morgan M. **Year:** 2000. **Citation:** Crowley S, Campain AC, Morgan M. (2000). An economic evaluation of a publicly funded dental prevention programme in regional and rural Victoria: an extrapolated analysis. *Community Dental Health.* 17;145-151 **Aim of study:** To model the effectiveness and cost-	**Source population(s):** Year 7 students attending the 32 schools in Ballarat or Geelong, Australia. **Setting:** Schools in Ballarat and Geelong, Australia. **Fluoridation:** Non-fluoridated water supply. **Follow-up:** Extrapolation of results from a 3-year study to 10-years. **Data sources:** Mean DFMS data for years 1 to 3 were	**Intervention(s):** Dental sealant and fluoride mouth-rinsing (DS and FMR) plus routine dental care from private dental practitioner. **Comparator(s):** Routine dental care. **Sample size:** Assumed an average of 3,500 students enter Year 7 annually for 10 years; **Intervention:** NR. **Control:** NR.	**Primary outcomes:** • Programme costs, benefits and net economic benefits; • Benefit-to-cost ratio: – subjective. **Time horizon:** 10 years. **Discount rates:** Annual rate of 5%. **Perspective**: Societal. **Measures of uncertainty:** Lower and upper ranges reported. **Modelling method:** • Outcomes from small-scale programme were projected for a hypothetical cohort of

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
effectiveness results of a 3-year preventative programme to all year 7 students from all 32 schools in Geelong and Ballarat, over a 10-year period. **Type of economic analysis:** Cost-benefit analysis. **Economic Perspective**: Societal. **Quality score: + (++,+,-)** **Applicability:** Partially applicable.	based on 3-year trial reported in Crowley 1996. These formed upper limit of benefit. The lower limit came from lowest quartile of the 3-year data. <u>Costs</u>: Programme and dental treatments costs extrapolated from the small scale programme, expanded to 32 schools. Study assumed purchase of mobile dental van. <u>Benefits</u>: Treatment benefits valued using average dental fees for Victoria.		all Year 7 students in Ballarat or Geelong, Australia, over 10 years; • Costs extrapolated from small scale study to 32 schools; • 75% participation rate; • Assumed dental exams conducted at same rate in both groups; • DMFS and disease increment during the first 3 years was based on values in the 3-year study; • Assumed the mean effectiveness rate declined at a constant rate from year 4 to10, varying between 0-60%; • Sensitivity analyses conducted for varying levels of effectiveness (0% - 60%) and lower and upper extremes of benefits.

Primary outcomes

<u>Costs of programme:</u>

- $33.00 per child per year – same as small scale study;

<u>Benefit-to-cost ratio:</u>

- Assuming lower estimate of benefit and 0% effectiveness rate, benefit-to-cost ratio = 1.0;
- Assuming upper estimate of benefit and 60% effectiveness rate, benefit-to-cost ratio = 1.7.

Incremental benefits-to-cost ratio improved with each successive year of programme. The most conservative estimate applied a lower estimate of effectiveness years 1 to 3 and 0% effectiveness thereafter had a benefit-to-cost ratio of 0.2 in year 1, which increased to 1.4 in year 10.

Secondary Analysis: NR.

Sensitivity analysis:

- Benefit-to-cost ratios were analyzed at varying levels of effectiveness and lower and upper estimates of benefits; range 1.0 to 1.7.

Notes

Limitations identified by author:

- No value was attached to improved quality of life from reduced caries and missing teeth; reduction in secondary caries and fewer working days lost as parents accompanied children to dentist on fewer occasions.;
- Model relies on assumptions;
- Baseline caries and trial effectiveness rates may not generalise to usual practice and data only from 1 study.

Limitations by review team:

- The programme costs were applied retrospectively and are thus at risk of bias;
- Preventative intervention delivered by a dental auxiliary not a dentist to save money; not known if this acceptable in E&W;
- The study was conducted in Australia in 1989-1991, which may limit the generalisability of the study to the current English context;
- Assumed same baseline mean caries experience as in the small scale programme, but in the wider setting, adolescents may have a lower mean baseline DFMS than the higher risk children targeted in the small scale programme;
- Retention rates and effectiveness rates over the 10 years were based on published studies and may not have been applicable to the current setting and year;
- Sources of costs not clearly defined;
- Residual effectiveness rate in years 4-10 were based on international literature and varied form 0-60%.

Evidence gaps and/or recommendations for future research:

- Further research should address opportunity cost of mix of programmes to determine most efficient use of resources.

Funding source: NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Davies GM, Worthington HV, Ellwood RP, Blinkhorn AS, Taylor GO, Davies RM, Considine J. **Year**: 2003. **Citation:** Davies GM, Worthington HV, Ellwood RP, Blinkhorn AS, Taylor GO, Davies RM, Considine J. (2003). An assessment of the cost-effectiveness of a postal toothpaste programme to prevent caries among five-year-old children in the North West of England. *Community Dental Health*. 20; 207-10. **Aim of study:** To assess the cost-effectiveness of a postal toothpaste programme to prevent caries.	**Source population(s):** Pre-school aged children (12-60 months) in England. **Setting:** Nine high-risk districts in North West of England. **Fluoridation:** Non-fluoridated water supply. **Follow-up:** The population cohorts entered the analysis at 12 months of age and were followed until 5 years of age. **Data sources:** Benefits: Efficacy data based on a published randomised controlled parallel group clinical trial.[5] Costs: Programme costs: Based on cost of running a dental service and postal programme in the UK. Labour costs were based on the NHS Whitley scale for Senior Dental Officers (SDO) and the	**Intervention(s):** A postal toothpaste programme of 4 years duration, comprising mailing quarterly, free toothpaste, containing 1450 ppm fluoride, and a leaflet encouraging brushing: a free toothbrush was included in the mailing once a year. **Comparator(s):** 'Do nothing' alternative was used as the control group. **Sample size:** **Total**: 6,781 entered and 5,344 completed. **Intervention:** NR. **Control:** NR.	**Outcomes:** • Reduction in decayed, filled, missing teeth (DMFT) – objective; • Cost per DMFT avoided/child – subjective; • Cost of child free of caries. **Time horizon:** 4 years. **Discount rates:** Present value was based on a 5% discount level. **Perspective:** NR. **Measures of uncertainty:** NR. **Modelling method:** All costs were priced using market costs in the UK but price date not stated. No other Modelling information provided.

[5] Davies GM, Worthington HV, Ellwood RP, Bentley EM, Blinkhorn AS, Taylor GO, Davies RM. A randomised controlled trial of the effectiveness of providing free fluoride toothpaste from the age of 12 months on reducing caries in 5-6 year old children. Community Dent Health. 2002 Sep;19(3):131-6.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Type of economic analysis: Cost-effectiveness analyses. **Economic Perspective:** NR. **Quality score: ++ (++,+,-)** **Applicability:** Partially applicable.	Administrative and Clerical (A&C) scale at Grade 4. All salaries were estimated at the mid-point of salary scale plus a 13% employer-cost. Agency hourly rates for database entry clerk and a product packer were used. Overhead costs were based on the mid-point range suggested by the Manchester NHS Estates Agency for a space of 30 sq meters. Treatment costs were not included.		

Primary analysis:

- Cost per tooth saved from DMFT = £80.83;
- Number of children kept free of caries experience: 351.72;
- Per child cost of preventing caries experience = £424.38;
- Per child cost of preventing extraction experience = £679.01;
- 12% of test children vs. 17% of control children needed at least 1 extraction; incremental benefit of 219.83 children not needing extractions.

Secondary analysis: NR.
Sensitivity analysis: NR.

Notes
Limitations identified by author:

- The model likely overestimated the costs, as it did not take into account the impact of incremental treatment costs;
- Final outcome of DMFT reduction was assessed at 5.5 years; this may have led to overestimation of costs as the longer term benefits of the programme were not included, which would have had the overall result of decreasing costs;
- The benefit of those who dropped out of the study prior to the end was not accounted for in the model.

Limitations identified by review team:

- Model assessed the effects based on one clinical trial, which may not reflect reality;
- Limited information on the efficacy data from the RCT on which the model was based;
- Limited information on the Modelling method and cost base provided.

Evidence gaps and/or recommendations for future research:

- Long-term benefit not measured.

