Fluoride varnish programmes for adolescents at school – caries, conceptions and costs

Eva-Karin Bergström

Department of Cariology
Institute of Odontology
Sahlgrenska Academy at University of Gothenburg

UNIVERSITY OF GOTHENBURG

Gothenburg 2016

Cover illustration: Samuel Brosché and Christine Ljungberg
Photo: Henrik Brosché/Kristina Reftel

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eva-karin.bergstrom@vgregion.se

ISBN 978-91-628-9686-7 (Print)
978-91-628-9687-4 (PDF)
http://hdl.handle.net/2077/41245

Printed in Gothenburg, Sweden, 2016
Ineko AB, Bangårdsvägen 8, SE-428 35 Kållered, Sweden

”Det är ingen stor grej. Fluorlack är bara fluorlack, liksom...”

Flicka, 15 år, i fokusgrupp 3, studie II

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Department of Cariology, Institute of Odontology
Sahlgrenska Academy at University of Gothenburg
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ABSTRACT

The overall aim of this thesis was to study the effects on caries, conceptions and costs of school-based fluoride varnish programmes for adolescents in Sweden.

Paper I was a 3.5-year randomised controlled study of 1,143 adolescents, in a low caries prevalence area. Two fluoride varnishes, Bifluorid 12® and Duraphat®, were compared, with a variation in the frequency of application. In Papers II and III, 26 adolescents and 15 dental nurses were interviewed and asked to describe their experiences as participants or performers in a fluoride varnish programme at school. Paper IV was an evaluation of a school-based fluoride varnish programme, implemented on a broad scale for all 12- to 15-year-olds in a region in Sweden and caries data on 27,943 adolescents were analysed retrospectively.

The results revealed no statistically significant differences in caries increment between Bifluorid 12 and Duraphat, after fluoride varnish applications every six months. The adolescents experienced taking part as positive, but had feelings of exposure, peer pressure and a lack of information during the programme. The dental nurses had positive experiences of meeting adolescents in a context in which the adolescents were comfortable and relaxed with an opportunity to identify individuals with poor dental health. The caries increment was significantly lower, with a prevented fraction of 32%, after the implementation of a fluoride varnish programme in a large region. A break-even was shown between costs and gains due to prevented fillings at the age of 15.

The main conclusions were that a school-based fluoride varnish programme for all 12- to 15-year-olds, implemented on a broad scale in a large region, appeared to affect the approximal caries increment in a positive way. The cost of the programme was similar to the cost of the avoided fillings, during the four-year study period, which suggests good cost effectiveness in both the short and long perspective. The adolescents had mainly positive experiences of participating in a school-based fluoride varnish programme, although a desire for greater respect of their integrity was noted. Dental nurses described a feeling of professional development originating from the challenges associated with working in an arena outside the dental clinic.

Keywords: Adolescents, Approximal caries, Caries incidence, Caries increment, Caries prevalence, Cost-analysis, Dental nurse, Fluoride varnish, Oral health promotion, Phenomenography, Population-based, School programme

ISBN: 978-91-628-9686-7 (Print)
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SAMMANFATTNING PÅ SVENSKA

Syftet med denna avhandling var att studera skolbaserade fluorlackningsprogram för ungdomar i Sverige, utifrån dess effekt på kariesutvecklingen, hur de upplevs och dess kostnader.

Delarbete I var en 3,5-årig randomiserad kontrollerad interventionsstudie på 1143 ungdomar i ett område med låg kariesförekomst. Två fluorlacker, Bifluorid 12® och Duraphat®, jämfördes, med olika fluorlackningsfrekvens. I delarbete II och III intervjuades 26 ungdomar och 15 tandsköterskor som fick beskriva hur de upplevt att ha deltagit i respektive utfört ett skolbaserat fluorlackningsprogram. Delarbete IV var en utvärdering av ett fluorlackningsprogram, som implementerats i en hel region i Sverige, för samtliga 12–15-åringar, där kariesdata för 27943 ungdomar analyserades longitudinellt och retrospektivt.

Resultatet visade inga statistiskt säkerställda skillnader i kariesutvecklingen mellan Bifluorid 12 och Duraphat när grupperna som fluorlackats var sjätte månad jämfördes. Ungdomarna som deltagit i ett skolbaserat fluorlackningsprogram upplevde att det var positivt att delta, men beskrev också känslor av utsatthet, grupptryck och brist på information under programmet. Tandsköterskorna hade positiva erfarenheter av att möta ungdomar i ett sammanhang där ungdomarna är bekväma och avslappnade, och där de kunde upptäcka ungdomar med dålig tandhälsa. Kariesutvecklingen var signifikant lägre, 32%, efter införandet av ett skolbaserat fluorlackningsprogram i en stor region. Kostnaden för programmet var i paritet med vinsterna, i form av förhindrade fyllningar, vid 15 års ålder.

De viktigaste slutsatserna från denna avhandling var att ett skolbaserat fluorlackningsprogram för 12–15-åringar hade en positiv effekt på kariesutvecklingen. Kostnaden för programmet var i paritet med besparingen i form av minskade fyllningar, under den 4 år långa studieperioden, vilket tyder på en god kostnadseffektivitet i både det korta och längre perspektivet. Ungdomarna hade positiva uppfattningar av att delta, men det framkom önskemål om att fluorlackningarna ska genomföras med större respekt för integriteten. Tandsköterskorna beskrev att de hade utvecklats i sin profession genom de utmaningar som var förknippade med att arbeta på en arena utanför sin tandvårdsklinik.

LIST OF PAPERS

This thesis is based on the following four papers, referred to in the text by their Roman numerals.

I. Bergström E-K, Birkhed D, Granlund C, Moberg Sköld U. 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 Dent Oral Epidemiol 2014;42:404-411.

II. Bergström E-K, Moberg Sköld U, Birkhed D, Lepp M. Adolescents' experiences of participating in a school-based fluoride varnish programme in Sweden.

Swed Dent J 2012;36:133-141.

III. Bergström E-K, Moberg Sköld U, Birkhed D, Lepp M. Dental nurses' experiences of performing a school-based fluoride varnish programme for children and adolescents in Sweden.

Swed Dent J 2016 (accepted).

IV. Bergström E-K, Lingström P, Hakeberg M, Gahnberg L, Moberg Sköld U. Caries and costs: an evaluation of a school-based fluoride varnish programme for adolescents in a Swedish region.

Community Dental Health 2016 (in press).

CONTENTS

ABBREVIATIONS

DeSa	Approximal tooth surfaces with enamel lesions
DFS	Tooth surfaces with dentin lesions and/or fillings
DFSa	Approximal tooth surfaces with dentin lesions and/or fillings
DFT	Teeth with dentin lesions and/or fillings
DSa	Approximal tooth surfaces with dentin lesions
FSa	Approximal tooth surfaces with fillings
N	Number of participants
PF	Prevented fraction
RCT	Randomised controlled trial
SD	Standard deviation

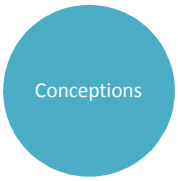
DEFINITIONS

Caries incidence	an initially caries-free surface that turns into an enamel or a dentin lesion or a filling during a specific time period
Caries increment	caries incidence + caries progression
Caries prevalence	tooth or tooth surface affected with caries at a specific point of time (DFT/DFS)
Caries progression	an enamel lesion that turns into a dentin lesion or a filling during a specific time period
Prevented fraction	the difference in caries increment between the control group and the intervention group divided by the increment in the control group (percentage caries reduction)

1 INTRODUCTION

Different aspects of fluoride varnish programmes for adolescents at school were the focus of this thesis.

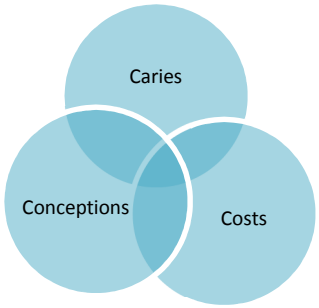
A preventive programme must first and foremost be effective in reducing caries and the studies of caries prevention by a population-based fluoride varnish programme at school are a major part of this thesis.



Another aspect of a preventive programme is the experiences and conceptions of those involved. In this thesis, adolescents have been given the opportunity to describe their experiences of participating in a fluoride varnish programme. Furthermore, the dental nurses running the programme were interviewed. The dental nurses' experiences and conceptions are very important when studying a school-based fluoride varnish programme.

The cost of a school-based fluoride varnish programme has been analysed in this thesis. Society, school and the Public Dental Service dedicate considerable resources to prevention and any population-based programme must be cost effective.

Considering all these aspects, there is an opportunity to implement an holistic approach, which should be the goal of any prevention programme, especially those involving people and health.



2 BACKGROUND

2.1 Dental caries

Dental caries is a disease affecting people of all ages, all over the world. The World Health Organisation has stated that 60-90% of schoolchildren worldwide and almost 100% of all adults have dental cavities (WHO, 2012). This means that dental caries is one of the most common diseases in the human race. Poor oral health may affect general health on an individual level and can lead to pain and discomfort. Problems with eating and chewing can affect the ability to maintain sufficient nutrition and untreated dental caries can also affect people's social life (Petersen et al., 2005). For society, the expenditure on dental care is high and in addition to direct costs, there are also indirect costs caused by loss of school and work hours. Estimates have shown that, in many industrialised countries, 5-10% of public health expenditure relates to oral health and the treatment of dental caries is very costly (Widström and Eaton, 2004).

Dental caries constitutes the signs and symptoms of the chemical dissolution of the tooth surface. This process is caused by metabolic events in the biofilm covering the tooth. Dental caries can affect every surface of a tooth where dental plaque is allowed to accumulate and mature in a biofilm over time (Fejerskov et al., 2013). This dental plaque and biofilm are a prerequisite for caries lesions to develop, but the mere presence of biofilms is not enough for caries to develop, as additional factors are involved (Bratthall et al., 1996; Bowen, 1999; Lingström et al., 2003; Fejerskov, 2004). Dental caries is therefore known as a multifactorial disease, in which behavioural, environmental and genetic risk factors interact (Fejerskov, 2004).

The frequent or high consumption of sugar products in combination with poor oral hygiene and insufficient fluoride exposure are the predominant behavioural risk factors for dental caries. It is well known that sugar and other fermentable carbohydrates increase the growth rate of several oral bacteria, which play an essential role in the caries process. This was already concluded in the clinical study of diet and dental caries at the Vipeholm Hospital during the 1940/50s (Gustafsson et al., 1954). Even though some of the results and first and foremost, the ethics of that study have been questioned, a frequent consumption of sugary foods, especially between meals, remains a risk behaviour for caries development (Lingström et al., 2003; Zero, 2004). An understanding of why and how caries develops and progresses is essential when the aim is to prevent or control disease.

