Community Dental Health (2016) **33,** 138–144
Received 15 October 2015; Accepted 15 December 2015

doi:10.1922/CDH_3875Bergström07

Caries and costs: an evaluation of a school-based fluoride varnish programme for adolescents in a Swedish region

E-K. Bergström[1, 2], P. Lingström[1], M. Hakeberg[3], L. Gahnberg[2] and U.M. Sköld[1]

[1]*Department of Cariology, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Sweden;* [2] *Department of Preventive and Community Dentistry, Public Dental Health Service, Västra Götaland Region, Sweden;* [3]*Department of Behavioral and Community Dentistry, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Sweden*

In 2003, 19 public dental clinics in Västra Götaland Region implemented a population-based programme with fluoride varnish applications at school every six months, for all 12 to 15 year olds. In 2008, the programme was extended to include all 112 clinics in the region. ***Objective:*** To evaluate caries increment and to perform a cost analysis of the programme. ***Basic research design:*** A retrospective design with caries data for two birth cohorts extracted from dental records. Three groups of adolescents were compared. For Group 1 (n=3,132), born in 1993, the fluoride varnish programme started in 2003 and Group 2 (n=13,490), also born in 1993, had no fluoride varnish programme at school. These groups were compared with Group 3 (n=11,321), born in 1998, when the programme was implemented for all individuals. The total cost of the four-year programme was estimated at 400SEK (≈44€) per adolescent. ***Results:*** Caries prevalence and caries increment in 15 year olds were significantly lower after the implementation of the programme. Group 2, without a programme, had the highest caries increment. The cost analysis showed that it was a break-even between costs and gains due to prevented fillings at the age of 15. ***Conclusions:*** This school-based fluoride varnish programme, implemented on a broad scale for all 12 to 15 year olds, contributed to a low caries increment at a low cost for the adolescents in the Västra Götaland Region in Sweden.

Key words: *adolescent, caries prevalence, dental caries, fluoride varnish, prevention, school based prevention*

Introduction

The mechanisms of fluoride are well known and the ability of fluoride to control caries is primarily due to its topical effect on tooth surfaces. Even in low concentrations, topical fluorides are able to reduce enamel demineralisation and enhance remineralisation (Buzalaf *et al.*, 2011; ten Cate, 2013). The use of fluoride is seen as one of the most important factors for the improved dental health among children and adolescents in the world (Bratthall *et al.*, 1996). Fluoride toothpaste is probably the main source of fluoride for most children and adolescents today, with strong evidence regarding its efficacy in caries prevention (Marinho *et al.*, 2003). In addition, fluoride rinses and fluoride varnishes have a well-documented effect in caries prevention (Marinho *et al.*, 2013; Poulsen, 2009). Sweden has a tradition of population-based prevention aimed at improving dental health. Back in the 1960s, programmes for school-based fluoride rinsing were designed and evaluated, showing a well-documented caries-reducing effect (Torell and Ericsson, 1965).

Fluoride varnishes contain high levels of fluoride and are designed for optimal retention to the tooth, prolonging the contact time between the enamel surface and the varnish. In a meta-analysis by Helfenstein and Steiner (1994), the caries reduction on permanent teeth was estimated at 38%. In 1998-2001, Moberg Sköld *et al.* (2005) conducted a study of school-based fluoride varnish programme for adolescents from different caries risk areas in the Västra Götaland Region in Sweden. The results showed that fluoride varnish every six months had a significant caries-preventive effect in reducing new approximal caries lesions, especially in medium and high caries risk areas. The study led to the implementation of a population-based programme with fluoride varnish applications at school every six months, for adolescents aged 12 to 15 at 19 clinics in the Public Dental Service, in one part of the Västra Götaland Region, in 2003. This school-based fluoride varnish programme was then extended to include all 112 clinics in the Västra Götaland Region in 2008.

A systematic review from 2003 of 17 studies with economic evaluations of different caries preventive programmes stated that those studies did not provide support for the economic value of caries prevention, but concluded that "the scarcity of well-conducted studies, as well as contradictory evidence in the reviewed articles, makes it difficult to judge the health-economic effect of the studied caries-prevention methods" (Källestål *et al.* 2003). More recently, a fluoride rinsing programme was compared with a fluoride varnish programme in terms of cost containment, by Moberg Sköld *et al.*, (2008). A better result for the fluoride varnish programme was found, given that the programme could be performed at school. Nevertheless, no evaluation of the efficacy of a school-based fluoride programme implemented on a broad scale and in field conditions has been performed, neither concerning caries prevention nor costs.