Funding source: NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Hirsch GB, Edelstein BL, Frosh M, Anselmo T. **Year:** 2012. **Citation:** Hirsch GB, Edelstein BL, Frosh M, Anselmo T. (2012). A simulation model for designing effective interventions in early childhood caries. *Preventing Chronic Disease*. 9: E66. **Aim of study:** To formulate a system dynamics model to assess and compare early childhood caries	**Source population(s):** Colorado preschool children, under 72 months. **Setting:** Colorado, USA. **Fluoridation:** Mostly a fluoridated water supply. **Follow-up:** 10 years. **Data sources**: <u>Benefits</u>: • Assumptions on treatment efficacy are based on published literature and written communication with author; • Epidemiology of ECC, by age and income, informed by the Colorado Child Health	**Intervention(s):** • Expansion of community water fluoridation to the entire population; • Expanded use of fluoride varnish; • Efforts to reduce *S. mutans.* transmission from parents and other caregivers to children using xylitol gum, chlorhexidine, or behavioural interventions; • Use of xylitol products directly with older children; • Aggressive screening for and treatment of caries activity to reduce progression to cavities; • Focused preventive care and education for children who already have cavities to reduce recurrence; • Motivational interviewing with strong educational and behavioural components; • Educational programmes that reduce	**Outcomes:** • Change from baseline in cavities, untreated cavities, decayed , filled treated teeth (DFT) – subjective; • 10 year cumulative cost and savings of restorative care vs. baseline – subjective; • 10 year cumulative programme cost – subjective. **Time horizon:** 10 years. **Discount rates:** 5% discount rate. **Perspective:** NR. **Measures of uncertainty:** NR. **Modelling method:** • A system dynamics model was used; • Model categorised children by age (0-6 month; 7-24 months, 25 to 72 months)

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
(ECC) interventions for benefits and costs among young children in Colorado. **Type of economic analysis:** Cost analysis. **Economic Perspective:** NR. **Quality score:** - **(++,+,-)** **Applicability:** Partially applicable.	Survey; baseline prevalence data based on several valid sources of Colorado data including 1999-2002 National Health and Nutritional Examination Survey (NHANES) , the Medical Panel Expenditure Survey (MEPS) and other published studies. Costs: • Interventions costs: No details provided on source of costs of interventions or unit resources within each programme; • Costs of restorative care and other treatment costs were obtained from the MEPS survey, Colorado Medicaid and the National Survey of Ambulatory Survey.	consumption of sugary drinks, nocturnal bottle use, and other harmful behaviours. **Comparator(s):** As above. **Sample size:** **Total:** NR. **Intervention:** NR. **Control**: NR.	and by risk categories (high, medium, low, based on family income). Prevalence of symptomatic and non-symptomatic cavity status in the model and rates of children moving between stages of tooth decay were based on study in the literature, including NHANES and published studies.
Primary analysis: **Benefits:** • Cavities prevalence.			

	10-year cavities prevalence among Colorado children < 6 years of age	10-year net savings (cost of baseline restorative care – care post intervention – cost of intervention ($ m)
Baseline (no intervention)	18.2	
Community water fluoridation	17	8
Fluoride varnish:		
Children > 6 months	12.4	-53
Children, high risk, > 6 months	14.7	-22
All children > 24 months	16	-58
Xylitol (mother):		
All mothers	10.8	-23
Mothers of high-risk children	15	3
Xylitol (children):		
Children > 24 months, low impact (reduces caries by 44%)	15.2	-57
Children > 24 months, high impact (reduces caries by 73%)	13.3	-33
High risk children > 24 months, low impact	16.9	-10
High risk children > 24 months, high impact	16	3
Children > 6 months, high impact	5.6	24
Clinical treatment		
Children > 6 months, low treatment intensity	14.2	-2
Children > 6 months, high treatment intensity	12.8	-9
Prevention of recurrence:		
50% reduction	18.2	22
75% reduction	18.2	39
Motivational interviewing:		
All families	6.5	11
High risk families only	12.9	29
Secondary analysis: NR. **Sensitivity analysis:** NR.		
Notes **Limitations identified by author:**		

- Weakness related to the quality of data used: proxies, estimates, expert opinion, and extrapolations were used when data was not available.

Limitations identified by review team:

- Limited information on efficacy and costs; difficult to make a judgment on appropriateness of findings for England;
- Limited information on the study outcomes on which the cost-effectiveness analysis was based;
- The study was conducted in USA, which may limit the generalisability of the study to the UK context.

Evidence gaps and/or recommendations for future research:

- None.

Funding source: Centre for Disease Control and Prevention.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Ichihashi T, Muto T, Shibuya K. **Year:** 2007. **Citation:** Ichihashi T, Muto T, Shibuya K. (2007). Cost-benefit analysis of a Worksite Oral-Health Promotion Programme. *Industrial Health*. 45, 32–36. **Aim of study:** To examine whether oral-health promotion programmes provided as an occupational health service for employees are	**Source population(s):** Male employees of household product company in Japan. **Setting:** A household product company in Tokyo, Japan. **Fluoridation:** NR but most of Japan does not have fluoride applied as a public health measure [Sakuma]. **Follow-up:** 7 years. **Data sources:** Data is based on a cohort study. Benefits: Accumulated dental expenses for the seven years (from 1992 to	**Intervention(s):** An oral-health promotion programme offered at the workplace between 1992 and 1997, once a year. The programme consisted of oral-health checkups by dentists and oral health instruction, in addition to calculus scaling at the anterior mandibular teeth by dental hygienists. Population was categorised by number of visits they attended over the 7-year programme: 0 visits; light users (once); middle users (2 to 4 visits); heavy users (5 and 6 visits). **Comparator(s):** The 0 visit group was the control group. **Sample size:** **Total:** 357.	**Outcomes:** • Dental expenses by group – objective; • Cost of programme by group – subjective; • Cost-benefit analysis of light, medium, heavy group vs. 0 group – subjective. **Time horizon:** 7 years. **Discount rates:** A discount rate of 3% was used. **Perspective:** An employer's perspective was taken. **Measures of uncertainty:** Standard error used in cost-benefit analysis. **Modelling method:** • The groups were compared in terms of

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
cost-beneficial for employers. **Type of economic analysis:** Cost-benefit analyses. **Economic Perspective:** Employers perspective. **Quality score: + (++,+,-)** **Applicability: Partially** applicable.	1998) were used to calculate benefits, which were determined based on the differences between those that did not participate (0 visits) and the groups that did (≥ 1 visit). <u>Costs:</u> Programme costs included direct costs (staff salary and teaching materials) and indirect costs (time required for employee participation). Sources included records from health insurance societies, personnel record within the company and programme files. Payment of dental staff and teaching materials stated as $25.76 per person but derivation not described. The dental costs were based on the general practitioner's fee for dental treatment, set by the Japanese government and claimed from the health insurance society. Employees were all insured through company's health insurance society.	**Intervention:** Light (1 visit/7 years) n = 103; Medium (2-4 visits/7 years) n = 160; Heavy (5-6 visits/7 years) n = 59; **Control:** 0 visits (0 visits/7 years) n = 35.	programme cost, dental expenses and benefits; • The exchange rate used was 1 U.S. dollar = 124.80 Yen (Annual average exchange rate for 1992). No further Modelling information provided.

Primary analysis:

Dental expenses (accumulated dental expenses per person, 1992-1998):

- 0 visits: $645.82;
- Light: $719.84;
- Medium: $522.14;
- Heavy: $528.65.

Benefit: Calculated as dental expenses in each group minus dental expenses in 0-visit group:

- Light: $ -74.02;
- Medium: $123.68;
- Heavy: $117.17.

Cost of the programme ($/person/7 yr):

- Light: $30.16;
- Medium: $84.93;
- Heavy: $159.78.

Benefit/cost ratio:

- Light: -2.45;
- Medium: 1.46;
- Heavy: 0.73.

The medium group was the only group to show a ratio greater than 1.

Benefit – Cost ($/person/7 yr):

- Light: $-104.18;
- Medium: $ 38.75;
- Heavy: $-42.61.

The worksite oral-health promotion programme of medium frequency is cost-beneficial for employers.

Secondary analysis: NR.
Sensitivity analysis: NR.

Notes

Limitations identified by author:

- The contents of the dental treatments obtained from the insurance company (diagnosis, oral condition, prevention and dental treatments) were not precisely detailed; therefore not clear which dental treatments contributed to the dental expenses;
- At risk of participation bias due to the voluntary nature of the study – those participating may differ in some important way from those not participating, thus generalisability may be an issue;
- Private patients were removed from the study.

Limitations identified by review team:

- Study excluded women, retired employees, those admitted to hospital, and those who spent > $4,006 for medical treatment during the period, thus limiting generalisability;
- Cost of the programme reflects labour costs for dental staff in Japan 20 years ago; dental expenses are from a nationally agreed set of treatment fees from a similar period; both of little relevance to NHS/PSS cost;
- All employees were insured through company's health insurance society.

Evidence gaps and/or recommendations for future research:

- Long-term benefit not measured.