2.2 Caries prevalence

In Sweden, caries prevalence among children and adolescents from the 21 different counties and regions has been reported annually to the Swedish National Board of Health and Welfare since 1985. During the last few decades, a general decrease in caries prevalence has been seen, as in most other high-income countries (Socialstyrelsen, 2015). The latest update from 2013 showed that the mean number of decayed and filled teeth (DFT) in 12-year-olds was 0.73 (range 0.42-0.87). The corresponding value for 19-year-olds was a mean of 2.44 (range 1.69-3.91). The percentage of caries-free 12-year-olds was a mean of 66%, ranging from 58% to 75%, and for 19-year-olds 34%, ranging from 23% to 40% (Socialstyrelsen, 2015). These changes for the worse in dental health between 12 and 19 years of age show that dental caries remains a health problem for individuals and society.

It is also important to remember that enamel lesions are not included in the epidemiological caries data from the Swedish National Board of Health and Welfare. Several researchers have pointed out that enamel lesions account for more than 80% of the total number of caries lesions on the approximal surfaces in adolescents (Moberg Sköld et al., 1995; Moberg Sköld et al., 2005a,b; Alm et al., 2007). This means that national reports underestimate the true value of caries prevalence and, in the report from 2006, it was stated that leaving out enamel lesions fails to present a relevant picture of the caries prevalence in the population as it whitewashes the real caries status (Socialstyrelsen, 2006). Several studies have shown that, if enamel lesions are incorporated in the caries recording, there are huge differences in caries prevalence (Bjarnason et al., 1992; Machiulskiene et al., 1998; Forgie et al., 2000). In a Swedish study, three- to six-year-olds were longitudinally followed in terms of caries prevalence and increment. The result showed that only 50.6% of the six-year-olds were caries free, when enamel lesions were included, and that enamel lesions accounted for the majority of all lesions (André Kramer et al., 2014).

In Sweden, the focal point for caries prevention during adolescence is the approximal surfaces, as caries on these surfaces accounts for the need for restorations during adulthood. The National Board of Health and Welfare has shown that, in 2011, 73% of all fillings and restorations performed on adults involved teeth with previous restorations, even if there were large variations in different age groups (Socialstyrelsen, 2013). Remaining caries free for as long as possible during childhood and adolescence is therefore most important in order to minimise future dental health problems.

2.3 Bitewing radiographs

With a knowledge of the large proportion of approximal enamel lesions, the bitewing radiograph is a very important tool, as it is the best method available for diagnosing caries on surfaces not available for visual inspection. The aim must be to identify all lesions at an early stage, in order to facilitate non-operative treatment. The European Academy of Paediatric Dentistry (EAPD) has drawn up guidelines for the use of radiographs in children and adolescents and recommends bitewing radiographs within one to two years after the eruption of premolars and second molars (Espelid et al., 2003). Further bitewing controls should be based on the individual caries risk and caries activity.

The interval of radiographic examination of high risk individuals should be one year, while the interval of low risk should be two to three years. At the key age of 12-14 years, about 20% of adolescents have at least one approximal caries lesion that will not be detected without bitewing examinations, even in a low caries prevalence population (De Vries et al., 1990). That study revealed that the greatest discrepancy in diagnosis between clinical examination and bitewing examination related to enamel lesions, which is also in agreement with the findings of Flinck et al. from 1999.

In 2007, The Swedish Council on Technology Assessment in Health Care (SBU, 2007) stated that radiographic examinations of approximal surfaces have a high specificity on dentin lesions but that the sensitivity is low. The first three to four years after tooth eruption and the establishment of approximal contacts constitute a period of particular risk for new approximal lesions (Mejáre et al., 2004), which is during adolescence.

2.4 Fluoride in caries prevention

Fluoride is an important tool for preventing and controlling caries, with several mechanisms of action. The most important effects are due to the topical action on the tooth surface (Ellwood and Fejerskov, 2013). Fluoride inhibits the demineralisation of the hard tissue of the tooth and promotes the remineralisation of the tooth surface. In addition, it reduces the metabolic activity in acid-producing bacteria (Hamilton, 1990; ten Cate, 1999; ten Cate, 2013).

After topical fluoride treatment, the fluoride ions form fluoride-hydroxyapatite and/or calcium fluoride. This effect is dependent on both the pH and the fluoride concentration. A lower pH and a high concentration of fluoride favour

the formation of calcium fluoride (Rølla, 1988). Calcium fluoride particles adhere particularly well to demineralised surfaces which are more porous. This means that high-concentration treatments with fluoride could form fluoride reservoirs. Under acidic conditions, the calcium fluoride can release fluoride ions and calcium ions, which prevent the enamel from being dissolved (Saxegaard and Rølla, 1989; ten Cate, 1997; Øgaard, 2001). Even if high fluoride concentration applications have advantages, even low, yet frequent exposure to fluoride is known to be favourable for the tooth, as it shifts the balance from demineralisation to remineralisation (ten Cate, 1990). With this knowledge, there is an opportunity for fluoride to act in different application forms.

Fluoride toothpaste is the most widespread form of fluoride application and the decline in caries prevalence among children and adolescents in recent decades is primarily attributable to the wide-spread use of this product (Bratthall et al., 1996). The scientific evidence for daily toothbrushing with fluoridated toothpaste is very strong and is recommended worldwide (Twetman et al., 2003; Marinho et al., 2009). In spite of this, studies have shown that not all adolescents brush their teeth regularly. On the contrary, two Nordic studies independently of each other have shown that 25% of 14-year-olds did not brush their teeth every day (Klock et al., 1989; Koivusilta et al., 2003) and this is important to remember when designing programmes for preventing caries. Hugoson et al. (2005) and Wikén Albertsson and van Dijken (2010) reported that 73-95% of the questioned adults in Sweden brushed their teeth at least twice a day, which means 5-27% do not. Jensen et al (2012) reported that 11% of 15-16-year-olds brushed their teeth once per day or less. Furthermore, Jensen et al. (2014) studied oral health professionals' strategies, considerations and methods for teaching patients the most effective way of toothbrushing with fluoride toothpaste and found that oral health professionals did not focus on this, even if it was described as very important. One reason given was that there was an assumption that the patients were already familiar with this.

Additional fluoride supply should also be recommended for individuals with an increased risk of caries (Zimmer, 2001; Ellwood et al., 2013). These forms of fluoride application could be fluoride-containing rinses, varnishes and gels with a documented caries-preventive effect (Marinho et al., 2004; Marinho et al., 2009; Poulsen, 2009). The effect of fluoride is greatest on smooth surfaces and far less on occlusal surfaces. Occlusal surfaces are the focus for fissure sealants or ground fillings (Hiiri et al., 2006; Ahovuo-Saloranta et al., 2013).

It is well known that, during the period of mineralisation of the permanent teeth, between birth and six years of age, the ingestion of too high

concentration of fluoride can cause dental fluorosis. This could derive from swallowing fluoridated toothpaste or drinking tap water with too high fluoride concentration (Davies et al., 2003). For this reason, fluoride ingestion should be controlled during this period. After the age of six, the risk of fluorosis is negligible, with the exception of the third molars. In recommended doses, no adverse effects of fluoride have been reported and its use is considered to be safe, in addition to being effective in preventing caries (Ekstrand et al., 1980; Marinho et al., 2004; Petersen and Lennon 2004; Toumba et al., 2009; Wong et al., 2011; ten Cate, 2013).

2.5 Fluoride varnish

Fluoride varnishes were developed in the 1960s with the aim of prolonging the contact time between the tooth and the fluoride in the varnish. In this way, the fluoride uptake would be both increased and improved (Petersson, 1975; De Bruyn and Arends, 1987; Beltran-Aguilar et al., 2000). Since the 1980s, fluoride varnishes have been widely used. The caries-reducing potential of fluoride varnishes is well studied and their effects have been evaluated in many studies. The Swedish Council on Technology Assessment in Health Care concluded, after reviewing 17 clinical studies, that fluoride varnish applications twice a year had a caries-preventive effect in children and adolescents. This also applies with the concurrent use of fluoride toothpaste (SBU, 2002). Moreover, Azarpazhooh and Main (2008) found clear evidence of the efficacy of fluoride varnish, with two applications a year, in preventing dental caries in children and adolescents. A meta-analysis of eight clinical studies of Duraphat revealed a mean reduction in caries of 38% (Helfenstein and Steiner, 1994), which could be compared with the result in a review of clinical trials in 2004, showing an average prevented fraction of 30%, in permanent teeth, when compared with untreated controls (Petersson et al., 2004). In the updated review by Marinho et al. (2013), a total of 13 trials were included, which studied children and adolescents with primary and permanent teeth. The review found an average 43% reduction in decayed, missing and filled tooth surfaces, after fluoride varnish applications. Poulsen (2009) performed a review of six clinical trials on the effect of fluoride varnishes, which also confirmed the evidence that fluoride varnishes appear to have a caries-preventive effect on the young permanent dentition.

One of the very first fluoride varnish studies performed at school, on adolescents was carried out in 1998-2001 in the western part of Sweden, by Moberg Sköld et al. (2005b). In this study, a total of 758 adolescents aged 13-16, from three different caries-risk areas, participated in a three-year clinical

study. The result showed 69% fewer new approximal caries lesions in a high-risk area, 66% fewer new approximal caries lesions in a medium-risk area and 20% fewer new approximal caries lesions in a low-risk area, after fluoride varnish applications twice a year with a six-month interval. A higher frequency of applications, eight times per year during the semesters with one-month intervals, was also studied and had an even better caries-preventive effect but was not considered to be cost effective. Nevertheless, as it was performed in the same region, the results from this study were used when the Västra Götaland Region designed the population-based programme for all adolescents which started in one part of the region in 2003 and in the whole region in 2008 (Moberg Sköld et al., 2005b).

Today many fluoride varnishes are available on the global market. A search for "fluoride varnish" on the internet in October 2015 produced more than 45 varnishes. Summarising the findings, most varnishes contain sodium fluoride and the distribution forms are tubes, bottles or single doses. There are a large number of varnishes with flavours, such as mint, melon, cherry, caramel and strawberry. In Sweden, the most widely used fluoride varnishes are Bifluorid 12® (VOCO), ClinPro White Varnish® (3M ESPE), Duraphat® (Colgate) and Fluor Protector® (Ivoclar Vivadent). Since the 1960s, Duraphat has been the most used varnish in scientific studies and also the most common in use in daily practice. Considerably fewer studies have been performed on the other fluoride varnishes available in Sweden. As these varnishes could have additional advantages compared to Duraphat, it would be of great interest to study them, especially Bifluorid 12 as it is a varnish with both NaF and CaF_2.

Fluoride varnish application is an easy, safe and well-accepted application procedure. Moreover, from a toxicological, safety point of view, varnishes are preferable, as the bioavailability of fluoride in varnish is relatively low (Øgaard et al., 1994; Bawden, 1998). No acute toxic reactions have been reported. Ekstrand et al. (1980) showed that the fluoride concentration in plasma and urinary excretion was low after fluoride varnish applications with Duraphat in children. This is due to the fact that the major part of the fluoride in the varnish is not absorbed in the body but is excreted in the faeces (Ekstrand et al., 1980).