Correspondence to: Eva-Karin Bergström, Department of Cariology, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Box 450, SE-405 30 Gothenburg, Sweden. Email: eva-karin.bergstrom@vgregion.se

Figure 1. *Fluoride varnish programme in school: information and flossing in groups, application of fluoride varnish and lessons on oral health and tobacco use*

The aims of this study were therefore to evaluate the caries increment after the implementation of a school-based fluoride varnish programme for 12 to 15 year olds, in the Västra Götaland Region in Sweden and to perform a cost analysis of the programme. The null hypothesis was that the fluoride varnish programme would not have any effect on caries increment and that the costs would thereby exceed the decrease in costs due to prevented fillings.

Method

The Västra Götaland Region, in the south-western part of Sweden, consists of 49 municipalities with more than 1.6 million inhabitants, approximately 350,000 inhabitants of whom are children and adolescents under 18 years. The Public Dental Service gives tax-subsidised dental care to more than 95% of the children and adolescents in the region. Since 2008, all public dental clinics in the region have performed a population-based fluoride varnish programme for all 12 to 15 year olds at school.

The fluoride varnish programme was mostly performed by dental nurses from the public dental clinics. The dental nurses met the adolescents at school in small groups for fluoride varnish applications (Duraphat®, 2.26% F) every six months, from the 6th to the 9th classes. In addition, the adolescents participated in two lessons on oral health and tobacco use during this time, illustrated in Figure 1. Before the fluoride varnish applications, the adolescents were instructed to floss their teeth under supervision. The fluoride varnish applications were made using a syringe. Fluoride varnish was applied to all approximal surfaces from the distal surface of the canine to the mesial surface of the second molar. This procedure was designed after an earlier study by Moberg Sköld *et al.* (2005), performed in the same region.

This programme was a complement to the daily use of fluoride toothpaste at home and regular dental check-ups at the public dental clinics, normally with an interval of 18 months for adolescents when the risk of caries was considered to be low or medium. At these check-ups the adolescents received one fluoride varnish application. The small number of adolescents considered to have a high risk of caries were invited for dental check-ups every 12 months and received supplementary individual treatments at the clinics. The risk calculation was based on a number of factors, such as dietary and tooth-brushing habits and previous caries experience. This means that, for the majority of the adolescents, the school-based fluoride varnish programme constituted the main part of caries prevention during these ages. The fluoride content in the drinking water is generally low in this region, as Sweden do not fluoridate the drinking water.

Of the 112 public dental clinics which started with the fluoride varnish programme in 2008, 15 were defined as situated in areas were the adolescents had an increased risk of caries due to socio-economic reasons. In those areas, the school-based fluoride varnish programme started already when the children were six years old and the number of fluoride varnish treatments at school were 4-8 times per year, for the adolescents in Group 3 (Intervention 2008).

As Sweden has a system with tax-subsidised dental care for all children and adolescents up to the age of 19 and in the Västra Götaland Region up to the age of 24, the dental check-ups and the school-based fluoride varnish programme were free of charge to the adolescents.

A retrospective longitudinal design was used. Caries data for adolescents in two birth cohorts were extracted from the dental records at the Public Dental Service's dental health-care register in Västra Götaland, Sweden. All the adolescents had attended dental check-ups at a public dental clinic in the Västra Götaland Region, Sweden.