Funding source: NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Marino R, Fajardo J, Morgan M. **Year:** 2012. **Citation:** Marino R, Fajardo J, Morgan M. (2010). Cost-effectiveness models for dental caries prevention programmes among Chilean schoolchildren. Community *Dental Health*. 29: 302-8. **Aim of study:** To establish the cost-effectiveness of 7 dental caries prevention programmes among schoolchildren in Chile. **Type of economic analysis:** Cost effectiveness analyses. **Economic Perspective:** Societal perspective. **Quality score:** + **(++,+,-)** **Applicability:** Partially	**Source population(s):** Two hypothetical populations of school age children, age 6 in Chile. **Setting:** One of the hypothetical populations was set in a large Chilean city and the other a rural community in Chile. **Fluoridation:** In Chile, the large cities use fluoridated water but the rural communities do not. **Follow-up:** 6 years. **Data sources**: Benefits: Treatment effects of DMFT and ranges were based on published studies, most of which were conducted in Chile. Costs: Programme costs: • Water fluoridation based on charges authorised by the Ministry of Economy; • Cost of dental sealant application fees were based on the public fee structure; • Costs of other programmes	**Intervention(s):** Seven interventions were assessed: • Two community-based programmes: water-fluoridation and dental sealants; • Four school-based programmes: milk-fluoridation, fluoridated mouth-rinses (FMR), APF-Gel, and supervised tooth brushing with fluoride toothpaste. In addition, even though it is not available in Chile, salt fluoridation was included as a community intervention, as it is the predominant modality of public health fluoridation in Latin America. **Comparator(s):** Two non-intervention communities, one representative of the hypothetical city (but without the intervention of water and salt fluoridation) and another was representative of the rural communities. **Sample size:** **Total:** 80,000 school aged children in the large city and 6,000 school aged children in the rural setting. **Intervention:** NR. **Control**: NR.	**Outcomes:** • Incremental cost-effectiveness of the programme per averted DMFT – subjective. **Time horizon:** 6 years. **Discount rates:** Costs discounted to 3%. Outcomes not discounted. **Perspective:** Societal perspective. **Measures of uncertainty:** NR. **Modelling method:** • All children entered the model at age 6; • Effects accrued to age 12 only; • Assumed dental caries increment was constant in each year; • Costs of repair took place in the same year of the DMFT increment; • All decayed teeth were restored and no restorations were replaced; • Risk for dental caries was constant; • For dental sealants, it was assumed each child had their 4 first molars sealed, and 10% of sealants replaced over a 6-year period; • Costs set at 2009 market costs in Chile and converted to US dollars.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
applicable.	not clearly defined; • Programme coordinators were assumed to work part-time: water and salt fluoridisation programmes had a 0.1 full time equivalent (FTE) a year; gels and sealant programmes a 0.1 FTE for 2 months a year; FMR and tooth brushing had a 0.1 FTE for 3.5 months a year; • Mean loss in work time due to dental visits was estimated at 1.5 hours per decayed tooth surface and per extraction; • FMR and tooth brushing programmes included cost of training supervising teachers plus teachers' supervision time; • The cost of adult time was estimated as value of lost production, assumed equivalent for all parents and calculated as the minimum wage for 2009; • The cost of public transportation to and from the community health centre were included;		

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
	• The cost of time spent by children was excluded; • Dental fees were based on the public health fee structure, in Chile, in 2009.		

Primary analysis:

Incremental saving per averted DMFT (US $)(discounted):

- Water-fluoridation: $14.89;
- Salt fluoridation: $16.21;
- Dental sealants: - $11.56 (cost);
- Milk-fluoridation: $14.78;
- FMR: $8.63;
- Supervised tooth brushing and fluoride toothpaste - $8.55 (cost);
- APF-Gel: - $21.30 (cost).

For water-, salt-, and milk-fluoridation and FMR, the cost-effectiveness ratio of the programme dominated the comparator. Supervised toothpaste use, dental sealants placement and APF-Gel application, represent programmes that produced a cost to society.

Secondary analysis: Cost of treatment averted and cost of the preventative programme.
Sensitivity analysis: The incremental cost per averted DMFT changed as follows, under the following conditions:

Water-fluoridation:

- Worst scenario*, 0% discount rate = savings per DMFT averted decreased to $13.25;
- Best scenario**, 6% discount rate = savings per DMFT averted increased to $16.87.

Salt fluoridation:

- Worst scenario, 0% discount rate = savings per DMFT averted decreased to $15.10;
- Best scenario, 6% discount rate = savings per DMFT averted increased to $17.63.

Dental sealants:

- Worst scenario, 0% discount rate = savings per DMFT averted decreased to -$26.11;
- Best scenario, 6% discount rate = savings per DMFT averted increased to $4.01.

Milk-fluoridation:

- Worst scenario, 0% discount rate = savings per DMFT averted decreased to $12.64;
- Best scenario, 6% discount rate = savings per DMFT averted increased to $16.47.

Fluoride Mouth Rinse:

- Worst scenario, 0% discount rate = savings per DMFT averted decreased to $5.36;
- Best scenario, 6% discount rate = savings per DMFT averted increased to $10.27.

Supervised tooth brushing and fluoride toothpaste:

- Worst scenario, 0% discount rate = savings per DMFT averted decreased to - $13.06;
- Best scenario, 6% discount rate = savings per DMFT averted increased to - $4.73.

APF-Gel:

- Worst scenario, 0% discount rate = savings per DMFT averted decreased to - $39.97;
- Best scenario, 6% discount rate = savings per DMFT averted increased to $1.50.

* Best scenario = the highest value of effectiveness within the range; **Worst scenario = the lowest value of effectiveness within the range.

Cost-effectiveness ratios were sensitive to changes in discount rates, cost of programme coordinator (for the APF-Gel intervention) and effectiveness of intervention. Water-fluoridation, salt-fluoridation, milk-fluoridation and FMR continued to dominate under any combination of sensitivity analyses.

Supervised tooth brushing and fluoridated toothpaste programme had no evidence of cost saving under any combination of conditions.

Notes

Limitations identified by author:

- Model was short-term, thus likely underestimating the longer term benefits of these programmes;
- Effects on oral health beyond age 12 were not included in the models;
- Intangible benefits of preventive programmes were not measured;
- Dental fees were based on the public health fee structure, which represents the lower end of dental treatment costs, thus, may have led to an underestimation of the costs; model assumed that sealants were placed on all four permanent molars of all children, regardless of their susceptibility to caries- thus potentially decreasing the programmes cost-effectiveness;
- Model did not assume any overlapping of preventative programmes (i.e., combination of fluorides and dental sealants), which may have led to underestimation of effectiveness;
- Model assumed 100% compliance with school programmes, perhaps favouring the programme effectiveness.

Limitations identified by review team:

- The source of cost for some of the resources not clearly defined;
- Concern intervention resources are understated;
- Limited information on the study outcomes on which the cost-effectiveness analysis was based;
- No utilities used;
- The study was conducted in Chile, which may limit the generalisability of the study to the UK context.

Evidence gaps and/or recommendations for future research:

- Long-term benefit not measured**.**

Funding source: Not declared.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Marino R, Morgan M, Weitz A, Villa A. **Year:** 2007. **Citation:** Marino R, Morgan M, Weitz A, Villa A. (2007). The cost-effectiveness of adding fluorides to milk-products distributed by the National Food Supplement Programme (PNAC) in rural areas of Chile. *Community Dental Health.* 24; 75-81.	**Source population(s):** A simulated population of children, aged 3 to 6 years, attending public kindergarten and primary schools. **Setting:** Setting is public kindergarten and primary schools in 2 rural communities from Codegua and La Punta. **Fluoridation:** Both communities have low levels of fluoride in the water. **Follow-up:** Children were followed for 4 years.	**Intervention(s):** Milk is distributed to all children up to age of 6 years in Chile through a National Complementary Feeding Programme (PNAC). The intervention was fluoride added to the milk during a 4-year period in one community (Codegua). Children were examined at school every year for decayed, missing and filled teeth in both communities. **Comparator(s):** La Punta was the control, which did not receive added fluoride in milk. The communities were matched on geographic proximity, community size and similar prevalence of dental caries. **Sample size:** **Total:** 2,000. **Intervention:** 1,000.	**Outcomes:** • Difference in the decayed, filled, missing teeth (DMFT) index between intervention and control group, from baseline to year 4 – objective; • Cost effectiveness per DMFT avoided/per child - subjective. **Time horizon:** 4 years. **Discount rates:** Costs were discounted at 3%. Outcomes were not discounted. **Perspective:** Societal perspective. **Measures of uncertainty:** Standard deviation used in the measure of DMFT.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Aim of study: To estimate the cost effectiveness of a programme to add fluoride to milk products, to prevent dental caries in school aged children. **Type of economic analysis:** Cost effectiveness analyses. **Economic Perspective:** Societal perspective. **Quality score:** - **(++,+,-)** **Applicability:** Partially applicable.	**Data sources**: Benefits: Treatment effects were from a community trial with 2 non-randomised arms.[6] Costs: Programme costs included resources to buy and add fluoride to milk and were a retrospective analysis of resource use during study. Included were salary of the field coordinator (0.10 FTE); data analysis fees, fluoride, office rental, office furniture, overhead costs; all based on regional costs. Also included: Transportation costs and productivity losses (assuming a dental visit is 1.5 hours); work productivity losses were based on 1999 minimum hourly salary. Dental expenses were from 1999 Ministry of Health fees.	**Control**: 1,000.	**Modelling method:** The analyses assumed: • Increased in decayed and missing teeth occurred at the same rate in each year of the study; • Dental caries increment was constant in each year; • All decayed teeth received a one-surface restoration; • Deciduous teeth restorations were not replaced; • Treatment costs occurred in the year of the event; • Benefits accrued to age 6; • Costs set at 1999 Chilean pesos value.

[6] Mariño R, Villa A, Guerrero S. A community trial of fluoridated powdered milk in Chile. Community Dent Oral Epidemiol. 2001 Dec;29(6):435-42.

Primary analysis:

Effectiveness of the programme based on study outcomes at end of study (1999):

Mean (SD) DMFT:

- Test (Codegua): 2.08 (2.85) vs;
- Control (La Punta) 3.49 (3.42).

Cost of programme: RCH $1,839.75 per annum per child.