2.6 The school as an arena for health promotion and prevention

Health promotion refers to the process of enabling individuals to increase their control of the determinants of health according to the World Health Organisation (WHO, 1986). With this definition, it is crucial to define these

determinants but also to have an holistic approach to the individuals. Nutbeam (1998) stated that "Health promotion is an activity directed towards enabling people to take action. Thus, health promotion is not something that is done on or to people, it is done with people, either as individuals or as groups. Participation and partnership are valued processes in health promotion." (Nutbeam, 1998, p 28).

If health promotion mainly focuses on the factors promoting health, prevention focuses on identifying the risk factors for disease. Prevention is usually described in three parts, known as primary, secondary and tertiary prevention. Primary prevention refers to preventing the disease completely, secondary prevention reduces the risk of the disease worsening or reoccurring and tertiary prevention includes rehabilitative measures to eliminate or reduce disability due to illness or injury (SBU, 2013). Nevertheless, oral health promotion and prevention are concepts that often overlap.

As adolescents spend a large proportion of their time at school, this arena could be very suitable for health promotion and prevention. Most adolescents are comfortable and relaxed at school and there is peer pressure that could be taken advantage of in a positive way. The time period of adolescence is also important, as health-related behaviours and attitudes towards health are formed during this time (St Leger and Nutbeam, 2000; Kwan et al., 2005). In addition, health promotion in schools has been proven to score well in terms of cost effectiveness (St Leger and Nutbeam, 2000).

In Sweden, back in the 1960s, the Public Dental Service recognised this potential and began to use schools as an arena for caries prevention, showing good results in terms of caries reduction, with regular fluoride mouth-rinsing programmes (Torell and Ericsson, 1965; Birkeland and Torell, 1978). Furthermore, activities designed to prevent the use of alcohol, drugs and tobacco are well-known examples of school-based prevention programmes performed in recent decades. Other examples are programmes for promoting good dietary habits, safety in traffic and sexual health (Swinburn and Egger, 2002).

2.7 Population-based strategies

Both population-based strategies and high-risk strategies have been used for caries prevention for children and adolescents in Sweden. During the 1960s-1980s, fluoride-rinsing programmes at schools were conducted and studied, showing good effect in terms of caries prevention (Torell and Erisson 1965; Birkeland and Torell, 1978; Petersson et al., 1998). Population-based strategies

are directed at large groups and focus on prevention and health promotion. In the mid-1980s, there was a shift in Sweden towards more high-risk strategies.

The high-risk strategy focuses on those running a high risk of disease or with high disease activity. High-risk strategies have several limitations, however (Batchelor and Sheiham, 2006). Many studies have shown that the opportunity to identify caries-risk individuals before they develop caries is limited (Rose, 1992) and past caries prevalence in the form of enamel lesions is the most reliable predictive method used in clinical practice (Lith and Gröndahl, 1992; Hausen, 1997; Mejàre et al., 2014). Furthermore, the ability to reach the high-risk individuals and affect them with preventive measures is crucial. The skewed distribution of approximal caries lesions in a population with low caries prevalence means that the majority of lesions occur in the majority of the population, as there are so few high-risk individuals (Sheiham and Fejerskov, 2003). This means that, if a population-based preventive programme reduces the mean caries increment, even in small numbers, the total effect in the population will be large. The population-based strategy for caries prevention is considered to be the best alternative today and the recommendation is to target certain risk ages or risk areas (Burt, 1998; Hausen et al., 2000; Batchelor and Sheiham, 2002).

Another factor contributing to the need for population-based programmes is the large number of immigrants and refugees in Sweden. Dental caries levels among most of the young people in immigrant groups in Europe are higher than among the resident groups (Jacobsson et al., 2005; Stecksén-Blicks et al., 2014) This means these two strategies should go hand in hand.

2.8 Adolescents

Adolescence is a period of developmental change, involving biological and psychological changes, affecting various areas of life (Nounopoulos et al., 2006). The way this period is experienced is individual and could be affected by an interaction between both genetic and environmental factors for the individual. Nevertheless, it is clearly a process towards increasing autonomy.

When working with individuals in these age groups, it is most important to understand their development, from a social, cognitive, emotional and educational point of view. Furthermore, it requires an insight into the differences between adolescents and adults related to stages in their development. During adolescence, the personal identity develops and personal values are formed, together with an emerging striving for autonomy. During the same period, the influence of peer pressure and parental conflicts often

emerge. Moreover, adolescence is often a period of mood disruptions and risk behaviour (Arnett, 1999). The focal area of this thesis is adolescents aged 12-16 years. Meeting adolescents of these ages at school requires an insight into this sometimes stormy period of life. Nevertheless, this is also a period during which patterns of health-related behaviour are established, which are often difficult to change as adults (Routh, 1988). The ability to enhance healthy lifestyle habits is good, but the challenges that are involved in becoming an adult should be taken into account when designing treatment plans or prevention programmes, as well as in any interaction.

Adolescents have a large number of newly erupted unfilled permanent approximal tooth surfaces that could be at risk. During adolescence, the way of living often changes from a fairly controlled environment to fewer restrictions relating to dietary habits and oral hygiene. Even if the relationship between sugar consumption and caries is weaker when the fluoride exposure is high, minimising sugary intakes remains a goal of caries prevention (Moynihan and Kelly, 2014). In Sweden, the consumption of sweet carbonated drinks increased from 22.3 litres per person and year in 1960 to 86.8 litres per person and year in 2013 (Jordbruksverket, 2015) and this probably means that the numbers among adolescents are even higher. This emphasises the importance of caries-preventive strategies during these caries-risk ages.

In Sweden, all children and adolescents up to the age of 20 are entitled to free, tax-subsidised dental care. According to the Swedish Dental Care Act (SFS 1985:125), this dental care should focus on the prevention of oral disease and be of good quality. When implementing preventive programmes one should consider how they are experienced of the participating adolescents, but this aspect is rarely covered.

2.9 Dental nurses and oral health prevention

According to Statistics Sweden, a total of 10,410 dental nurses were employed in Sweden at dental clinics in 2013. The vast majority were females and in 2013, only 50 dental nurses were men (Statistics Sweden, 2015). Depending on the work area, interest and further education, the duties of a dental nurse can differ. The specific tasks and skills that are required are to provide assistance to dentists, manage administration and be responsible for utensils and machines. In addition, being involved in oral health promotion and prevention is a common task for many dental nurses.

The occupation of “dental nurse” is not protected by any law, which means that “anyone” can call him/herself a dental nurse. Nevertheless, in Sweden,

dental nurses have an education of approximately 1.5 years and are specially trained in all the tasks and skills, listed above, at a dental clinic. Furthermore, dental nurses in Sweden have been working on caries prevention for a long time since the 1960s, both at dental clinics and outside at child health centres and at schools. The term “prophylactic dental nurse” is common in Sweden and originates from the time in the mid-1970s when dental nurses started to take special courses in prevention for children and adolescents. Nowadays, prevention is part of the regular education and is a common task for most dental nurses. Nevertheless, how this is experienced of the dental nurses have been explored in few studies.

2.10 Health economics in caries prevention

The discipline of health-care economics was created to ensure a maximum of benefit from available resources (Folland et al., 2004). Economic assessments are of great value for a society, not least when planning prevention programmes or the range of available treatments. Decisions must be made to allocate the resources in a way that will result in the maximum total benefit to the individuals in a community, according to the concept of economic efficiency (Drummond et al., 1997). The goal for oral health promotion, from a cariological perspective, is to preserve healthy teeth. Nevertheless, even if a tooth is preserved from fillings, it is difficult, perhaps not even possible, to define a financial sum for the benefit gained (Mitchell and Murray, 1989). Most cost-analysis studies attach a value to a healthy tooth in terms of treatment costs averted. In spite of this, future restorations and possible replacement needs are very difficult to measure and foresee.

Oral diseases are expensive to treat and restorative dentistry places an economic burden on industrial countries. Calculations have shown that 5-10% of the money spent on public health is allocated to oral health care (Petersen et al., 2005). This is a severe underestimation of the real costs, as no calculations of all the indirect costs of oral diseases are presented. Indirect costs are costs that are directly, or indirectly, connected to oral diseases or disorders, such as loss of productivity and medical care (Oscarson et al., 1998). Calculations of the real costs of oral health care, or a better calculation of the financial value of a healthy tooth, are scarce, but it is a common belief that most caries-prevention measures are cost effective compared with restorative dentistry approaches (Griffin et al., 2001). Nevertheless, the costs of preventive programmes are dependent on the availability of resources and the existing infrastructure in a country, which means that the costs must be analysed for each individual programme.

A cost-effective programme must use effective preventive methods but also be performed by the correct category of dental personnel, which Oscarson et al. (2003) concluded in a study of cost effectiveness. The aim was to evaluate the cost effectiveness of caries-prevention measures in young people's dental care in Sweden. They stated that only calculating the fees, according to the pricelist, is not sufficient as an alternative to a more detailed cost analysis, in general dentistry in Sweden. Furthermore, in that study, Oscarson et al. also compared the dental health-care perspective with the societal perspective in relation to the sensitivity of the method for calculating the cost of averted DeMFS. The total costs were also related to the treatment costs. In an earlier study, Oscarson et al. (1998) aimed to find suitable methods for calculating costs in the public dental health-care sector and for comparing the actual costs with the pricelist.

Moberg Sköld et al. (2008) compared two school-based fluoride programmes, one with fluoride varnish applications every six months and one with supervised fluoride mouth-rinsing on the first three and the last three days of every school term, for 13- to 16-year-olds. The results showed that the fluoride varnish programme had a better effect with a benefit-to-cost ratio of 1.8:1 for the fluoride varnish programme and 0.9:1 for the fluoride mouth-rinsing programme.

2.11 The fluoride varnish programme in the Västra Götaland Region

The Västra Götaland Region consists of 49 municipalities with more than 1.6 million inhabitants. In 2007, the board of the Public Dental Service decided to create and implement a population-based prevention strategy for all children and adolescents, aged 0-19 years. The reason was that the 112 public dental clinics in the region faced a lack of guidance and routines for population-based prevention. Moreover, the joint population strategy was intended to ensure that every child or adolescent in the region was offered equal preventive measures regardless of their residential area. The main aim was that the prevention programme should ensure that children and adolescents with a low risk of oral diseases should be able to maintain good oral health and the focal point should be health factors rather than risk factors. The emphasis should be placed on good self-care and promote personal responsibility for dental health.

To design this population-based programme, a group of experts in the field of caries prevention was assembled with the assignment to present a suggestion for a population-based strategy for the region. The basic requirements for the prevention strategy were that as far as possible, it should be evidence based,

cost effective and rational. During the autumn of 2007 and spring of 2008, the strategy was planned and the start of the programme was set for the autumn of 2008.

The school was defined at an early stage as an important arena for a population-based strategy (Kwan and Petersen, 2003) and contact was made with all the principals of the schools in the region at this time, to prepare for collaboration. The target group for the school programme was adolescents 12 to 15 years of age. Dental personnel, mostly dental nurses, were specially educated and prepared for the new programmes. In addition, written instructions and guidelines were produced, in order to make the programme clear. Furthermore, information letters as well as consent letters for all parents and adolescents were produced and distributed. To enable more preventive measures in areas with a higher risk of caries, a socio-economic analysis was conducted in order to identify areas in need of increased population-oriented prevention in the region (Reisine and Psoter, 2001; Källestål and Wall, 2002).