Table 1. Number of participants in each group, year of birth and year of caries data extraction - Groups 1 and 3 were the intervention groups with a fluoride varnish programme at school, while Group 2 was the control

Group	*N*	*Birth cohort*	*Fluoride varnish at school from 12-15 years*	*Extracted data for years*
1, Intervention 2003	3,132	1993	Yes	2005-2008
2, Historical control	13,490	1993	No	2005-2008
3, Intervention 2008	11,321	1998	Yes	2010-2013

Table 2. Number of identified dental records in the three groups, number of involved public dental clinics and number of adolescents with dental check-ups at age 12 to 15

	Group 1, Intervention 2003	*Group 2, Historical control*	*Group 3, Intervention 2008*
Number of dental records	3,132	13,490	11,321
Number of public dental clinics	19	92	112
Dental check-up at age 12	2,550	10,160	10,624
Dental check-up at age 13	2,204	8,348	5,785
Dental check-up at age 14	1,957	8,266	8,285
Dental check-up at age 15	1,992	7,781	6,978

In 2003, 19 public dental clinics started a school-based fluoride varnish programme, while all 112 public dental clinics started the programme in 2008. Three groups of adolescents, two born in 1993 and one born in 1998, were compared. Group 1 (Intervention 2003), born in 1993, belonged to those clinics which started the fluoride varnish programme in 2003 and Group 2 (Historical control), also born in 1993, had no fluoride varnish programme at school. These groups were compared with Group 3 (Intervention 2008), born in 1998, which all had a fluoride varnish programme at school (Table 1).

In Group 1 (Intervention 2003), a total of 3,132 dental records were identified. In this group, 45% of the adolescents had attended dental check-ups three times between the ages of 12 to 15 years (at intervals of 18 months), 25% had attended dental check-ups twice, 21% had attended dental check-ups four times and 9% had attended dental check-ups once during this period. The corresponding numbers for Group 2 (Historical control) were 13,490 identified dental records, where 47% of the adolescents had attended dental check-ups three times, 30% had attended dental check-ups twice, 11% had attended dental check-ups four times and 12% had attended dental check-ups once during this period. In Group 3 (Intervention 2008), a total of 11,321 dental records were identified and 55% of the adolescents had attended dental check-ups three times between the ages of 12 and 15 years, 22% had attended dental check-ups twice, 16% had attended dental check-ups four times and 7% had attended dental check-ups once during this period. Table 2 shows the total number of adolescents with dental check-ups in each group and each year. 48% of the participants in all groups were girls and 52% were boys, and the gender distribution in the groups was even.

For the ability to evaluate the caries increment, those adolescents attending dental check-ups both at the age of 12 and at the age of 15 were specifically identified. This enabled the caries increment to be defined as the caries prevalence at the age of 15 minus the caries prevalence at the age of 12. For this calculation, 1,584 adolescents were identified in Group 1 (Intervention 2003), 5,831 adolescents in Group 2 (Historical control) and 6,527 adolescents in Group 3 (Intervention 2008).

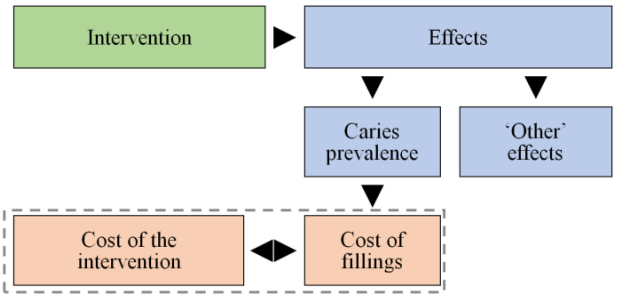

Figure 2. *The cost analysis model: the intervention leads to effects on caries prevalence and possible other effects. A reduction in caries prevalence leads to reduced costs for fillings. The cost of the fillings is compared with the cost of the intervention. Other effects are not analysed in this model*

Data were collected from the dental records in the Public Dental Services in Västra Götaland, Sweden, using a script. For each adolescent, the following information was extracted; Clinic, Gender, Number of Decayed and/or Filled Teeth (DFT), number of Decayed and/or Filled approximal Surfaces (DFSa) and number of approximal enamel lesions (DeSa), for each year, from 2005-2008, for those born in 1993 (Group 1 and Group 2), and from 2010-2013, for those born in 1998 (Group 3). DFT and DFSa express caries into dentin and DeSa caries into enamel.

Preventive fraction was measured as the difference in mean caries increment between the intervention groups and the historical control group, and was expressed as a percentage of the mean increment in the control group (Kleinbaum *et al.*, 1982).