Dental treatment costs over the 4 years, per annum, per child (discounted):

- Test (Codegua): RCH $4,177.40;
- Control (La Punta): RCH $7,087.85.

Costs/benefits (ICER):

- Incremental savings per DMFT avoided, over 4 years, in test group vs. control: RCH $2,695.61;
- Incremental savings per child over 4 years, in test group vs. control: RCH $3,800.8.

It will cost RCH (1999) $1,839.75 per child, per year, to achieve RCH $673.9 reduction in dental treatment costs per year; or a RCH $2,695 per DMFT saved.

Secondary analysis: NR.

Sensitivity analysis:

This cost-effectiveness analysis was sensitive to changes in DMFT outcome, discount rates and increases coordinator time (0.05 FTE and 0.15 FTE), with ratios ranging from a net savings of RCH $5,006.26 to a net cost of RCH $3,822.57 per DMFT averted.

Notes

Limitations identified by author:

- Replacement of dental restorative work was not replaced in this analysis;
- Costlier treatments were not considered (space retainers, etc);
- All restorations were considered as single fillings;
- Benefits such as pain avoided and improved quality of life were excluded.

Limitations identified by review team:

- Dental fees were based on the public health fee structure, which represents the lower end of dental treatment costs, thus, may have led to an underestimation of the costs;
- In England children do not have access to powdered milk provided by the State so intervention less feasible in England;

- The study was conducted in Chile, in 1999, which may limit the generalisability of the study to the UK context; access to dentists also likely to be different;
- Treatment costs were estimated using 1999 public fees and hence of little relevance to NHS/PSS cost;
- The generalisability of effectiveness measure to England is unknown; similarly baseline oral health may differ.

Evidence gaps and/or recommendations for future research:

- Long-term benefit not measured and requires prospective collection of cost information for treatments and programme.

Funding source: The study was funded by a grant received from The Borrow Foundation (UK). This charity promotes improved of oral health by wider use of fluorides in particular, through their use in milk and milk products.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Petersson LG, Westerberg I. **Year:** 1994. **Citation:** Petersson LG, Westerberg I. (1994). Intensive fluoride varnish programme in Swedish adolescents: economic assessment of a 7-year follow-up study on proximal caries incidence. *Caries Research*. 28:59-63. **Aim of study:** To assess	**Source population(s):** Study population was 11-14-year old children in Sweden. **Setting:** Sweden. **Fluoridation:** NR. **Follow-up:** 3 year programme with follow up 4 years after end of programme. **Data sources:** Benefits: Benefits are cost savings from avoided fillings. This data is derived from a published RCT.[7]	**Intervention(s):** An annual intensified fluoride varnish programme, which included 3 applications in the time span of 1 week, plus a basic preventive programme including introduction of oral hygiene and dietary information. Regular use of Fluoride toothpaste was recommended. **Comparator(s):** A standard fluoride varnish treatment twice a year plus a basic preventive programme including introduction of oral hygiene and dietary information. Regular use of Fluoride toothpaste was recommended. **Sample size:** **Total:** 160.	**Outcomes:** • Caries incidence over 7 years- objective; • Net savings due to prevention of caries increments – subjective; • Net savings due to arrested progression of existing lesions to cavitations requiring restoration – subjective; • Net costs for the programme – subjective; • Cost-benefit analysis – subjective. **Time horizon:** 7 years. **Discount rates:** Costs and benefits were discounted and deflated to 1983 with an annual discount rate of 5%.

[7] Petersson LG, Arthursson L, Ostberg C, Jönsson G, Gleerup A. Caries-inhibiting effects of different modes of Duraphat varnish reapplication: a 3-year radiographic study. Caries Res. 1991;25(1):70-3.

the long-term effects of an intensive fluoride varnish programme. **Type of economic analysis:** Cost-benefit analysis. **Economic Perspective:** NR. **Quality score:** + **(++,+,-)** **Applicability:** Partially applicable.	<u>Costs</u> Costs included programme costs and restorative costs. Dental treatment costs were excluded. Unit cost estimates not defined, only overall costs for programmereported; treatment pathways derived from published studies.	**Intervention:** n = 80. **Control**: n = 80.	**Perspective:** NR. **Measures of uncertainty:** 95% Confidence intervals reported. **Modelling method:** • Disease course and treatment pathways based on published literature; • Benefits calculated over a 10-year period; • Costs set at 1983 Swedish krona (SEK) value.

Primary analysis:

<u>Caries incidence:</u>

- No significant difference in proximal caries incidence between treatment and control group at the end of the 3-year programme;
- Test group had significantly more proximal caries at the end of the 4-year follow-up (year 7).

<u>Benefits:</u>

- Net benefit due to prevention of caries increment: 1,800 SEK;
- Net benefit due to arrested progression of existing lesion to cavitation requiring restoration: 3,200 SEK.

<u>Costs:</u>

- Net total cost for the preventative programme was 3,880 SEK.

Cost benefit analysis:

- Total net costs are 3,880 SEK and the total benefits are 5,000 SEK; a positive result over a time period of 10 years.

Secondary analysis: NR.

Sensitivity analysis:

Not reported but alluded to in discussion. Sensitivity analysis of discount rates at 10% conducted. Cost-benefit analyses conducted at 7 years as well, at discount rate of 5% and 10%.

Notes

Limitations identified by author:

- NR.

Limitations identified by review team:

- Little information on source of costs;
- Data based on one small study which had a high dropout rate is high (approx 29%), although equally split between the 2 groups;
- The standard of care for dentistry in Sweden may differ from that in UK (i.e. control group received biannual fluoride varnish);
- Dental expenses not included in the costs;
- The costs associated with this programme in Sweden, in 1983, may differ substantially from current NHS and PSS costs.

Evidence gaps and/or recommendations for future research:

- None.

Funding source: NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis

Authors: Ramos-Gomez FJ & Shepard DS.
 	
Year: 1999.
 	
Citation: Ramos-Gomez FJ & Shepard DS. (1999). Cost-effectiveness model for prevention of early childhood caries. *Journal of the California Dental Association.* 27; 539-44.
 	
Aim of study: To assess the cost-effectiveness of 3 dental caries prevention programmes.
 	
Type of economic analysis: Cost effectiveness.
 	
Economic Perspective: NR.
 	
Quality score: -
(++,+,-)
 	
Applicability: Partially applicable.
	Source population(s): A hypothetical cohort of 1-year-old children.
	
	Setting: Low income area in California, 1996
	
	Fluoridation: Non-fluoridated and fluoridated water supply.
	
	Follow-up: 5 years.
	
	Data sources:
	<u>Benefits:</u>
	Treatment effects for the minimal intervention (40% reduction in caries) were obtained from 1 published study; treatment effects for the intermediate (70%) and comprehensive interventions (80%) were based on clinical observation at the UCSF Paediatric Dental Clinic.
	
	<u>Costs:</u>
	Programme costs for each intervention were based on 1996-97 California Dental Medicaid reimbursement rates and rate for the Spokane Dental Prevention Programme.
		Intervention(s):
		Three levels of successively more complete levels of preventive interventions:
		• Minimal: Annual risk assessment based on parental and sibling caries, feeding practices and risk behaviours plus a prevention treatment of fluoride varnish, applied by a dental hygienist, at 6-month intervals;
		• Intermediate: Annual risk assessment, fluoride varnish plus oral hygiene counselling on age-specific topics;
		• Comprehensive: Fluoride varnish + counselling + outreach which included telephone and personal prompts to encourage dental appointment attendance.
		
		Comparator(s): No intervention.
		
		Sample size:
		Total: NR.
		Intervention: NR.
		Control: NR.
			Outcomes:
			• Incidence of individuals with occlusal caries on first permanent molars – subjective;
			• Costs of intervention – subjective;
			• Cost of dental expenses – subjective.
			
			Time horizon: 5 years.
			
			Discount rates: NR.
			Perspective: NR.
			
			Measures of uncertainty: NR.
			
			Modelling method:
			• Assumed 75% of the recommended services would be utilized;
			• Effectiveness rates used per intervention:
			  ○ Minimal: 40%;
			  ○ Intermediate: 70%;
			  ○ Comprehensive: 80%;
			• Assumed the number of carious surfaces over 5 years with no intervention = 10.80.
			• 84% live in non- fluoridated areas and 16% in fluoridated areas.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
	Treatment costs were from 115 patients at a dental clinic at University of California. The average cost of treatment per category and average cost per surface treated per category were provided.		

Primary results:

5-year cost of intervention, per child, over 5 years:

- Minimal: $314;
- Intermediate: $497;
- Comprehensive: $570.

Number of carious surfaces averted per child over 5 years (vs. no intervention at 10.80):

- Minimal: 4.32;
- Intermediate: 7.32;
- Comprehensive: 8.36.

Cost per carious surface averted:

- Minimal: $72.69;
- Intermediate: $65.74;
- Comprehensive: $66.28.

Secondary results: NR.

Sensitivity analysis: NR.

Notes

Limitations identified by author:

- The study was limited by the shortage of data that address the cost of treatment, prevention and effectiveness of preventive interventions for carious lesions in children younger than 6;
- Margins of error for the estimates used in the study were large.