The result of the experts' recommendations was a broad programme for population-based prevention, which in the region was to be called FRAMM, which was short for the Swedish words "Fluor, Råd, Arena, Mat och Motivation" (Fluoride, Advice, Arena, Motivation and Diet). For 12- to 15-year-olds, this programme was based on the study by Moberg Sköld et al. (2005b) previously performed in one part of the region. This meant that all adolescents were visited at school twice a year, at six-month intervals, for a fluoride varnish application. This study showed even better results in a high-risk area after fluoride varnish application eight times a year and this was the model implemented for the areas with a low socio-economic status. The two main goals for the FRAMM programme were to focus on good daily home care, such as toothbrushing with fluoride toothpaste twice a day and promoting good dietary habits for all age groups, and to use the school as a health-promotion arena. The basic programme, implemented for all adolescents in the 6th to 9th classes, contained brief information about oral health and supervised flossing and approximal applications of fluoride varnish twice a year, at six-month intervals. In addition, all adolescents were offered two lessons about oral health and tobacco use during this period. The extended programme, for adolescents in areas in need of increased population-oriented prevention, begins as early as in the first class and in these areas the fluoride varnish application are performed four to eight times/year. In addition, children and adolescents with special needs are offered an individualised programme, focusing primarily on toothbrushing and training for good oral care. Dental personnel visit these children and adolescents eight times/year at school.

In 2010, 96% of all school classes in grades 6-9 had been visited by dental personnel for oral health information and fluoride varnish applications. In 2014, more than 99% of all school classes in the region received oral health education and fluoride varnish applications at school.

3 RATIONALE

Dental caries is a disease that could possibly be prevented but, in reality, it can be controlled. One measure for preventing and controlling caries is application of fluoride varnish, which has been shown to enhance remineralisation and inhibit demineralisation. Furthermore, the Public Dental Service has used schools as an arena for dental health promotion and prevention for more than 50 years. In recent years, fluoride varnish programmes at school have become more common and this is the background of this thesis.

In the *first study,* the most frequently used varnish, Duraphat, was compared with the varnish, Bifluorid 12. It is important to receive and share knowledge about new varnishes, even though Duraphat is considered to be "the golden standard". There are only a few studies of Bifluorid 12 in caries-prevention programmes for adolescents but, in spite of this, Bifluorid 12 contains a larger amount of fluoride and has a different texture, taste and composition. Most studies of caries-prevention programmes are performed in areas with a high caries prevalence, but this study was developed in an area in the Västra Götaland Region, Sweden, with an expected low to medium caries prevalence. The aim was to compare the two varnishes, with the same application frequency, with a group with a higher frequency of Bifluorid 12 applications and a control group.

During the time of the first study, a school-based fluoride varnish programme for all adolescents in the Västra Götaland Region began. This raised the question of how adolescents participating in a programme of this kind experienced it. There are reasons to believe that the experience of a programme affects willingness to participate and also the outcome in terms of dental health. Moreover, when making decisions which affect adolescents, they have the right to have a voice and to have their opinions taken into account. This was the basis for the *second study*, which aimed to explore and describe adolescents' experiences of participating in a school-based fluoride varnish programme.

One finding in the second study of adolescents' experiences was that the dental nurses performing the programme appeared to be largely responsible for creating the atmosphere in the programme. Based on this finding, dental nurses were therefore interviewed for the *third study*. In this study, dental nurses'

experiences of performing a school-based fluoride varnish programme were explored.

With knowledge of how both adolescents and dental nurses experienced the programme, but with uncertain data on the caries-preventive effect, the *fourth study* aimed to study the caries increment related to the costs, in a large programme, implemented on a broad scale and in field conditions in the whole Västra Götaland Region. The study included two birth cohorts, with and without a fluoride varnish programme from 12- to 15-years, and the participants belonged to all the public dental clinics in the Västra Götaland Region. A retrospective longitudinal design was used and two intervention groups were compared with an historical control group.

4 AIMS

4.1 Overall aim

The overall aim of this thesis was to study the effects on caries, conceptions and costs of school-based fluoride varnish programmes for adolescents in Sweden.

4.2 Specific aims

In more detail, the specific aims of this thesis were:

- to compare two fluoride varnishes, Bifluorid 12 and Duraphat, with the same frequency of applications, on the approximal caries increment in 12- to 16-year-olds in a low caries prevalence area, and to find out if a higher frequency of Bifluorid 12 applications affected the caries increment (Paper I),

- to describe how a school-based fluoride varnish programme is experienced by participating adolescents (Paper II),

- to describe dental nurses' experiences of performing school-based fluoride varnish programmes for children and adolescents (Paper III) and

- 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, and to perform a cost analysis of the programme (Paper IV).

5 METHODS

The thesis is based on four papers of which Paper I and Paper IV are quantitative studies, on the effects of school-based fluoride varnish programme regarding caries and costs. Paper II and Paper III are qualitative studies, exploring the experiences of the programme among adolescents and dental nurses participating in the programme. All the studies were performed in the Västra Götaland Region, Sweden. The methods and results are described in detail in each paper, included as an appendix in this thesis, but are here briefly summarised in Table 1.

Table 1. Overview of the four papers in this thesis

Paper	Study design	Participants	Data collection	Data analysis
I	Quantitative Randomised controlled trial (RCT)	Adolescents 12-16 years N = 1,143	Analyses of bitewing radiographs	Statistical analyses
II	Qualitative	Adolescents 15 years N = 26	Focus group interviews	Phenomenography
III	Qualitative	Dental nurses 40-63 years N = 15	Individual interviews	Phenomenography
IV	Quantitative Retrospective longitudinal design	Adolescents 12-15 years N = 27,943	Caries data extracted from dental records	Statistical analyses

5.1 The quantitative studies - Papers I and IV

Paper I

Study design

In this 3.5-year randomised controlled trial (RCT), the participants were randomly selected on an individual basis, within each school class at seven secondary schools, into four groups (Table 2). Group 1 received Bifluorid 12 every six months, Group 2 received Duraphat every six months, Group 3 received Bifluorid 12 every three months and Group 4 acted as a control, and received no fluoride varnish applications at school (Fig. 1). All the groups participated in supervised tooth brushing at school and all the groups took part in regular dental check-ups at the public dental clinics, according to their individual needs.

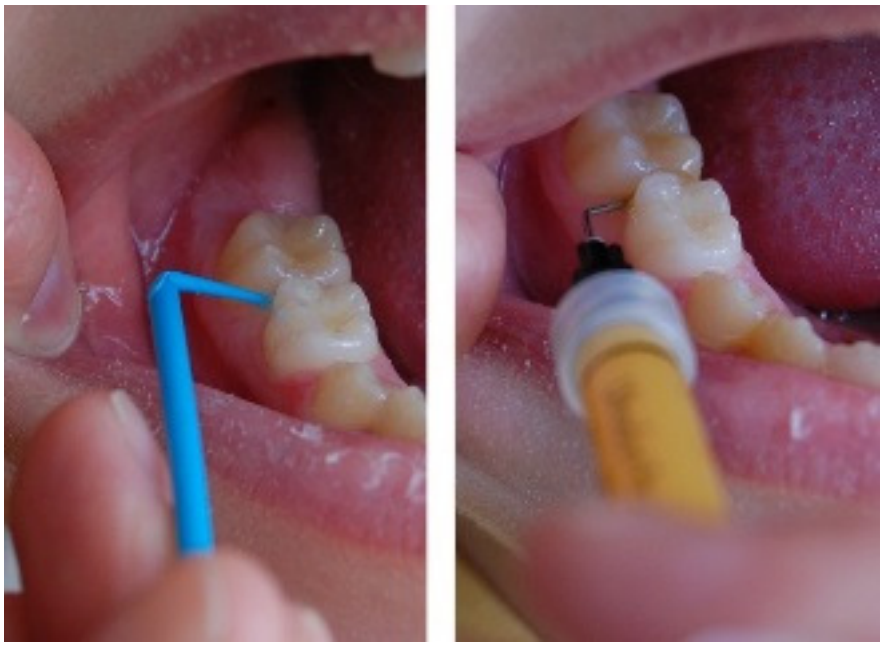


Figure 1. The method for fluoride varnish applications in Paper I. Application of Bifluorid 12 with a quick-stick, to the left, and Duraphat with a syringe, to the right. The application of Duraphat with a syringe was also used in Paper IV.

Participants

All adolescents, 1,620 individuals, from seven secondary schools in the Municipality of Härryda, in the Västra Götaland Region in Sweden, were invited to participate in the study. In all, 1,365 adolescents were enrolled at the age of 12 and 1,143 individuals (84%) completed the 3.5-year programme as 16-year-olds (Table 2). All participants received regular dental check-ups and dental care at the three public dental clinics in the municipality.

Table 2. Study design in Paper I: groups, number of included and completed participants and intervention in the groups

	Group 1	**Group 2**	**Group 3**	**Group 4**
Included participants	338	381	315	331
Fluoride varnish	Bifluorid 12	Duraphat	Bifluorid 12	-
Intervals of varnish	6 months	6 months	3 months	-
Supervised tooth brushing every	6 months	6 months	3 months	6 months
Completed participants	287	315	262	279

Data collection

Four bitewing radiographs were taken at baseline and after 3.5 years on all participants at the regular check-ups at the three public dental clinics in the municipality, where the adolescents participating in the study received their regular dental care. The radiographs were analysed by a specialist in oral radiology and the author of this thesis, side by side, and for each approximal surface from the distal surface of the canine to and included the mesial surface of the second molar. A modified index by Gröndahl et al. (1977) was used, and after consensus each surface was scored from 0 to 7, as described in Table 3, which also shows the corresponding definition in Paper IV.

Table 3. Definitions in Papers I and IV for scoring approximal surfaces

Score	Definition in Paper I	Definition in Paper IV
0	Caries-free surface	
1	Caries lesion in the outer half of the enamel	Enamel lesion
2	Caries lesion more than half way through the enamel but not passing the enamel-dentin junction	
3	Caries lesion extending into the dentin but not more than halfway through to the pulp	Dentin lesion
4	Caries lesion more than half way through the dentin to the pulp	
5	Restored surface	Filling
6	Surface not possible to score	
7	Missing surface	

Statistical analysis

The data were recorded in a Microsoft Excel document. A statistician made the analyses using statistical SAS computer software. Descriptive statistics (means, standard deviations and frequency distribution) were calculated for all the groups and the differences between the groups were tested by ANOVA and unpaired two-sample t-tests. In addition, a multiple comparison test, Student-Newman-Keuls, was performed after each analysis of variance. The power calculation, made before the study, showed that a minimum of 269 participants in each group would be enough to obtain statistically significant values of $P < 0.01$. This was based on an estimated difference of 40% or more in caries prevention, a standard deviation of 2.6 and the power of 70%.