The cost analysis aimed to evaluate the difference between the intervention cost and the assumed cost decrease due to possible prevented fillings under a period of four years. The cost-analysis model is described in Figure 2. The intervention, the fluoride varnish programme, possibly leads to a reduction in caries prevalence, which leads to lower costs for fillings. This cost decrease due to prevented fillings are compared with the cost of the intervention (prevented fillings being here the difference in DFSa and not in enamel

lesions which would not be filled). An intervention will most probably have additional effects. If there is a reduction in caries prevalence, there is consequently an increase in dental health, possibly resulting in improved quality of life, fewer visits to dental clinics or other effects, but those effects are not analysed in this model. This means that we performed a partial cost analysis taking only in consideration clinical costs.

The cost of the programme was estimated at approximately 100SEK (≈11€) per adolescent and year, based on the reimbursement which covered all necessary services in the programme. Therefore, the value of the reimbursement in this study is equal to the total cost of the intervention. The programme was free of charge to the participating adolescents.

The cost reduction is based on the statistical results that show the difference in DFSa between Group 2 (Historical control) and Group 3 (Intervention 2008), during the same period, from 12 to 15 years. This means two groups, with similar socioeconomics and sample size, were compared regarding the need for approximal fillings during the study period. The cost of a filling on two surfaces (i.e. a filling of an approximal caries lesion) is estimated at 1,087SEK, according to the pricelist in the region (2013). However, all dental care, including fillings, are free of charge for the adolescents in the region.

Descriptive statistics, analysis of variance and general linear models for repeated measures were used using SPSS v.21 with $P<0.05$ was applied for statistical significance.

Table 3. Caries prevalences: DFT, DFSa, DeSa, total caries DFSa + DeSa, in the three groups at ages 12, 13, 14 and 15 years

	Group 1 Intervention 2003 Mean, SD	*Group 2 Historical control Mean, SD*	*Group 3 Intervention 2008 Mean, SD*
As 12 year-olds			
DFT	0.56, 1.08	0.86, 1.44	0.76, 1.32
DFSa	0.12, 0.48	0.22, 0.70	0.18, 0.62
DeSa	0.57, 1.47	0.86, 1.74	0.67, 1.58
Total caries prevalence	0.68, 1.61	1.08, 2.04	0.83, 1.80
As 13 year-olds			
DFT	0.71, 1.27	1.09, 1.69	0.88, 1.50
DFSa	0.17, 0.59	0.30, 0.87	0.22, 0.74
DeSa	0.84, 2.07	1.25, 2.43	1.05, 2.26
Total caries prevalence	1.01, 2.31	1.56, 2.83	1.31, 2.63
As 14 year-olds			
DFT	0.90, 1.50	1.35, 1.98	1.10, 1.76
DFSa	0.23, 0.73	0.40, 1.09	0.30, 0.95
DeSa	1.37, 2.96	1.72, 3.05	1.18, 2.55
Total caries prevalence	1.61, 3.28	2.14, 3.57	1.48, 3.00
As 15 year-olds			
DFT	1.13, 1.73	1.59, 2.22	1.25, 1.94
DFSa	0.31, 0.89	0.51, 1.31	0.37, 1.11
DeSa	1.86, 3.42	2.18, 3.53	1.61, 3.05
Total caries prevalence	2.18, 3.82	2.70, 4.19	2.00, 3.59

DFT = Decayed and/or Filled Teeth, DFSa = approximal surfaces with fillings and/or dentin lesions,
DeSa = approximal surfaces with enamel lesions, Total caries prevalence = DFSa + DeSa

The fluoride varnish programme at school was part of the regular prevention and health-promotion strategy in the region. An ethical review of the extraction of data from the dental records was performed and approved by the Regional Ethical Review Board in Gothenburg, Sweden (Dnr: 273-14).

Results

The caries prevalence (mean and SD) at the age of 12, 13, 14 and 15 years in all groups is presented in Table 3. Group 2 (Historical control), without any prevention programme, had the highest caries prevalence. Group 1 (Intervention 2003) and Group 3 (Intervention 2008) had significantly lower caries prevalence. The total approximal caries prevalence (DFSa + DeSa) ranged from 0.68 (SD 1.61) to 1.08 (SD 2.04) at 12 years of age increasing from 2.00 (SD 3.59) to 2.70 (SD 4.19) at 15 years of age, and the differences were statistically significant ($P<0.01$). Group 1 (Intervention 2003) had the lowest caries prevalence at 12 and 13 years of age. At age 14 and 15, Group 3 (Intervention 2008) had a lower caries prevalence regarding enamel lesions (DeSa), but Group 1 (Intervention 2003) had a lower DFT and DFSa.