Limitations identified by review team:

- The sources on which the treatment effects are based are limited (1 study and clinical observation) and likely to lead to biased results;
- No data sources provided for incidence rates and disease course;
- Detail on resource use costs in interventions not provided;
- Lack of transparency on efficacy measures and programme costs limits confidence in the results;
- The study was conducted in USA in 1996, which may limit the generalisability of the study to the current UK context.

Evidence gaps and/or recommendations for future research:

- Longer term benefit not measured;
- Authors recommend further studies to test accuracy of assumptions on costs and effectiveness, compliance, lost to follow-up, migration, unemployment and psychological trauma for child of emergency dental treatment at such early age.

Funding source: NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Sakuma S, Yoshihara A, Miyazaki H, Kobayashi S. **Year:** 2010. **Citation:** Sakuma S, Yoshihara A, Miyazaki H, Kobayashi S. (2010). Economic Evaluation of a School-based Combined Programme with a Targeted Pit and Fissure Sealant and Fluoride Mouth Rinse in Japan. *The Open Dentistry Journal*. 4:	**Source population(s):** Japanese 8 and 11-year old children who attended two nursery/primary schools in 1999. **Setting:** Combined nursery/primary schools, in Japan. Schools in different municipalities but both were in tourist areas and similar social and economic environment. **Fluoridation:** Non-fluoridated water supply. **Follow-up:** FMR administered from age of 4. Hence 4 years for 8	**Intervention(s**): Targeted sealant (TS) and fluoride mouth rinse (FMR). TS indicated for 'sticky' surfaces, annually in nursery school (2 years) and twice a year in primary school (5 years). Sealant application performed by school based dentist and were replaced if necessary. FMR: Daily 60-second mouth rinse with 0.05% sodium fluoride (NaF) in nursery school and and 0.2% NaF solution weekly in primary school. Delivered by school director and nurse. **Comparator(s):** Dental treatment, including sealant placement, performed as usual at 2 private clinics. **Sample size:** **Total:** 221.	**Outcomes:** • Cost per child of FMR- subjective; • Mean decayed and filled teeth (DFT) – objective; • Cost effectiveness per DFT avoided/child/year - subjective. **Time horizon:** 4 years and 7 years. **Discount rates:** NR. **Perspective:** NR. **Measures of uncertainty:** Standard deviation (SD) provided for DFT rates but not used in economics.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
230-236. **Aim of study:** To estimate the cost-effectiveness ratio and cost-benefit ratio of a school-based programme combining FMR and TS and vs. a control group of primary school children. **Type of economic analysis:** Cost effectiveness and cost-benefit analyses. **Economic Perspective:** NR. **Quality score:** + **(++,+,-)** **Applicability:** Partially applicable.	years old and 7 years in 11 year olds. **Data sources:** <u>Benefits</u>**:** Caries prevalence (decayed and filled surfaces) obtained from primary research study. <u>Costs</u>: Cost of sealant placement and treatment fees according to Japanese dental insurance scheme in 2002.	**Intervention:** 66 8 - year olds and 58 11-year olds. **Control**: 43 8-year olds and 54 11 -year olds.	**Modelling method:** • Assumed decayed surfaces were restored; • No model was used, retrospective estimation of costs used to compare with benefits.
Primary analysis: **Benefits:** <u>Mean DFT, at end of programme in 1999, intervention vs. control (% difference between groups)</u>: • Age 8: 0.05 vs. 1.49 (96.9%*); • Age 11: 0.31 vs. 3.48 (91.1%*). *p<0.00.			

Costs:

Programme cost (yen) per child:

Fluoride Mouth Rinse:

- Age 8: 2,336;
- Age 11: 3,008.

Targeted Sealant:

- Age 8: 505;
- Age 11: 1,477.

Total programme cost (yen) per child:

- Age 8: 2,841;
- Age 11: 4,485.

Treatment costs (yen) / child:

Intervention vs. control group:

- Age 8: 131 vs. 5,348;
- Age 11: 1,087 vs. 11,953.

Cost effectiveness analysis:

Cost per DFT avoided /child/per year (yen):

- Age 8: 493;
- Age 11: 202.

Cost-benefit ratio:

Intervention vs. control group:

- Age 8: 1 : 1.84;
- Age 11: 1 : 2.42.

Secondary analysis: NR.

Sensitivity analysis: NR.

Notes

Limitations identified by author:

- Data limited to 1 school using a small sample size;
- Excluded patient, family and wider societal costs;
- Excluded costs related to supervision by teachers and management;
- Assumed decayed tooth was restored using standard method and may overstate costs;
- Sealant use in control may be under-reported;
- Time duration too short.

Limitations identified by review team:

- Perspective, use of fees not cost of treatment, no utilities, limited generalisability;
- Major issues are health-related resource in schools in Japan are greater than in England and generalisability of clinical effectiveness and cost data to England may be limited.

Evidence gaps and/or recommendations for future research:

- Long term benefit not measured.

Funding source: NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Skold UM, Petersson LG, Birkhed D, Norlund A. **Year:** 2008. **Citation:** Skold UM, Petersson LG, Birkhed D, Norlund A. (2008). Cost-analysis of school-based fluoride varnish and fluoride rinsing programmes. *Acta Odontol Scand*. 66(5):286-92. **Aim of study:** To examine the cost-effectiveness of a dental caries prevention programme of fluoride varnish treatment (FVT) or FMR, in an extended period of follow-up.	**Source population(s):** Simulated population of school age children (aged 13-16). **Setting:** School setting in Sweden, in a medium risk caries area. **Fluoridation:** NR. **Follow-up:** Programme was 3 years, with 5-year follow-up. **Data sources:** Benefits: Treatment effects of fluoride supplements were based on published results on an RCT [8] (FVT intervention) and a controlled trial [9] (FMR intervention), both set in schools in Sweden. Benefits monetarised by estimating treatments avoided	**Intervention(s):** School-based prevention programme of FVT and FMR. FVT was administered every 6 months, for a total of 6 times in 3 years; FMR was administered on the first and last 3 days of each school semester for a total of 36 times during the 3 year study period; both interventions were performed at school by a dental nurse. **Comparator(s):** The 2 studies on which the interventions were based had the same control group. **Sample size:** Results expressed as per 100 in each arm. **Total:** 300 **Intervention:** 100 FMR, 100 FVT. **Control:** 100.	**Outcomes:** • Number of avoided enamel and dentin fillings and re-fillings – objective; • Cost savings associated with avoided fillings - subjective. **Time horizon:** 8 years. **Discount rates:** 3% discount level. **Perspective:** Dental care perspective. **Measures of uncertainty:** NR. **Modelling method:** • A decision-tree analysis using excel simulated the programme for a hypothetical cohort of 100 students. • Model assumed a start from year 4. • The 'natural course' of caries development during the 3-year study and 5-year follow-up was based on the results of a longitudinal study of the development of caries in schoolchildren.[10] • Assumed 2.5% of restorations were replaced, per year. • Costs set in 2006 SEK value.

[8] Moberg Sköld U, Petersson LG, Lith A, Birkhed D. Effect of school-based fluoride varnish programmes on approximal caries in adolescents from different caries risk areas. Caries Res. 2005 Jul-Aug; 39(4):273-9.

[9] Moberg Sköld U, Birkhed D, Borg E, Petersson LG. Approximal caries development in adolescents with low to moderate caries risk after different 3-year school-based supervised fluoride mouth rinsing programmes. Caries Res. 2005 Nov-Dec; 39(6):529-35.

[10] Mejàre I, Källestål C, Stenlund H, Johansson H. Caries development from 11 to 22 years of age: a prospective radiographic study. Prevalence and distribution. Caries Res. 1998;32(1):10-6.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Type of economic analysis: Cost-effectiveness analyses. **Economic Perspective:** Dental care perspective. **Quality score:++** **Applicability:** Partially applicable.	and cost per treatment. <u>Costs</u>: Resource use per programme based on published studies. Programme costs included salaries of 2 dental nurses for 4 hours for FVT and 1 dental nurse for 4 hours per day for FMR, payroll taxes (year 2005), materials, overhead costs (11.85% based on a published study in Sweden) and transport cost of nurses; cost of school space excluded. Dental treatment costs based on the public fee structure in 2005 (SEK 825 per filling).		

Primary analysis:

<u>Number of avoided fillings compared to natural course</u> (per 100 students at end of 5 year follow-up):

<u>From enamel:</u>

- FVT: - 16.8;
- FMR: - 14.9.

<u>From dentin:</u>

- FVT: - 8.3;
- FMR: - 7.3.

<u>Avoided re-fillings:</u>

- FVT: - 2.2;

- FMR: - 1.9.

Per 100 students, there was an expected additional 3.2 avoided fillings in the FVT group compared to the FMR group.

Programme costs:
The expected cost of the FVT programme, according to the base case, was 43% lower per year than that of the FMR programme. FVT produced a better outcome at a better price.

Programme costs compared to utility (cost of avoided fillings):

- FVT: Savings of SEK 315 per avoided filling;
- FMR: Savings of SEK 63 per avoided filling.

FVT programme was more cost effective than the FMR programme; FVT was expected to result in possible cost containment.

Ratio of expected benefits to costs:

- FVT: 1.8 : 1;
- FMR: 0.9 : 1.