Paper IV

Study design

A school-based fluoride varnish programme for all 12- to 15-year-olds, including all 112 public dental clinics in the Västra Götaland Region, was implemented in 2008, based on the results by an earlier study by Moberg Sköld et al. (2005b), and performed in the same region. The programme was an extension of a programme implemented in one part of the region in 2003 for 19 public dental clinics. For this study, a retrospective longitudinal design was used, where caries data for three groups were compared. Group 1, called Intervention 2003, belonged to the public dental clinics which started the fluoride varnish programme in 2003, while Group 2, called Historical control, had no fluoride varnish programme at school. The adolescents in these two groups were born in the same year, 1993, and were compared with a group of adolescents born five years later in 2008, Group 3, called Intervention 2008, all of which had a fluoride varnish programme at school (Table 4). In the fluoride varnish programme, the adolescents met dental nurses at school, in small groups, for fluoride varnish applications with Duraphat every six months, from the sixth to the ninth classes. Before the fluoride varnish application, the adolescents were instructed to floss their teeth under supervision. Furthermore, the adolescents participated in two lessons on oral health and tobacco use during this time period.

Table 4. Study design in Paper IV: groups, number of adolescents, year of birth, intervention in the groups and year of extraction of data

	Group 1	**Group 2**	**Group 3**
	Intervention 2003	Historical control	Intervention 2008
Number of adolescents	3,132	13,490	11,321
Year of birth	1993	1993	1998
Fluoride varnish programme at school from 12-15	Yes	No	Yes
Extracted data for years	2005-2008	2005-2008	2010-2013

A cost analysis, taking only clinical costs into consideration, was also performed and the model for this is described in Fig. 2. The fluoride varnish programme was assumed to result in a reduction in caries prevalence, with lower costs for fillings. This reduction in cost, and no other effects, was compared with the cost of the intervention.

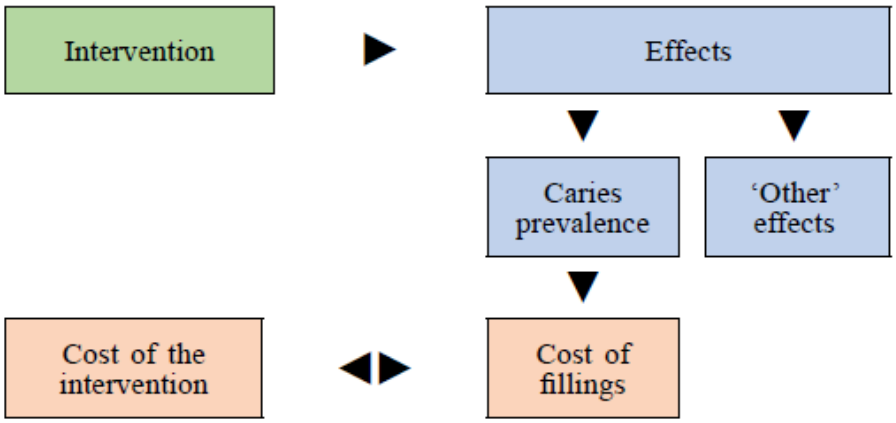


Figure 2. The cost analysis model: the cost of the intervention is compared with the cost of fillings.

Participants

All adolescents in two birth cohorts, who had attended dental check-ups at one of the 114 public dental clinics in the Västra Götaland Region, at least once, from 12- to 15-years of age, were selected for this study. This meant that the participants represented different areas with different caries prevalence, and socio-economic background. Caries data were extracted from the Public Dental Service's dental health-care register. The number of identified dental records were 3,132 in Group 1 (Intervention 2003), 13,490 in Group 2 (Historical control) and 11,321 in Group 3 (Intervention 2008) (Table 4).

Those adolescents who attended dental check-ups both at the age of 12 and at the age of 15 were specifically identified, and approximal caries increment was defined as the caries prevalence at the age of 15 minus the caries prevalence at the age of 12. The number of identified records were 1,584 in Group 1 (Intervention 2003), 5,831 in Group 2 (Historical control) and 6,527 in Group 3 (Intervention 2008).

Data collection
Data were extracted from the dental records at the Public Dental Service in the Västra Götaland Region, using a script. 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). This was done for each individual and 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).

Calculations of the costs were based on information from the Public Dental Service in the Västra Götaland Region, and related to the cost of the programme as well as the cost of fillings. In this study, the reduction in costs was based on the statistical results for differences in DFSa between the Intervention group 2008 and the Historical control.

Statistical analysis
The data were delivered as Microsoft Excel documents and were analysed using SPSS (version 21) computer software. Descriptive statistics (means and standard deviations) were calculated and the differences between the groups were tested by ANOVA and unpaired two-sample t-tests. In addition, analyses of variance and general linear models for repeated measures were used for caries increment. $P < 0.05$ was applied for statistical significance.

5.2 The qualitative studies - Papers II and III

Paper II

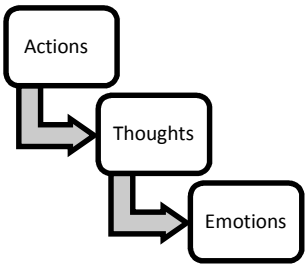
Study design
For this study, a qualitative research methodology based on interviews was chosen and the adolescents were interviewed in focus groups. The main open interview question was “Can you describe your experiences of participating in a fluoride varnish programme?” The interviews were analysed according to the phenomenographic approach.

Participants
In all, 26 adolescents, 22 girls and 4 boys, chose to participate. They were all aged 15 and were recruited from one secondary school in a medium-sized municipality in the Västra Götaland Region in Sweden. They all had several years’ experience of participating in a fluoride varnish programme.

Data collection

The adolescents were interviewed in four focus groups, and the number of participants in the groups ranged from four to nine. Focus groups, in academic research, can be defined as a group discussion on a particular topic, and this discussion is guided, monitored and recorded by a researcher (Kitzinger, 1994). The purpose of using focus groups is to generate a rich understanding of the participants' experiences and beliefs. The key to success with a focus group interview is the interaction between the participants, which can produce more extensive material compared to individual interviews would have provided (Kitzinger, 1994; Krueger, 1994; Gibson, 2007).

The interviews were performed at school, directly after a fluoride varnish application, and started with renewed information about the study and information on the voluntary set-up. The interviews were semi-structured and the participants were asked to describe their experiences of participating in a fluoride varnish programme. To help the participants start to describe their experience, the interview followed three main steps, described in Fig. 3. Following these steps is suitable for interviews with adolescents, as they can have difficulty expressing and describing emotions. It is often easier to describe actions and behaviours at a certain moment. The next step could then be to describe thoughts during these actions and moments and finally, the emotions could perhaps be expressed (Thomsson, 2010).



1. The participants were asked to describe their actions during the fluoride varnish programme.

2. The participants were asked to describe their thoughts during the fluoride varnish programme.

3. The participants were asked to describe their emotions during the fluoride varnish programme.

Figure 3. The three steps that were followed when interviewing the adolescents.

The author of the study (EKB) carried out the interviews, with one of the co-authors (ML) functioning as an observer and co-interviewer. The average time for an interview was 20 minutes, ranging from 16 to 26 minutes.

Paper III

Study design

A qualitative method was used where 15 dental nurses from different public dental clinics in the Västra Götaland Region, were individually interviewed. The main interview question was "Can you describe your experiences of performing a fluoride varnish programme?" All interviews were analysed according to the phenomenographic approach.

Participants

The 15 dental nurses were chosen strategically, in order to represent a variety of experience of fluoride varnish programme. The participants were all females, aged 40-63, from various parts of the region, working in both rural areas and in cities, with responsibility for fluoride varnish programme in different schools and with both long and short working experience from this field.

Data collection

The dental nurses were interviewed individually, with the aim of finding the participants' personal experiences, the second-order perspective (Marton, 1981). This can provide a deeper understanding of a phenomenon, which cannot be obtained from quantitative methods, such as questionnaires (Silverman, 2000). In an individual interview, the focus should be on listening attentively to what the participants have to say, in order to acquire more knowledge of the study topic (Kvale, 1997). In this study, the topic was not regarded as sensitive, even if it related to the participants' work situation.

The interviews were semi-structured with a main open question, followed by additional questions based on the participant's answer. These questions strived to be open-ended, neutral, sensitive and understandable, following the recommendations for research interviews in qualitative research (Britten, 1999). After the first pilot interview, a map of possible areas for questions related to their experiences of performing a fluoride varnish programme was designed, and both the participants and the interviewer had this map on the table during the interview as a reminder of possible areas of interest. On the map, there were also "empty circles" to encourage the dental nurses to cover all aspects of importance, according to their views and opinions (Fig. 4).

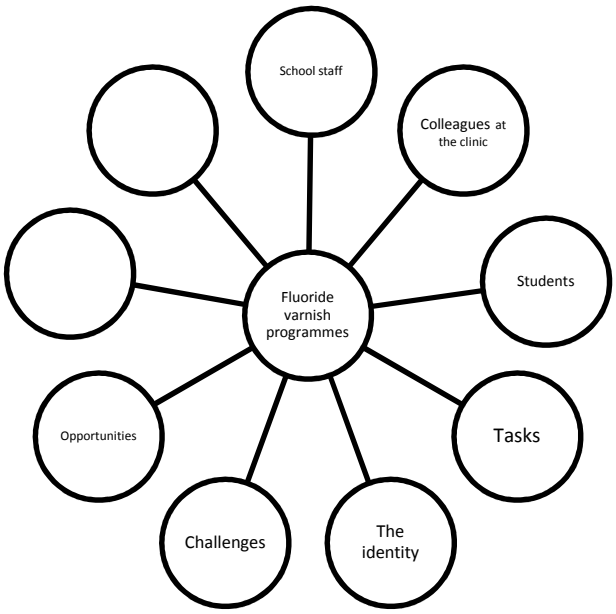


Figure 4. The map used during the interviews with the dental nurses, as a reminder of possible areas of experiences to be described during the interviews.

The interviews were carried out by the author of this thesis at a location chosen by the participant. The average time for an interview was 40 minutes, but ranged from 22 to 70 minutes.

Data analysis in Papers II and III

The interviews were analysed according to the phenomenographic approach (Wenestam, 2000; Lepp and Ringsberg, 2002). Phenomenography is a qualitative research approach developed by researchers at the Department of Education and Educational Research, at the University of Gothenburg, in the early 1970s. The research group was interested in studying "What is learnt" by students, rather than the more common question: "How much is learnt". They found that students reading the same text could understand it in many different ways. The basis for the phenomenographic approach is that people hold finite numbers of qualitatively different understandings of all kinds of phenomena in the world around them (Marton 1986).