Approximal enamel lesions (DeSa) accounted for the major part of the total approximal caries prevalence, ranging from 83-86% in Group 1 (Intervention 2003) to 79-81% in Group 2 (Historical control) and 79-84% in Group 3 (Intervention 2008).

The caries increment was calculated on those adolescents who had attended their regular check-ups both at the age of 12 and at the age of 15. The calculation showed a total approximal caries increment (DFSa + DeSa) from 12 to 15 years of 1.41 for Group 1 (Intervention 2003), 1.60 for Group 2 (Historical control) and 1.09 for Group 3 (Intervention 2008) and are presented in Table 4. The substantial part of the increment consisted of approximal enamel lesions (DeSa), ranging from 80% in Group 3 (Intervention 2008), at 12 years, to 86% in Group 1 (Intervention 2003), at 15 years.

General Linear Models showed statistically significant differences within groups and also between the groups over time ($P<0.001$), indicating a lower caries increment for Group 1 and Group 3, which took part in the fluoride varnish programme at school, compared with Group 2 which was the historical control (Figure 3).

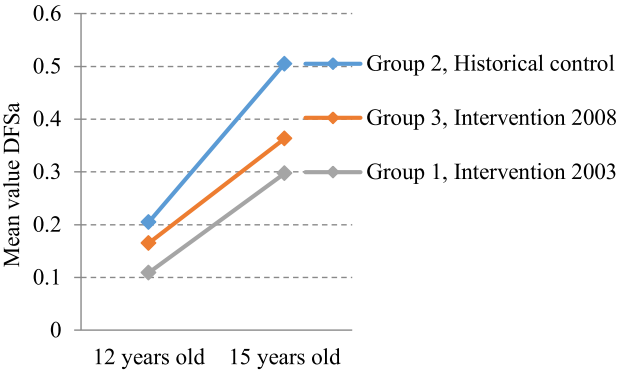

Figure 3. *General Linear Models showing the differences in approximal caries increment (DFSa) between the groups from 12 to 15 years*

Table 4. Caries increment from 12 to 15 years in the three groups, calculated for the same individuals attending dental check-ups at both the ages (mean, SD)

	Group 1, Intervention 2003 N=1,584			*Group 2, Historical control N=5,831*			*Group 3, Intervention 2008 N=6,527*		
	12yr-olds Mean, SD	*15yr-olds Mean, SD*	*Increment*	*12yr-olds Mean, SD*	*15yr-olds Mean, SD*	*Increment*	*12yr-olds Mean, SD*	*15yr-olds Mean, SD*	*Increment*
DFSa	0.11, 0.45	0.30, 0.88	0.19	0.21, 0.65	0.51, 1.31	0.30	0.17, 0.58	0.36, 1.07	0.19
DeSa	0.59, 1.52	1.81, 3.41	1.22	0.90, 1.77	2.19, 3.54	1.29	0.68, 1.62	1.58, 3.04	0.90
Total caries prevalence	0.70, 1.66	2.11, 3.78	1.41	1.10, 2.03	2.70, 4.20	1.60	0.85, 1.83	1.94, 3.56	1.09

DFSa = approximal surfaces with fillings and/or dentin lesions; DeSa = approximal surfaces with enamel lesions; Total caries prevalence = DFSa + DeSa

Table 5. Cost analysis of the programme and calculation of the differences in DFSa comparing Group 2 (Historical group) with Group 3 (Intervention 2008)

Age, years	*Group 2 DFSa, Historical control*	*Group 3 DFSa, Intervention 2008*	*Difference in DFSa* [1]	*Decrease in cost, SEK*[2]	*Cost of the programme, SEK*[3]	*Accumulated outcome, SEK*[4]
12	0.22	0.18	0.04	43	100	-57
13	0.30	0.22	0.08	87	100	-70
14	0.40	0.30	0.10	109	100	-61
15	0.51	0.37	0.14	152	100	-9
Actual costs and savings from 12-15 years				391	400	-9
16			0.18	196	0	187
17			0.22	239	0	426
18			0.26	283	0	709
19			0.30	326	0	1,035
Estimated costs and savings from 12-19 years				1,435	400	1,035