Secondary analysis: NR.
Sensitivity analysis:
The FVT programme results continued to produce a positive net value using the upper limits of the 95% CI for expected number of prevented fillings and varying the cost of the programme by ± 20%, with the exception if the programme was increased by 20% and the number of avoided fillings was based on the lower limit of the 95% CI.

The FMR resulted in a positive net value only at the upper limit of the 95% CI or if the programme costs were reduced by 20%.

The FMR programme results in a positive net present value at 0% discount rate only; while FVT remained positive using 0%, 3% and 5%.

Notes
Limitations identified by author:

- None reported.

Limitations identified by review team:

- The study was conducted in Sweden, which may limit the generalisability of the study to the current English context.

Evidence gaps and/or recommendations for future research:

- Longer-term benefit not measured.

Funding source: This study was supported by grants from the Swedish Patent Revenue Fund for Research in Preventive Dentistry.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Splieth CH, Fleba S. **Year:** 2008. **Citation:** Splieth CH, Fleba S. (2008). Modelling lifelong costs of caries with and without fluoride use. *European Journal of Oral Sciences.* 116: 164–169. **Aim of study:** To develop an economic prognostic model for the lifetime costs associated with caries treatment and to estimate the effect of caries prevention with fluorides.	**Source population(s):** Simulated population of 1 million individuals, aged 6 to 100 years, living in East Germany, without fluoride use. **Setting:** Germany. **Fluoridation:** No water fluoridation. **Follow-up:** Lifetime. **Data sources:** Data for the no fluoride (control group) was obtained from the Survey of Health In Pomerania (SHIP) study in East Germany, which included 4,310 participants aged 20-80 years. <u>Benefits</u>: • Treatment effectiveness	**Intervention(s):** <u>Interventions included</u>: • Fluoridated salt; • Fluoride gel, weekly home application; • Fluoridated toothpaste; • Professional biannual fluoride application; • Fluoridated salt + toothpaste; • Fluoridated salt + toothpaste + gel; • Fluoridated salt + toothpaste + gel + professional biannual fluoride application. **Comparator(s):** Restorative approach, no fluoride use during the lifetime. **Sample size:** **Total:** 1 million. **Intervention:** NR. **Control**: NR.	**Outcomes:** • Caries incidence over a lifetime-subjective; • Lifetime costs of dental treatments by fluoride regime - subjective. **Time horizon:** Lifetime. **Discount rates:** Costs were discounted at 5%. **Perspective:** NR. **Measures of uncertainty:** NR. **Modelling method:** • A system dynamics model, based on the principles of a Markov model was used; • Monthly transitional probabilities were applied, with 8 health states (healthy to failure of crown/replaced with bridge); • Dental caries prognosis data based on

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Type of economic analysis: Cost-effectiveness analyses. **Economic Perspective:** NR. **Quality score:** + **(++,+,-)** **Applicability:** Partially applicable.	based on published studies, including systematic reviews. <u>Costs</u>: • Costs of the different fluoride prophylaxis regimens were adapted from the literature and based on the German National Health Fee system and current German price levels; • Treatment costs were based on the German national health system.		published epidemiological literature conducted in Germany and other countries; • Treatment pathways were based on the eruption tables for permanent teeth, mortality table of Germany and current literature; • Caries development was predicted over the lifetime; • The model was restricted to the permanent dentition and third molars were excluded; • Data used for model of no fluoride scenario was based on SHIP data; • The price level is not stated but estimated to be 2007.

Primary analysis:

<u>Cost effectiveness of each fluoride regime was calculated under 4 conditions:</u>

- Fluoride use from age 6-18 years, constant effect;
- Fluoride use from age 6-18 years, decreasing effect past 18 years;
- Fluoride use from age 6-18 years, linearly increasing effect to 12 years then decreasing after 18 years;
- Lifelong use of fluoride, constant effect.

<u>Costs, lifetime (discounted at 5%):</u>

No fluoride scenario: euro (€) 932.

All preventative fluoride regimes resulted in lower overall costs than the no fluoride scenario (ranges based on 4 conditions):

- Fluoride salt: €246 to €305;
- Fluoride salt + Fluoride toothpaste: €191 to €248;
- Fluoride salt, Fluoride toothpaste + gel: €148 to €214;
- Fluoride salt, Fluoride toothpaste, gel + professional Fluoride application: €222 to €410;
- Professional Fluoride application: €457 to €579.

The combination of fluoride salt, fluoride toothpaste, and fluoride gel were most cost-effective. They reduced the costs for caries treatment and prophylaxis to €148 (5% discounting), when applied from age 6–18 years, and to €214 for lifelong use (present value, 5% discounting). **Secondary analysis:** NR. **Sensitivity analysis:** Sensitivity analysis of discount rates at 0%-10% conducted. Only at high discounting rates (> 9%) were preventive regimens with moderate effectiveness economically preferable, due to the fact that the higher costs of expensive restorations have to be paid later than the payments for prevention, which have to be paid earlier. Fluoride regimes always cost-effective compared to restorative approach.
Notes **Limitations identified by author:** • Treatment costs understated by excluding dental implants. **Limitations identified by review team:** • This study was conducted in Germany; the standard of care for dentistry in Germany and treatment pathways and assumptions used in the study may differ from the UK context; • The costs associated with this programme in Germany may differ substantially from current NHS and PSS costs; • The generalisability of the study to the UK context is limited. **Evidence gaps and/or recommendations for future research:** • None **Funding source:** NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Weintraub et al. **Year:** 1993. **Citation:** Weintraub JA, Stearns SC, Burt BA, Beltran E, Eklund SA. (1993). A retrospective analysis of the cost-effectiveness of dental sealants in a children's health center. *Social Science and Medicine.* 36(11):1483-93. **Aim of study:** To compare, under usual practice conditions, the cost-effectiveness of dental treatment with and without the inclusion of sealants among low-income children. **Type of economic analysis:** Cost-effectiveness analysis. **Economic Perspective:** NR.	**Source population(s):** 278 children, mean age 7.37 years. **Setting:** Setting is in a Mott Children's Health Center for low-income children in Flint, Michigan. **Fluoridation:** Community has fluoridation. **Follow-up**: Children were followed for a mean of 5.8 years, with a range of 3 and 11 years. **Data sources:** Treatment effect was measured as the number of years the tooth remained restoration-free from the 6th birthday until each child's last visit. This was based on a retrospective analysis of clinic data. Costs were calculated for restorations and sealants by using the 1985 American Dental Association median fee schedule.	**Intervention(s):** The intervention was use of dental sealants on at least one first permanent molar and at least 3 years between first and most recent dental visits. **Comparator(s):** The control group was matched to the test group on age distribution of the children at their first dental visit, who did not receive sealants on their tooth. **Sample size:** **Total:** 230. **Intervention:** 125. **Control:** 105.	**Outcomes:** • Cumulative number of years the tooth remained restoration-free – objective; • Cost of programme by child – subjective. **Time horizon:** Time horizon was based on the amount of time between the child's 6th birthday, which was assumed to be when first molars erupted, and last visit. The mean number of years between the first and last visit was 5.8 years, with a range of between 3 and 11 years. **Discount rates:** Years of survival and costs were both discounted using an annual rate of 5%. **Perspective:** NR. **Measures of uncertainty:** NR. **Modelling method:** • Conducted a lifetable analysis that looked at the cumulative years without restoration and the cumulative costs of treatment (sealant and restoration costs) for each year following the child's 6th birthday until a maximum of 11 years; • Each molar was at risk of decay either until a molar restoration was placed or for as long as the child was observed; • Each molar was at risk of costs (sealant

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Quality score: **- (++,+,-)** **Applicability:** Partially applicable.			or restoration costs) for as long as the child was observed; • In the lifetable analysis, partial years were excluded from the calculations; • Assumed all molars erupted at child's 6th birthday; • Grouped children by no sealant, any sealant or four first molars sealed.

Primary analysis:

Cumulative years without restorations, at 11 years:

- No sealants: 7.03;
- Any sealant: 7.13;
- 4 molars sealed: 8.51.

Cumulative cost per tooth, at 11 years:

- No sealants: $11.79;
- Any sealant: $19.93;
- 4 molars sealed: $17.79.

ICER:

ICERs became more favourable over time.

No sealant vs. any sealant: ICER was unfavourable until the 10th year of observation following the 6th birthday. Children with sealants incurred higher costs and few years of tooth survival, from year 1-10 following the 6th birthday. In the 11th year, sealants were still more costly, but the cumulative years of survival increased over the no sealant group.

The 11-year ICER was $81.96 per additional restoration-free tooth year using 5% discounting.

1st 4 molars sealed vs. no sealant: After 11 years, the discounted ICER was $4.06 per additional well tooth year.

The use of sealants became more favourable as time passed and was cost effective by the tenth year, with cost-effectiveness improving in the 11th year. However, the threshold for cost-effectiveness was not defined.