Performing a data analysis according to the phenomenographic approach meant that all the interviews were recorded digitally and then transcribed verbatim. This is in accordance with the qualitative interview tradition, in order to avoid bias and to provide a permanent record of what was said during the interviews. The data analysis followed the steps described by Alexandersson (1994). In the first step, all the interviews were read thoroughly several times in order to obtain an overall impression of the material. In the second step, similarities and differences in the material were noted. In the third step, the statements were sorted into descriptive categories of conceptions. In the fourth and final step, the categories were reflected upon and the themes emerged, describing the participants' experiences. The themes and the categories constituted the outcome of the study and were defined as the participants' various experiences of the phenomenon (Sjöström and Dahlgren, 2002).

6 ETHICS

In Paper I, the adolescents and their parents were informed about the study orally and by letter when the adolescents started the sixth class and consent forms were handed out with the help of teachers. All the participants were free to withdraw at any time without giving any reason. The study was approved by the Regional Ethical Review Board in Gothenburg, Sweden (Dnr: 327-05), and by the Medical Products Agency in Sweden (EudraCT-nr: 2005-003984-22).

In Paper II and Paper III, all participants received both written and verbal information about the study. In addition, the parents of the adolescents in Paper II received written information. All adolescents and their parents in Paper II, as well as all dental nurses in Paper III, signed consent forms prior to the interviews. Permission to perform the study was obtained from the Regional Ethical Review Board in Gothenburg, Sweden (Dnr: 384-09).

In Paper IV, 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).

7 RESULTS

7.1 Caries

Caries prevalence

Paper I

The mean caries prevalence on the approximal surfaces showed no statistically significant differences at baseline or after 3.5 years comparing the four different groups. Group 3, with Bifluorid 12 application 4 times/year at 3 months intervals, had the lowest total approximal caries prevalence both at baseline and after 3.5 years, but the differences were not statistically significant (Table 5). Sixty-nine per cent of the adolescents in all groups were caries-free at baseline.

The approximal enamel lesions accounted for about 90% of the total caries lesions on these surfaces both at baseline and after 3.5 years. Thirty per cent of the adolescents in all groups had enamel lesions, 2% had dentin lesions and 4% had approximal fillings at baseline. No statistically significant gender difference was found, either at baseline or after 3.5 years, regarding caries prevalence.

Paper IV

The total caries prevalence in mean on the approximal surfaces showed statistically significant differences both at the age of 12 and at the age of 15 comparing the three groups, as seen in Table 5. Group 2, which was the Historical control, without the prevention programme, had the highest caries prevalence both at the age of 12 and at the age of 15. The two intervention groups had a significantly lower caries prevalence.

The approximal enamel lesions constituted the largest part of the lesions and ranged from 83-86% in Group 1 (Intervention 2003), from 79-81% in Group 2 (Historical control) and from 79-84% in Group 3 (Intervention 2008) during the four-year study period.

Table 5. Caries prevalence at 12 and 15/16 years in Paper I and Paper IV, expressed as mean and SD

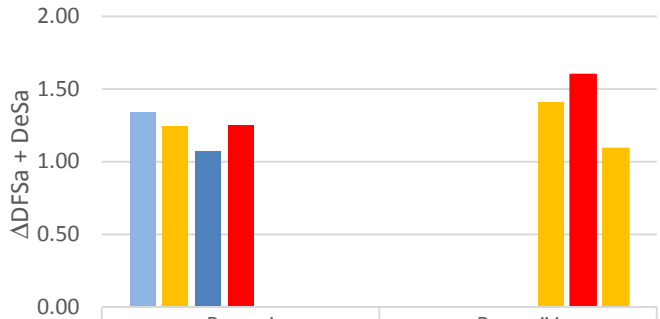
		Paper I					Paper IV			
		Group					Group			
		1	2	3	4		1	2	3	
		Fluoride varnish and frequency					Fluoride varnish and frequency			
		Bifluorid 12 2/year	Duraphat 2/year	Bifluorid 12 4/year	Control	P-value (ANOVA)	Duraphat 2/year	Historical control	Duraphat 2/year	P-value (ANOVA)
12 years	DeSa	0.67 ± 1.34	0.85 ± 1.88	0.66 ± 1.23	0.65 ± 1.78	0.362	0.57 ± 1.47	0.86 ± 1.74	0.67 ± 1.58	P < 0.001
	DFSa	0.10 ± 0.44	0.05 ± 0.28	0.08 ± 0.31	0.11 ± 0.55	0.253	0.12 ± 0.48	0.22 ± 0.70	0.18 ± 0.62	P < 0.001
	DFSa+ DeSa	0.77 ± 1.56	0.90 ± 1.99	0.72 ± 1.34	0.76 ± 2.12	0.671	0.68 ± 1.61	1.08 ± 2.04	0.83 ± 1.80	P < 0.001
15/16 years	DeSa	1.90 ± 3.52	1.92 ± 3.66	1.67 ± 3.23	1.84 ± 3.48	0.821	1.86 ± 3.42	2.18 ± 3.53	1.61 ± 3.05	P < 0.001
	DFSa	0.21 ± 0.95	0.22 ± 0.74	0.20 ± 0.68	0.23 ± 1.07	0.992	0.31 ± 0.89	0.51 ± 1.31	0.37 ± 1.11	P < 0.001
	DFSa+ DeSa	2.11 ± 3.88	2.14 ± 4.10	1.87 ± 3.55	2.07 ± 4.05	0.847	2.18 ± 3.82	2.70 ± 4.19	2.00 ± 3.59	P < 0.001

DeSa=Approximal surfaces with enamel lesions, DFSa=Approximal surfaces with dentin lesions or fillings

Caries increment

Paper I

There were no statistically significant differences in approximal caries increment between the four groups. This meant, there were no statistically significant differences between the applications of Bifluorid 12 and Duraphat twice a year with 6 months intervals. Furthermore, not to the application with Bifluorid 12 more frequently, such as 4 times/year with 3 months interval, and also not to the control group without fluoride varnish application at school (Fig 5). New approximal caries lesions constituted 92-94% of the total caries increment on these surfaces and caries progression was the remaining part of the increment. The majority, 95-98%, of the new caries lesions on the approximal surfaces were enamel lesions.



	Paper I	Paper IV
Group 1: Bifluorid 2/year	1.34	
Group 2: Duraphat 2/year	1.24	
Group 3: Bifluorid 4/year	1.07	
Group 4: control	1.25	
Intervention 2003		1.41
Historical control		1.60
Intervention 2008		1.09

Figure 5. Total approximal caries increment (DFSa + DeSa) from 12- to 15-years, in Papers I and IV.

In Paper I, the participants were additionally pooled according to caries experience at 12 years. There were differences in caries increment between the individuals in the three fluoride varnish groups pooled together who were caries free at baseline and the individuals in the fluoride varnish groups who had caries on the approximal surfaces already at baseline, 0.57 versus 2.58. The corresponding figures in the control group were 0.51 versus 3.22.

Paper IV

Statistically significant differences in approximal caries increment from 12- to 15-years of age were seen when comparing the three groups. The two intervention groups had a significantly lower caries increment compared to the historical control group and Intervention 2008 had the lowest increment (Fig. 5).

The treatment effect between the Intervention 2008, with a fluoride varnish programme at school, and the control group, with no fluoride varnish programme, gave a prevented fraction of 32%.

7.2 Conceptions

The adolescents' conceptions

Paper II

The phenomenographic analysis of the interviews with the adolescents emerged in three themes, with eight attendant categories, representing different conceptions of having participated in a school-based fluoride varnish programme (Table 6).

The first theme, "Conceptions in relation to the individual", dealt with the individual's perspective of participating in a fluoride varnish programme. The categories in this theme contained conceptions of the way the adolescents perceived participating both psychologically and physically. The statements showed that *the first contact could be a cool and scary event*, as participation in the programme could be anticipated but at the same time scary, not knowing exactly what it meant. After that, the adolescents described the programme as *further on an ordinary event and no big deal* and they stated that participating in a school-based fluoride varnish programme was positive and not a dramatic event in their day. Nevertheless, conceptions of feeling exposed and insecure

were found and participation in the programme could be experienced as *overall an exposed situation*, as it meant opening their mouths in front of the dental nurse and their peers. A physical individual aspect was the conception of *varnish that tastes good or bad,* with large individual differences in these conceptions.

The second theme, "Conceptions in relation to the school dental nurse", contained conceptions of the role of the dental nurse and the interaction between the adolescents and the dental nurses. The adolescents' conceptions were that *more knowledge is wanted* about the reason for fluoride varnish programmes. In addition, the conceptions showed that the way a school-based fluoride varnish programme was experienced was related to *the approach of the school dental nurse* (which is) *important for confidence*. Confidence in the school dental nurse could motivate behavioural changes, according to the statements.

The third theme, "Conceptions in relation to the group and school", covered statements related to being treated in groups and at school. *Small groups for feeling safe* categorises the statements relating to experiences of the positive aspects of being treated with friends. In a small group, this was experienced as an advantage and made the treatment feel easier. This meant treatment in sufficiently small groups, as large groups could increase negative peer pressure. The statements on this theme also revealed that *the school is a smooth and convenient arena*, suited to the programme.

Table 6. Themes and categories that emerged in the analysis of the interviews with the adolescents in Paper II

Theme 1. Conceptions in relation to the individual	
1.1.	The first contact with the programme – a cool and scary event
1.2.	Further on an ordinary event – no big deal
1.3.	Overall an exposed situation
1.4.	Varnish that tastes good or bad
Theme 2. Conceptions in relation to the school dental nurse	
2.1.	More knowledge is wanted
2.2.	The approach of the school dental nurse important for confidence
Theme 3. Conceptions in relation to the group and school	
3.1	Small groups for feeling safe
3.2	The school is a smooth and convenient arena

The dental nurses' conceptions

Paper III

In the phenomenographic analysis of the interviews with the 15 dental nurses, three themes and eleven categories emerged. These themes and categories represent various conceptions of performing a school-based fluoride varnish programme. The results are presented in Table 7, showing the themes and categories, as well as the participants' conceptions that were covered in each category.

The first theme, "Working in someone else's arena", contained conceptions of working outside the dental clinic. Experiences from working at school were that it was mostly positive and enlightening, but challenges were associated with *the need to adapt to the school's conditions*. The dental nurses had experienced *freedom and variety at work*, when working in a different environment and meeting a variety of persons. In addition, *collaborating with the school's staff* was described in this theme and was considered to be enlightening. In addition, the dental nurses had experiences from *being a local celebrity,* as a consequence of their work at school.

The second theme, "Meeting students in a school environment", dealt with experiences from meeting children and adolescents at school. There were several differences, compared with meeting them at the dental clinic. The statements showed that the adolescents appeared to have *more security at school than at the clinic* and this could enhance the ability to reach the children and adolescents more effectively. The dental nurses' experience was that the ability to establish *good contact with the students is meaningful* and a key to satisfaction and meaningfulness for the dental nurses when performing the programme. Furthermore, the dental nurses stated that they had had the opportunity to *identify students with ill-health* at school, during the performance of the programme. Other statements related to *dealing with troublesome students*, which could be difficult to handle.