[1] The difference in caries prevalence (DFSa) calculated as Group 2 (Historical control) minus Group 3 (Intervention 2008);
[2] Number of prevented fillings multiplied by 1,087SEK: the cost of a two-surface filling according to the regional pricelist;
[3] The total cost of the programme per adolescent and year; [4] The difference in caries prevalence multiplied by 1,087SEK minus the cost of the programme, accumulated for each year

The preventive fraction, the difference in caries increment expressed as a percentage of the increment in Group 3 (Historical control), was in Group 1 (Intervention 2003) 12% and in Group 3 (Intervention 2008) 32%. The diagnostic threshold was approximal enamel lesions.

The cost of the fluoride varnish programme in this region, estimated at 100SEK per adolescent and year, resulted in a total of 400SEK per adolescent from 12-15 years. According to the pricelist in the region, the cost of a filling on two surfaces (i.e. a filling of an approximal caries lesion) is estimated at 1,087SEK (2013). The cost decrease produced by the programme could therefore be described as the difference in DFSa between Group 2 (Historical control) and Group 3 (Intervention 2008) multiplied by 1,087SEK. This means that it is possible that the fluoride varnish programme, during this four-year period, prevented fillings for a total cost of 391SEK for each individual taking part (Table 5). Assuming the difference in caries increment between the groups continues to grow up to the age of 19, this means the decrease in fillings could be estimated at a cost of 1.435SEK.

Discussion

This study showed that the caries prevalence and caries increment in 15 year olds was significantly lower after the implementation of a population-based fluoride varnish programme. This programme was implemented in field conditions on a broad scale at all secondary schools in the Västra Götaland Region in Sweden. This meant that the null hypothesis could be rejected, as the caries increment was significantly lower for the groups participating in a fluoride varnish programme. In addition, the reduction in fillings as a consequence of the reduction in caries prevalence meant that the cost of the programme appeared to be profitable for both the Public Dental Service (society) and, in the longer perspective, the participating adolescents.

Many studies have shown that fluoride varnish programmes are effective in promoting dental health (Helfenstein *et al*., 1994; Marinho *et al*., 2013; Moberg Sköld *et al*., 2005; Petersson *et al*., 2004). The Swedish Council on Technology Assessment in Health Care (2002) calculated the caries-preventive effect at 30%, which is similar to the findings in our study. Nevertheless, recently published data from one part of the Västra Götaland Region, relating to adolescents aged between 12 and 15 years, did not show any caries preventive effect from a fluoride varnish programme (Bergström *et al*., 2014). This is in contrast to the findings in this study. The low caries prevalence and the lack of a blind control group could have affected the results in that study.

Oscarson *et al*. (2003) performed a study of cost effectiveness from a societal perspective with the aim of comparing the costs and consequences of different caries-prevention programmes in a caries high-risk population. The estimated cost of the prevention in that study was similar to the cost of the intervention in our study, especially in high-risk groups, even though that study was performed 10 years earlier.

There is a need for studies or evaluations of programmes conducted in field conditions. The programme in the present study was implemented on a broad scale and has been running for more than five years with the aim to continue for many years. However, as this fluoride varnish programme was not designed as a clinical study, but as a general intervention, comparisons have to be made with historical control groups or groups from different areas with different settings. The possibility of finding matching areas without population-based interventions is challenging, as most parts of Sweden have some kind of population-based prevention for adolescents. In this study we chose to compare a small group, which started with a fluoride varnish programme at an early stage, with a larger group in the same birth cohort, which did not have a fluoride varnish programme. These groups were in turn compared with the group attending the programme at a later stage, with an awareness of its possible bias. The most obvious bias is the fact that dental health has improved between 2005 and 2013 and it is not possible to define the exact role of the fluoride varnish programme in this improvement. It is also important to remember that, even before the implementation of a fluoride varnish programme, efforts were made to promote dental health and prevent caries. The fact that the caries increment in Group 3 (Intervention 2008), where everyone participated in the fluoride varnish programme, was very similar to the caries increment in Group 1 (Intervention 2003), where the participants started the fluoride varnish programme in 2003 could support the idea of a more structured population-based prevention, including the use of fluoride varnish, at school. This is in line with the study by Moberg Sköld *et al*. (2005), who also stated that the economic efficiency of the school-based fluoride varnish programmes must be evaluated.