Secondary analysis: NR. **Sensitivity analysis:** No other analyses conducted.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Wennhall I, Norlund A, Matsson L, Twetman S. **Year:** 2010. **Citation:** Wennhall I, Norlund A, Matsson L, Twetman S. (2010). Cost-analysis of an oral health outreach programme for preschool children in a low socioeconomic multicultural area in Sweden. *Swedish Dental Journal.* 34(1): 1-7. **Aim of study:** Calculate total costs for implemented 3-year programme up to the age of 5 years, estimate net costs when adjusted for	**Source population(s):** Pre-school children, aged 2 years, living in Sweden. **Setting:** A low-socio-economic multi-cultural urban area in southern Sweden. **Fluoridation:** NR. **Follow-up:** 3 years. **Data sources:** Benefit: Treatment effect (number of caries avoided) is based on a non-randomised prospective study[11], which is reported in a separate publication. Costs: Programme costs were collected retrospectively and included labour costs (dentists,	**Intervention(s):** A 3-year oral health outreach programme of diet information, tooth brushing training and provision of free fluoride tablets, fluoride toothpaste, toy and pamphlets at each visit. The preschool children were regularly recalled to an outreach facility. **Comparator(s):** This study used a historical reference group as a control, consisting of children with a similar background, from the same area that were born immediately before the implementation of the project. **Sample size:** **Total:** Approx 1,600 children. **Intervention:** Approx 800 children. **Control:** Approx 800 children.	**Outcomes:** • Number of avoided fillings per child – objective; • Cost of programme by child – subjective; • Net cost of programme by child (cost of conventional care in reference group and revenue of avoided fillings in intervention group deducted) – subjective. **Time horizon:** 3 years. **Discount rates:** Costs were discounted at 3% for 3 years. **Perspective:** NR. **Measures of uncertainty:** 95% confidence intervals used in the calculation of the absolute risk reduction at 5 years of age. **Modelling method:** • No model was used; an aggregation of costs and financial savings was done; • Costs set at net 2008 SEK and

[11] Wennhall I, Matsson L, Schröder U, Twetman S. Outcome of an oral health outreach programme for preschool children in a low socioeconomic multicultural area. Int J Paediatr Dent 2008; 18:84-90.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
costs of conventional care and revenue of avoided fillings and estimate expected costs in a sensitivity analysis. **Type of economic analysis**: Cost analysis. **Economic Perspective**: NR. **Quality score:** **+ (++,+,-)** **Applicability:** Partially applicable.	dental nurses, dental hygienists), based on Swedish consumer price index reports; and material based on standardised prices (not further defined). Unit costs for fluoride tablets, overhead and cost of filling a molar were based on a Swedish Dental Care Reform paper of 2008.		converted to Euros (1 Euro = 9.6055 SEK).

Primary analysis:

- Prevented DEFS fraction of 27%.

Cost of programme:

- Total cost for 1 child to complete the 3-year programme was 310.11 Euro;
- The estimated cost per child for dental care in the control group, up to 5 years of age, was 96 Euro and the net present revenue for an average of three avoided fillings per child was estimated to 184 Euro (67.15 Euro per filling).

Net cost of programme:

- 30 Euro per child in the programme.

Secondary analysis: NR

Sensitivity analysis:

Using the limits of the 95% confidence interval of the benefits (DEFS) (1.66 to 4.34), the net costs of a minimum outcome was 109 Euro per child and the net costs of a maximum outcome was a net gain of 61 Euro per child.

Notes

Limitations identified by author:

- Indirect and intangible costs were not included;
- Longer term benefits in adolescence excluded;
- No replacements of fillings assumed;
- 50% overhead rate may be too high;
- Costs were divided by the number of children who enrolled in the programme at 2 years of age, and did not take into account the 19% who dropped-out, which may have led to an underestimation of the costs.

Limitations identified by review team:

- Limited data on effectiveness only states the mean caries prevalence and a prevented DEFS fraction of 27%;
- Confidence in results limited by lack of information on efficacy measure and how this applied in cost calculations.

Evidence gaps and/or recommendations for future research:

- Long-term benefit not measured.

Funding source: This study was supported by grants from Region Skåne, Sweden and from The Public Dental Service, Skåne, Sweden.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
Authors: Zabos GP, Glied SA, Tobin JN, Amato E, Turgeon L. **Year:** 2002. **Citation:** Zabos GP, Glied SA, Tobin JN, Amato E, Turgeon L. (2002). Cost-effectiveness analysis of a school-based dental sealant programme for	**Source population(s):** The population was school-age children in grades 1 and 6. **Setting:** Two elementary schools in low socioeconomic status area in New York, USA, with poor access to dentists due to low Medicaid participation rates among private dentists. Children had high caries prevalence, most untreated.	**Intervention(s):** Sealant intervention targeting first and second molars provided to one elementary school, through the Peekskill Area Health Centre's School-Based Caries Preventive Programme. Children also received weekly sodium fluoride rinses, oral hygiene instructions and referrals to family dentists or local health centre. **Comparator(s):** Children from no treatment school, matched to children in the treatment	**Outcomes:** • Change in decayed, missing or filled surfaces (DMFS) over 5 years – objective; • Cost of programme and dental expenses - subjective. **Time horizon:** 5 years. **Discount rates:** Discounted at 3%. **Perspective:** NR.

Study Details	Population and Setting	Intervention/Comparator	Outcomes and Methods of Analysis
low-socioeconomic-status children: a practice-based report. *Journal of Health Care for the Poor and Underserved*. 38-48 **Aim of study:** To evaluate clinical outcomes and cost-effectiveness of a school-based programme on the use of dental sealants in 1st and 6th graders. **Type of economic analysis:** Cost-effectiveness analyses. **Economic Perspective:** NR. **Quality score:** **+ (++,+,-)** **Applicability:** Partially applicable.	**Fluoridation:** Non-fluoridated water. **Follow-up:** 5 years. **Data sources:** Benefits: Treatment effect data obtained from the programme outcomes (a comparative cohort study, primary research). Costs: • Programme costs included personnel, equipment and supplies; • The unit cost per surface treated and for a bridge is stated but source is not described; • Dental treatment costs based on private practice.	group. **Sample size:** **Total:** 60. **Intervention:** 30. **Control:** 30.	**Measures of uncertainty:** Standard deviation (SD) for DMFS. **Modelling method:** • Assumed sealant costs were incurred in 1987 and other costs were incurred in 1990; • Assumed each child could have had a maximum of 140 healthy tooth surfaces at the end of the study; • Children were referred for dental services for repair of lost sealants, sealing of newly erupted teeth and referrals for comprehensive dental care; • Costs set in 1992 US dollar value.
Primary analysis: No difference in baseline DMFS between the 2 groups; Mean (SD) increase in DMFS at end of programme (after 5 years): • Sealant: 2.2 (6.0) (p = 0.003); • Control: 6.8 (7.0).			

Discounted costs of treatment (programme & dental expenses):

- Sealant: $1,720;
- Control: $2,100.

Benefits (teeth not missing, not decayed, not filled):

- Sealant: 3,565;
- Control: 3,460.

Sealant programme was cost effective compared to ordinary practice.

Secondary analysis: NR.

Sensitivity analysis:

Sensitivity analyses conducted on discount rates (3%-5%); cost of sealants ($9.20; $30.00); cost of filling ($45.00; $35.00); timing of decay and filling. Results were most sensitive to varying costs of administering sealants (from $9.20 to $30.00).

Under the sensitivity analysis, cost of producing a non-decayed and non-filled tooth surface = $27.00.
Cost of producing a current non-decayed tooth surface = $39.00.

Notes

Limitations identified by author:

- Cost of administering sealants was less ($9.20) than private practice ($30.00); if cost increased to private practice rates, it is no longer cost saving.
- Treatment costs in both arms were lower than ideal because decayed surfaces were not filled regularly and missing teeth were not replaced.
- Model excluded possible orthodontic treatment due to loss first molars.

Limitations identified by review team:

- Cost sources not clearly defined;
- Cost-effectiveness analysis based on small sample size with high dropout rate;
- The study was conducted in USA in 1987, which may limit the generalisability of the study to the current English context.

Evidence gaps and/or recommendations for future research:

- None.

Funding source: NR.

APPENDIX D

Studies excluded following selection of full papers

This appendix identifies the reasons why full papers selected for retrieval were not included in the final section. Sixty-three full papers were identified for assessment from full text but only 17 papers were assessed as relevant for inclusion in the systematic review.

The main criteria for exclusion were: non OECD country; not an economic evaluation and inappropriate population, intervention, comparator or setting.

Table D.1: Excluded studies with reasons for exclusion

Title	Authors	Journal	Rationale for exclusion
Papers which could not be retrieved			
Cost-effectiveness study of a school-based sealant program.	Werner, C. W., A. C. Pereira, et al	Journal of Dentistry for Children 2000 67(2): 93-97, 82.	Not available.
Cost minimisation analysis of two occlusal caries preventive programmes,	Arrow P.	Community Dental Health 2000; 17: 85-91.	Not available.
Papers excluded because they report same study			
Economic evaluation of a pit and fissure dental sealant and fluoride mouthrinsing programme in two nonfluoridated regions of Victoria, Australia.	Morgan, M. V., S. J. Crowley, et al.	Journal of Public Health Dentistry 1998 58(1): 19-27.	Duplicates the results in Crowley 1996
An evaluation of a primary preventive dental programme in non-fluoridated areas of Victoria, Australia.	Morgan, M. V., A. C. Campain, et al.	Australian Dental Journal 1997 42(6): 381-388.	Duplicates the results in Crowley 1996
Other rejected full papers			
Oral health delivery systems for older adults and people with disabilities.	Helgeson, M. and P. Glassman	Special Care in Dentistry. 2013:33; 177-89.	Not an economic evaluation.
Cost-effectiveness of preventive oral health care in medical offices for young Medicaid enrollees.	Stearns, S. C., R. G. Rozier, et al.	Archives of Pediatrics & Adolescent Medicine. 2012 166(10): 945-951.	Setting not relevant to England.
Cost-effectiveness of an individually tailored oral health educational programme based on cognitive behavioural strategies in non-surgical periodontal treatment.	Jonsson, B., K. Ohrn, et al.	Journal of Clinical Periodontology 2012 39(7): 659-665.	Inappropriate intervention.
Cost-effectiveness simulation of a universal publicly funded sealants application program.	Bertrand, E., M. Mallis, et al.	Journal of Public Health Dentistry 2011 71(1): 38-45.	Inappropriate intervention.