The third theme, "Being challenged and developing in one's profession", dealt with conceptions related to the dental nurses' experiences of their role at school. The importance of *establishing yourself* at school was covered in many statements. *Being able to plan* was also, according to the statements, an important part of performing a fluoride varnish programme. The dental nurses had experience of *being influenced by the clinic management and colleagues* regarding several aspects of the planning and performance of a fluoride varnish

programme and examples given were time spent on the programme and the need for supplies.

Table 7. Themes and categories that emerged in the analysis of the interviews with the dental nurses in Paper III

Theme 1. Working in someone else's arena	
1.1.	The need to adapt to the school's conditions
1.2.	Freedom and variety at work
1.3.	Collaborating with the school's staff
1.4.	Being a local celebrity
Theme 2. Meeting students in a school environment	
2.1.	More security at school than at the clinic
2.2.	Good contact with the students is meaningful
2.3.	Identifying students with ill-health
2.4.	Dealing with troublesome students
Theme 3. Being challenged and developing in one's profession	
3.1.	Establishing yourself
3.2.	Being able to plan
3.3.	Being influenced by the clinic management and colleagues

Paper I

The dental nurses performing the fluoride varnish applications in Paper I answered a questionnaire on their preferences when comparing Bifluorid 12 and Duraphat. The result showed that the majority of the dental nurses preferred Duraphat, even if the Bifluorid 12 package and hygiene were also regarded as good (Fig. 6).

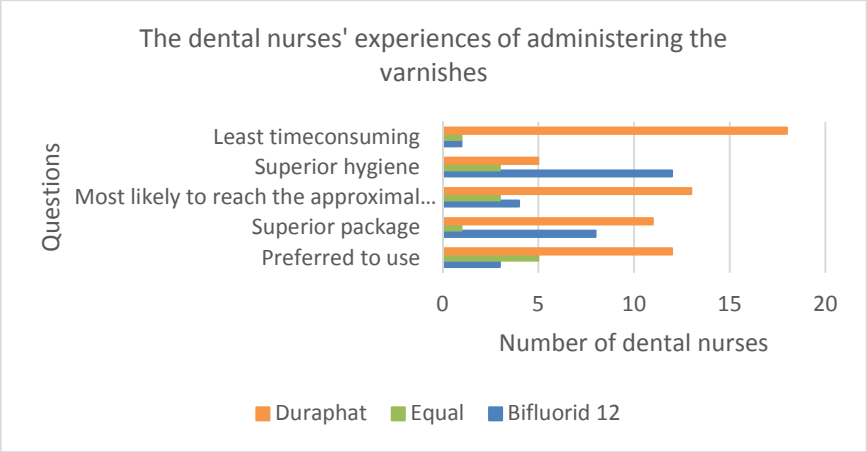


Figure 6. The dental nurses' experiences of Bifluorid 12 and Duraphat.

7.3 Costs

Paper IV

The cost analysis compared the cost of the fluoride varnish programme, implemented on a broad scale in the Västra Götaland region, with the reduced cost of fillings, due to a lower caries prevalence. Table 8 shows that the cost of the programme, with 400 SEK for four years per adolescent was very similar to the costs avoided, with 391 SEK per adolescent, due to prevented fillings. Assuming that the difference in approximal caries increment continued up to the age of 19 years, an estimate showed a decrease in cost of 1,435 SEK with the same cost for the programme with 400 SEK per adolescent. This will give an accumulated outcome of 1,035 SEK per adolescent from 12- to 19-years.

Table 8. Cost analysis of the programme; a calculation of the differences in DFSa comparing Group 2 (Historical group) with Group 3 (Intervention 2008). Cost of the programme and outcome

	DFSa			SEK		
Age	Group 2 Historical control	Group 3 Intervention 2008	Difference[1]	Decreased cost[2]	Cost of the programme[3]	Accumulated outcome[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	1035
Estimated costs and savings from 12-19 years→				1435	400	1035

[1] *The difference in caries prevalence (DFSa) comparing Group 2 (Historical control) and Group 3 (Intervention 2008)*

[2] *Number of prevented fillings multiplied by 1,087 SEK: the cost of a two-surface filling according to the pricelist in the region*

[3] *The total cost of the programme per adolescent and year*

[4] *The difference in caries prevalence multiplied by 1,087 SEK minus the cost of the programme, accumulated for each year.*

8 DISCUSSION

This thesis aimed to study the caries-preventive effect of a school-based fluoride varnish programme, to describe the conceptions of the people participating in and performing the programme and to analyse the costs. The reason for choosing several perspectives is that they are all important parts when it comes to creating a successful population-based programme. It is simply not enough for a programme to be effective in reducing caries if the experiences of the individuals participating in the programme are negative, as these experiences probably affect people's willingness to participate. Furthermore, any prevention programme is associated with costs that should be related to its outcome to ensure a maximised health outcome per invested Swedish krona (SEK). A successful school-based fluoride varnish programme should therefore be caries preventive and cost effective and those participating should have positive experiences (Fig. 7).

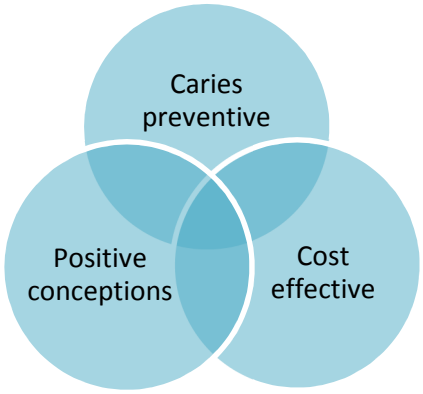


Figure 7. The concept of a successful prevention programme.

There are few studies of population-based programmes performed on a broad scale and in field conditions. The ability to study caries data for large cohorts during a long period is valuable for evaluations. In this thesis, caries data for more than 27,000 adolescents were analysed, showing a significantly lower

caries increment in a population participating in a school-based fluoride varnish programme.

Furthermore, there is a scarcity of studies in which adolescents are not only the focus of interventions and are examined clinically but are also asked to describe their experiences of participating. Moreover, it is quite unusual to hear the important voices of those performing the intervention, in this case the dental nurses, which are central to understanding whether the programme can be improved.

Determining the cost effectiveness of a fluoride varnish programme is a challenge, as the value of a sound, caries-free tooth is difficult to define. A simple comparison of the reduction in the cost of fillings due to a decrease in caries prevalence with the cost of a school-based fluoride varnish programme was performed in one of the studies in this thesis. In spite of its shortcomings, this simple comparison showed that the reduction in costs was very similar to the cost of the programme, during the four-year study period. This break-even in the short-term perspective suggests large-scale cost effectiveness over an extended period of time.

The attempt to study, analyse and describe a school-based fluoride varnish programme from this range of perspectives, to obtain a more holistic approach must be regarded as a strength of this thesis.

8.1 Methods

The quantitative studies

When it came to the quantitative studies of caries and costs, two different study designs were chosen, with an awareness of the strengths and weaknesses of each method (McKee et al., 1999). The advantage of a randomised controlled trial (RCT) is the control of its methodology. Furthermore, the ability to include control groups is an advantage (Hannan, 2008). The weakness could be the large effort made by the researcher, in both handling the trial and collecting the data, which limits the possible number of participants. In order to increase the number of participants, the retrospective longitudinal design, where data are extracted from dental records, is more suitable. This method is appropriate for evaluations of programmes that have already been implemented, if control groups can be found.

A more ideal design in Paper I would have been to include a control group without contact with dental personnel at school and thereby no supervised

toothbrushing every six months. Another alternative could have been to use a blind control with placebo varnish. Even if these alternatives might have strengthened the study, this was not possible from an ethical and practical point of view, as also previously stated by Petersson et al. (2004).

In Paper IV, there was no obvious control group, as a programme that had already been implemented was going to be evaluated. An alternative could have been to find matching areas without population-based interventions in other regions in Sweden. These are, however, difficult to find, as most areas in Sweden have some sort of population-based caries-prevention programme for children and adolescents. A small group, which started the fluoride varnish programme in 2003, was therefore compared with the rest of the adolescents from the same birth cohort in the region which did not have a fluoride varnish programme. These groups were then compared with all the adolescents in the region, born five years later, all of whom had been offered the chance to participate in a fluoride varnish programme at school. As dental health has improved during this period, this could have affected the results. Nevertheless, the aim of this study was to evaluate the preventive programme implemented on a broad scale in field conditions. Comparing only the two groups born in the same year would not have realised this aim. The circumstance that some clinics started the programme earlier enabled an additional comparison between two intervention groups that turned out to have a very similar caries increment. Moreover, the reason for choosing adolescents from the whole region for the main comparison was that they were considered to be more equal from a socio-economic perspective and size wise. Interestingly, both intervention groups had a very similar caries increment, even though their caries prevalence differed at baseline. The caries increment for both cohorts was significantly lower compared with the control group.

Official epidemiological data for adolescents in Sweden show an improvement during the last few decades (Socialstyrelsen, 2015). Together with a skewed distribution of caries prevalence, this is a challenge for caries studies, as large groups are needed to detect differences after an intervention. In Paper I, the adolescents were born in 1993-1995 and had a mean total approximal caries prevalence of 0.72-0.90 at the age of 12. In Paper IV, the corresponding numbers were 0.68-1.08 for those born in 1993 and 0.83 for those born in 1998. This could be compared with the caries prevalence for 12-year-olds, born in 1985, in the study by Moberg Sköld et al. (2005b) performed in the same region. In that study, the mean caries prevalence in the four groups ranged from 1.95-2.57 for 13-year-olds, which means that the caries prevalence had improved substantially from the years separating the studies.

In a previous study by Modéer et al. (1984), the effect of a fluoride varnish programme was seen where the caries increment ranged from two to eight new approximal caries lesions and when the increment was either higher or lower, no differences could be seen when comparing fluoride varnish groups with control groups. In neither Paper I nor Paper IV did the caries increment reach as high as 2, with the exception of the pooled groups that had caries at baseline in Paper I. Comparing these groups, a difference of 0.64 was detected, but the difference was not statistically significant, probably due to the small groups.

It is important to remember that, even if the caries increment and caries prevalence were similar in both Papers I and IV, the caries prevalence would probably have been even lower in Paper I, if the caries data had not been taken from four bitewing radiographs for each participant by two calibrated and trained examiners using a standardised method.

The qualitative studies

Qualitative research methods are often characterised by the systematic collection and analysis of textual data assessed by interviews or observations, with the aim of exploring how different phenomena are experienced by individuals themselves in their natural context (Malterud, 2001). There are several qualitative methods and the research question indicates which method to choose (Creswell, 2007). As in all research, there is a risk that the researcher will affect the research process. The disciplinary background, preconceptions and professional experiences of the researcher might affect the research questions that are investigated and the methods that are chosen, in both quantitative and qualitative research.

The criteria for scientific rigour in a qualitative study differ from the established criteria in quantitative research. However, credibility, conformability and transferability, which are used in qualitative research, could correspond to internal validity, objectivity and generalisability in quantitative research (Lincoln and Guba, 1985). There is no question that qualitative and quantitative research are complementary and combined findings from these research methods may contribute to a better understanding, not least in relation to public health concerns (Hallberg, 2002).