In this study, all adolescents attending dental check-ups at the Public Dental Service, in two birth cohorts, were analysed. This meant that even adolescents who, for example, chose not to participate in the fluoride varnish programme at school belonged to the "intervention groups". It is, however, important to remember that all population-based programmes will fail to reach every single person in the target population. A true evaluation of a programme could therefore benefit from including even those "non-participants" in the analysis, as they are part of the population and part of the outcome of a programme. Furthermore, even those adolescents who for some reason choose to decline fluoride varnish still participate in oral health education, receive information about oral home care and are reminded about dental health every time their classmates participate in the fluoride varnish programme. Receiving regular visits from dental personnel in school could possibly affect awareness of dental health.

One major challenge in caries research is the measurement of caries. In this study, caries data were collected from 114 public dental clinics and the examinations of the subjects were made in 2005-2013. This means that the study population's dental check-ups were made by a large number of examiners. When conducting caries research, it is more common to allow one or a few specially trained examiners to conduct the caries examinations. The quality of data from dental records are debateable, but, in spite of this, dental records from a wide variety of examiners are also the source of official caries data. Moreover, a study by Hausen *et al*. (2001) compared caries data for 824 children, by collecting both data from patient records and data from trained examiners, in Finland. The conclusion from the study was that, in large enough settings, data obtained from patient records could be used, as they are not decisively inferior to those obtained from examinations by trained examiners. This applies within countries, such as Sweden, where uniform patient records are available and where, on a national basis, the health authorities have given uniform instructions for record keeping.

The cost analysis of the fluoride varnish programme was limited to comparing the cost, in time and money, of the programme with the reduced number of fillings, i.e. costs avoided. An intervention like this inevitably also has other effects and, not the least, a reduction in caries prevalence means better dental health for the participants. No further analysis of those effects was performed, but, as the results showed a decrease in caries and a break-even in costs at age 15 the programme is clearly cost effective. In addition, the fluoride varnish programme had no negative effects, which is important in a programme like this. This matches the findings of the study by Seppä (1999), stating that fluoride varnishes are easy to apply, effective and safe.

Furthermore, the calculations in our study assumed that the control group did not have any costs for prevention, which is probably not true. Even though there was no common preventive programme for the adolescents in the control group, some of the public dental clinics probably spent both money and time on preventive measures before the implementation of the fluoride varnish programme on a broad scale. This means that calculations could have shown even greater cost effectiveness when comparing the cost of the programme with the costs saved on fillings. In this study, the effect on caries prevalence is known until the age of 15, but a longer follow-up period would probably continue to show a difference between the intervention and the control groups, giving even greater costs savings. This is based on the knowledge acquired from several studies that have shown positive effects for many years after the end of a fluoride programme (Haugejorden *et al*., 1990; Kobayashi *et al*., 1995; Leske *et al*., 1986).

Conclusion

This evaluation showed that a school-based fluoride varnish programme, implemented on a broad scale in field conditions, contributed to a low caries increment at a low cost for adolescents in Västra Götaland, Sweden. Further studies of the cost effectiveness of the programme could be of great interest, especially over a more extended period of time.

Acknowledgements

The authors thank the Public Dental Service in the Västra Götaland Region for economic support and providing the caries data. The authors also thank José Ferraz-Nunes, former senior lecturer and researcher in Health Economics at Faculty of Medicine, University of Gothenburg, Sweden, for valuable comments on the health economics.

References

Bergström, E-K., Birkhed, D., Granlund, C. and Moberg Sköld, U. (2014): Approximal caries increment in adolescents in a low caries prevalence area in Sweden after a 3.5-year school-based fluoride varnish programme with Bifluorid 12 and Duraphat. *Community Dentistry and Oral Epidemiology* **42**, 404-411.

Bratthall, D., Hänsel-Petersson, G. and Sundberg, H. (1996): Reasons for the caries decline: what do the experts believe? *European Journal of Oral Sciences* **104**, 416-422.