Title	Authors	Journal	Rationale for exclusion
Do interventions to prevent lifestyle-related diseases reduce healthcare expenditures? A randomized controlled clinical trial.	Babazono, A., K. Kuwabara, et al.	Journal of Epidemiology 2011 21(1): 75-80.	Not an economic evaluation.
Cost-effectiveness of an experimental caries-control regimen in a 3.4-yr randomized clinical trial among 11-12-yr-old Finnish school children.	Hietasalo, P., L. Seppa, et al.	European Journal of Oral Sciences 2009 117(6): 728-733.	Inappropriate intervention.
The Chemung County Perinatal Dental Coalition.	Curran, T.	New York State Dental Journal 2009 75(6): 37-42.	Inappropriate intervention.
Effects of a short behavioural intervention for dental flossing: randomized-controlled trial on planning when, where and how.	Schuz, B., A. U. Wiedemann, et al.	Journal of Clinical Periodontology 2009 36(6): 498-505.	Inappropriate intervention.
Cost-effectiveness of different caries preventive measures in a high-risk population of Swedish adolescents.	Oscarson, N., C. Kallestal, et al.	Community Dentistry & Oral Epidemiology 2003 31(3): 169-178.	Inappropriate intervention.
Practice-based study of the cost-effectiveness of fissure sealants in Finland.	Leskinen, K., S. Salo, et al.	Journal of Dentistry 2008 36(12): 1074-1079.	Inappropriate intervention.
Promoting oral health among the inner city homeless: a community-academic partnership.	Lashley, M.	Nursing Clinics of North America 2008 43(3): 367-379, viii.	Not an economic evaluation.
Four-year cost-utility analyses of sealed and nonsealed first permanent molars in Iowa Medicaid-enrolled children.	Bhuridej, P., R. A. Kuthy, et al.	Journal of Public Health Dentistry 2007 67(4): 191-198.	Inappropriate intervention.
Reduction of caries in rural school-children exposed to fluoride through a milk-fluoridation programme in Araucania, Chile.	Weitz, A., M. I. Marinanco, et al.	Community Dental Health 2007 24(3): 186-191.	Inappropriate intervention.
Cost-effectiveness of a long-term dental health education program for the prevention of early childhood caries.	Kowash, M. B., K. J. Toumba, et al.	European Archives of Paediatric Dentistry: Official Journal of the European Academy of Paediatric Dentistry 2006 7(3): 130-135.	Inappropriate intervention.
Simulating cost-effectiveness of fluoride varnish during well-child visits for Medicaid-enrolled children.	Quinonez, R. B., S. C. Stearns, et al.	Archives of Pediatrics & Adolescent Medicine 2006 160(2): 164-170.	Setting not relevant to England.
Efficiency of a schoolchildren program for oral care.	Bordoni, N., A. Squassi, et al.	Acta Odontologica Latinoamericana 2005 18(2): 75-81.	Not an economic evaluation.

Title	Authors	Journal	Rationale for exclusion
The effectiveness and estimated costs of the access to baby and child dentistry program in Washington State.	Kobayashi, M., D. Chi, et al.	Journal of the American Dental Association 2005 136(9): 1257-1263.	Not an economic evaluation.
Comparing the costs of three sealant delivery strategies.	Griffin, S. O., P. M. Griffin, et al.	Journal of Dental Research 2002 81(9): 641-645.	Setting not relevant to England.
Treatment outcomes and costs of dental sealants among children enrolled in Medicaid.	Weintraub, J. A., S. C. Stearns, et al.	American Journal of Public Health 2001 91(11): 1877-1881.	Setting not relevant to England.
Evaluation of oral health promotion in the workplace: the effects on dental care costs and frequency of dental visits.	Ide, R., T. Mizoue, et al.	Community Dentistry & Oral Epidemiology 2001 29(3): 213-219.	Inappropriate intervention.
Economic implications of evidence-based caries prevention in pediatric dental practice: a model-based approach.	Nainar, S. M.	Pediatric Dentistry 2001 23(1): 66-70.	Setting not relevant to England.
Sealants and xylitol chewing gum are equal in caries prevention.	Alanen, P., M. L. Holsti, et al.	Acta Odontologica Scandinavica 2000 58(6): 279-284.	Not an economic evaluation.
Identification of caries risk children and prevention of caries in pre-school children.	Holst, A., I. Martensson, et al.	Swedish Dental Journal 1997 21(5): 185-191.	Not an economic evaluation.
Treatment and posttreatment effects of fluoride mouthrinsing after 17 years.	Kobayashi, S., H. Kishi, et al.	Journal of Public Health Dentistry 1995 55(4): 229-233.	Not an economic evaluation.
Effect of a 3-year professional flossing program with chlorhexidine gel on approximal caries and cost of treatment in preschool children.	Gisselsson, H., D. Birkhed, et al.	Caries Research 1994 28(5): 394-399.	Not an economic evaluation.
A fissure sealant pilot project in a third party insurance program in Manitoba.	Cooney, P. V. and F. Hardwick	Journal Canadian Dental Association 1994 60(2): 140-145.	Not an economic evaluation.
Integrated caries prevention: effect of a needs-related preventive program on dental caries in children. County of Varmland.	Axelsson, P., J. Paulander, et al.	Caries Research 1993 27 Suppl 1: 83-94	Not an economic evaluation.
Evidence summary: Is smoking cessation an effective and cost effective service to be introduced in NHS dentistry?	Nasser, M. and Z. Powell.	British Dental Journal 2011 210(4): 169-177.	Not an economic evaluation.
Risk-based early prevention in comparison with routine prevention of dental caries: A 7-year follow-up of a controlled clinical trial; clinical and	Pienihakkinen, K., J. Jokela, et al.	BMC Oral Health 2005 5(2).	Not an economic evaluation.

Title	Authors	Journal	Rationale for exclusion
economic aspects.			
The impact of changing dental needs on cost savings from fluoridation (Provisional abstract).	Campain, A. C., R. J. Marino, et al.	Australian Dental Journal 2010 March 55 (1): 37-44.	Inappropriate intervention.
Assessing cost-effectiveness of sealant placement in children.	Quinonez, R. B., S. M. Downs, et al.	Journal of Public Health Dentistry 2005 65 (2): 82-89.	Inappropriate intervention.
Restorative cost savings related to dental sealants in Alabama Medicaid children.	Dasanayake, A. P., Y. Li, et al.	Pediatric Dentistry 2003 25 (6): 572-576.	No outcomes.
Modelling the long-term cost-effectiveness of the caries management system in an Australian population.	Warren, E., C. Pollicino, et al.	Value in Health 2010 13 (6): 750-760.	Inappropriate intervention.
Economic evaluation of a risk-based caries prevention program in preschool children.	Jokela, J. and K. Pienihakkinen.	Acta Odontologica Scandinavica 2003 61 (2): 110-114	Setting not relevant to England
Economic aspects of the detection of occlusal dentine caries.	Norlund, A., S. Axelsson, et al.	Acta Odontologica Scandinavica 2009 67 (1): 38-43	Inappropriate intervention.
Seal or Varnish? A randomised trial to determine the relative cost and effectiveness of pit and fissure sealants and fluoride varnish in preventing dental decay.	Chestnutt I., G. Chadwick B. L. et al.	Health Technology Assessment Database 2011(2). Project in progress.	Not an economic evaluation.
Preventing dental caries	Axelsson, S., H. Dahlgren, et al.	Swedish Council on Technology Assessment in Health Care 2002	Not an economic evaluation.
A randomised control trial to measure the effects and costs of a dental caries prevention regime for young children attending primary care dental services.	Tickle M., Milsom K.M.	Health Technology Assessment Database 2010(2). Project in progress.	Not an economic evaluation.
Fluoride in the prevention of dental caries: a tentative cost-benefit analysis.	Davies, G. N.	British Dental Journal 1993 135(2) 173-174.	Inappropriate intervention.
Comparative cost and time analysis over a two-year period for children whose initial dental experience occurred between ages 4 and 8 years.	Doykos J D, III	Pediatric Dentistry 1997 19(1):61-62.	Setting not relevant to England.
How often should a preventative procedure be repeated? An economic analytic model applied to dentistry.	Tzukert AA, Sgan-Cohen HD, Call R.	Community Dentistry and Oral Epidemology 1996 14:138-141.	Not an economic evaluation.