Buzalaf, M.A., Pessan, J.P., Honório, H.M. and ten Cate, J.M. (2011): Mechanisms of action of fluoride for caries control. *Monographs in Oral Science* **22**, 97-114.

ten Cate, J.M. (2013): Contemporary perspective on the use of fluoride products in caries prevention. *British Dental Journal* **214**, 161-167.

Haugejorden, O., Lervik, T., Birkeland, J.M. and Jorkjend, L. (1990): An 11-year follow-up study of dental caries after discontinuation of school-based fluoride programs. *Acta Odontologica Scandinavica* **48**, 257–263.

Hausen, H., Kärkkäinen, S. and Seppä, L. (2001): Caries data collected from public health records compared with data based on examinations by trained examiners. *Caries Research* **35**, 360-365.

Helfenstein, U. and Steiner, M. (1994): Fluoride varnishes (Duraphat): A meta-analysis. *Community Dentistry and Oral Epidemiology* **22**, 1-5.

Kleinbaum, D.G., Kupper, L.L. and Morgenstern, H. (1982): *Epidemiologic Research: Principles and Quantitative Methods*. New York: Wiley.

Kobayashi, S., Kishi, H., Yoshihara, A., Horii, K., Tsutsui, A., Himeno, T. and Horowitz, A.M. (1995): Treatment and post-treatment effects of fluoride mouthrinsing after 17 years. *Journal of Public Health Dentistry* **55**, 229–233.

Källestål, C., Norlund, A., Söder, B., Nordenram, G., Dahlgren, H., Petersson, L.G., Lagerlöf, F., Axelsson, S., Lingström, P., Mejàre, I., Holm, A.K. and Twetman, S. (2003): Economic evaluation of dental caries prevention: a systematic review. *Acta Odontologica Scandinavica* **61**, 341-346.

Leske, G.S., Ripa, L.W. and Green, E. (1986): Posttreatment benefits in a school-based fluoride mouthrinsing program. Final results after 7 years of rinsing by all participants. *Clinical Preventive Dentistry* **8**, 12-23.

Marinho, V.C.C., Higgins, J., Sheiham, A. and Logans, S. (2003): Fluoride toothpastes for preventing dental caries in children and adolescents. *Cochrane Database of Systematic Reviews* Issue 1.

Marinho, V.C.C., Worthington, H.V., Walsh, T. and Clarkson, J.E. (2013): Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database of Systematic Reviews* Issue 7.

Moberg Sköld, U., Petersson, L.G., Lith, A. and Birkhed, D. (2005): Effect of school-based fluoride varnish programmes on approximal caries in adolescents from different caries risk areas. *Caries Research* **39**, 273-279.

Moberg Sköld, U., Petersson, L.G., Birkhed, D. and Norlund, A. (2008): Cost-analysis of school-based fluoride varnish and fluoride rinsing programs. *Acta Odontologica Scandinavica* **66**, 286-292.

Oscarson, N., Källestål, C., Fjeldahl, A. and Lindholm, L. (2003): Cost-effectiveness of different caries preventive measures in a high-risk population of Swedish adolescents. *Community Dentistry and Oral Epidemiology* **31**, 169-178.

Petersson, L.G., Twetman, S., Dahlgren, H., Norlund, A., Holm, A-K., Nordenram, G., Lagerlöf, F., Söder, B., Källestål, C., Mejàre, I., Axelsson, S. and Lingström, P. (2004): Professional fluoride varnish treatment for caries control: a systematic review of clinical trials. *Acta Odontologica Scandinavica* **62**, 170-176.

Poulsen, S. (2009): Review: Fluoride-containing gels, mouth rinses and varnishes: an update of evidence of efficacy. *European Archives of Paediatric Dentistry* **10**, 157-161.

Seppä, L. (1999): Efficacy and safety of fluoride varnishes. *Compendium of Continuing Education in Dentistry* **20**, 18-26.

Swedish Council on Technology Assessment in Health Care, The (2002): Fluoride varnish. In: *Att förebygga karies* [Prevention of Dental Caries. A Systematic Review]. Stockholm: SBU, pp68-80.

Torell, P. and Ericsson Y. (1965): Two-year clinical tests with different methods of local caries-preventive fluorine application in Swedish school-children. *Acta Odontologica Scandinavica* **23**, 287-322.