In the qualitative studies, the phenomenographic approach was chosen and considered to be ideal for the aims, which were to collect a wide range of experiences. The phenomenographic approach strives to find and describe the participants' personal experiences of a phenomenon. Both focus-group interviews and individual interviews were conducted. The reason for using focus groups for the interviews with the adolescents was the opportunity for interaction between the participants, thereby contributing to extensive material

(Kitzinger, 1994; Krueger, 1994; Gibson, 2007). The number of participants in the groups ranged from four to nine. The optimum size for a focus group is considered to be six to eight participants, but three to 14 participants may work, depending on the group and the subject. Too few participants can result in limited discussions and too many participants can result in frustration if not everyone feels that they are given the opportunity to speak (Gibson, 2007; Gill, 2008). In addition, the research topic was probably suitable for focus groups, as it was of a less sensitive nature. The risk of using focus groups could be that disclosures by participants are shared both with the researcher and with the group and that intensive group discussion can make the participants feel exposed or stressed (Smith, 1995; Gibson, 2007).

In the second qualitative study, individual interviews were chosen for the dental nurses, as they perform the programme themselves or with a colleague. The focal point was identifying their inner experiences and this could be difficult for an interviewer who is inexperienced or is part of the studied phenomenon in any way. Nevertheless, as the dental nurses described both positive and negative experiences, this was probably not a source of bias in this study.

The number of participants in the qualitative studies was probably sufficient, but the gender distribution could be reflected upon. Of the 26 adolescents, only four were boys and all the dental nurses were female. When it came to the adolescents, efforts could probably have been made to persuade more boys to participate, but voluntariness was important. The reason more girls chose to participate in the study was perhaps that girls are more verbal and normally more willing to express their feelings and thoughts at this age (Lepp and Bagshaw, 1994). Regarding the question of male dental nurses, none could have been included, as there are no male dental nurses working at schools in the region. The age distribution among the dental nurses was relatively high, but this was nevertheless a mere reflection of the mean for dental nurses in the Västra Götaland Region.

8.2 Caries

In Paper I, no statistically significant differences in approximal caries increment were found after a 3.5-year fluoride varnish programme comparing the different groups with and without fluoride varnish. This is in contrast to the findings in Paper IV, showing a 32% reduction in approximal caries increment after a four-year fluoride varnish programme.

It could be difficult to compare these studies, as both have their strengths and weaknesses. Nevertheless, it is important to remember that the first study mainly focused on comparing two different fluoride varnishes, Bifluorid 12 and Duraphat. In addition, the caries prevalence in the studied area was lower than expected. Nor was the control group optimal, as all the adolescents in this group attended supervised toothbrushing every six months. In the second study, two large age cohorts were compared and the differences between the groups were statistically significant. As practically all the adolescents in these two age cohorts were included, it was not in fact a sample but almost the whole population of those ages. When comparing only those two groups born in the same year, it could be argued that the difference in caries increment was due to the difference in caries prevalence at 12 years of age. Nevertheless, when adding the large group from the whole region that was given fluoride varnish applications at school, the caries increment was very similar to the caries increment in the smaller fluoride varnish group five years earlier. This lends strong support to the notion of a structured population programme.

Another interesting finding in Paper I was the high caries increment for those that had caries at baseline compared with those that were caries free at baseline. Furthermore, even if not statistically significant, the difference (Δ0.64) between those that received fluoride varnish at school and the control group calculated only those with caries at baseline was interesting. This means that the prevented fraction was 20%.

This is in agreement with a number of reviews that have considered the evidence of the efficacy of Duraphat varnish to be well established (Petersson, 1993; Bawden 1998; Seppä, 1999; Beltran-Aguilar et al., 2000; Helfenstein and Steiner, 1994; Marinho et al., 2013). Nevertheless, there are studies that have not found any support for the effect of a fluoride varnish programme (Milsom et al., 2011; Oliveira et al., 2014). It is, however, important to compare different studies critically and consider the age of the participants, the follow-up period, how the varnish was distributed and how the caries registration was performed. For example, it is of less value to compare a study of seven- to eight-year-olds, where the fluoride varnish was applied to the occlusal surfaces and the follow-up was two years, with a study of 13- to 16-year-olds, where the fluoride varnish was applied to the approximal surfaces and the follow-up period was four years (Table 9).

Table 9. Comparison concerning study design and results between some recent fluoride varnish programmes

	Moberg Sköld et al., 2005b	Milsom et al., 2011	Slade et al., 2011	Oliveira et al., 2014
Age and number (N) of participants	13-16 years N=854	7-8 years N=2,967	1.5-2 years N=666	1-4 years N=200
Follow-up period	3 years	3 years	2 years	2 years
Diagnostic threshold	Approximal enamel lesions DFSa and DeSa	Occlusal dentin lesions DFS and DFT increment in the first permanent molars	Dentin lesions $d_3$mfs	Cavitated enamel (D_2) $d_2$mfs and $d_3$mfs
Fluoride varnish and application method	Duraphat Approximal application with a syringe	Duraphat One drop on the occlusal surface of the first permanent molar	Duraphat A thin film painted onto visible surfaces using a foam-tipped brush	Duraphat Applied to all surfaces with a disposable microbrush
Frequency of applications	two times/year at six month intervals	three times/year at four month intervals	2 times/year	2 times/year
Result	PF: 57%	N.S.	PF: 31%	N.S.
Area	Sweden: high-, medium- and low caries risk areas	England: high caries risk area	Australia: Aboriginal children with high caries prevalence	Brazil: high caries risk area

It is also important to remember the age of the participants. Adolescents have considerably more surfaces at risk than small children. Some studies have chosen to exclude enamel lesions, which means that the whole caries prevalence is not reported. The follow-up period is also important, as caries develops relatively slowly. This means that a short follow-up will fail to answer questions on the efficacy of a preventive programme. It is also important to consider how the fluoride varnish applications are performed and with which frequency when evaluating a study. The randomised control trial in Paper I, as well as the implemented fluoride varnish programme in Paper IV, were performed on adolescents with a large number of approximal surfaces at risk and the follow-up period was more than three years.

Nevertheless, the question of the exact role of the fluoride varnish itself, when combined with supervised toothbrushing and flossing, as well as oral health education, remains. In both Paper I and Paper IV, all the adolescents regularly met a dental nurse and this meeting is important, as was established in Paper II and Paper III. Furthermore, the dental nurses have the opportunity to identify adolescents with a high risk of caries or lesions. This means that the dental nurses had the ability to refer these adolescents to the dental clinic where they were able to receive extended prevention and even restorations. Oral health education, combined with other activities, such as fluoride administration, and provided on a regular basis, is likely to have a positive impact on oral health However, oral health education may have limited impact on its own (Jürgensen and Petersen, 2013).

In a study by Källestål from 2005, the effectiveness of four different caries-prevention programmes was compared within a group of adolescents at high risk of caries. The results after five years showed no significant differences in caries increment and the conclusion was that the caries-prevention programmes were equal in showing low efficacy in adolescents with a high caries risk, which can further strengthen the idea that population-based caries prevention is to be preferred, combined with extended prevention in single cases.

As no statistically significant differences were seen, when comparing Bifluorid 12 and Duraphat with the same frequency of applications, it could be argued that Bifluorid 12 could be an alternative to Duraphat in school-based fluoride varnish programmes. Nevertheless, other factors, such as the price and the conceptions of the participants, must also be considered.

8.3 Conceptions

The overall impression was that both the adolescents and the dental nurses had positive experiences of the school-based fluoride varnish programme. The adolescents generally described great trust and confidence in the school dental nurse, which was a positive finding. This trust probably also affects the outcome of a programme, as, according to the statements, it affects the motivation to follow given recommendations or receive oral health education. Hedman et al. (2009) studied dental professionals' view of knowledge, learning and health promotion and found a wish to reach people with health promotion. This is in conclusion with the results of Paper III, where the dental nurses found that good contact with the adolescents was positive, as it enhanced the ability to reach the adolescents more effectively. Another factor contributing to this was the experienced shift in the balance of power between the dental nurse and the adolescents when meeting in the school arena instead of the dental clinic.

Nevertheless, the adolescents also had some negative experiences, which should be considered and, if possible, prevented. Firstly, the introduction to the programme had been scary for some participants. It is plausible that the first time for most things is associated with some tension, but, knowing this, the dental nurse could place the emphasis on preparing for the first time.

Secondly, the adolescents described experiences of being in an exposed situation during the fluoride varnish application. This was due to the fact that they had to open their mouth for the dental nurse and for their peers. It is important to remember, according to the findings in this study, that a fluoride varnish application at school must always be performed so the participants' integrity is safeguarded. This means that no negative comments are made about dental health and no school friends are allowed to stand too near or look into the mouth of the adolescents that are receiving the application. Another way of ensuring this integrity could be to meet the adolescents in small enough groups, to reduce the number of spectators and to minimise the group pressure.

A third area for improvement could be the information given to the adolescents before performing the fluoride varnish programme. Even if information had been given, the adolescents stated that it had not been sufficient or was lacking. This indicates that the information should perhaps be developed further and designed in a more appropriate way to suit adolescents.

The fourth finding worth reflecting on is the relationship between the adolescents and the school dental nurses. Although the adolescents stated that

they had generally met pleasant dental nurses with a positive approach that had created a good atmosphere in the programme, some had also experienced meetings with dental nurses with an unfriendly attitude. This was experienced as affecting the whole programme in a negative direction. It is therefore important to support all dental nurses working at school, so that they are mentally equipped with the right tools to do a good job. This could involve education, networking and further education, as well as choosing the right individuals for the task.

8.4 Costs

The cost of a preventive programme can be analysed in many different ways. The choice of method depends on the data that are available and the perspective that is going to be studied. In Paper IV, the cost of the programme to the Public Dental Service was compared with the costs avoided for fillings, which means savings for the Public Dental Service. In a broader perspective, there are several other costs for both individuals and society. The individuals spend time and money on travelling to and from the dental clinics and the same things applies to younger children's parents or other adults.

Another way of measuring the effectiveness of a preventive programme was used in Kuwait, where a school oral-health programme resulted in a considerable reduction in the need for treatment, based on the reduced number of composite restorations performed during the programme (Ariga et al., 2014). The reduction in restorations indicates a decline in caries prevalence, which is preliminarily also confirmed by the results of a national oral-health survey of Kuwaiti schoolchildren, according to the authors (Ariga et al., 2014). This way of measuring the outcome differs from Paper IV, which instead calculated the possible number of fillings prevented. Measuring only the number of fillings performed before and after a programme could have several disadvantages, such as changes in the policy governing when to perform treatment of a caries lesion, over time.

The cost analysis in Paper IV calculated the difference in prevalence between two groups in terms of approximal decayed and filled surfaces, DFSa. The reason was that the analysis aimed to measure actual avoided costs, which means dentin lesions which, with a high degree of probability, would be the target of fillings. An alternative would have been to compare the total approximal caries prevalence, including enamel lesions. Nevertheless, as only dentin lesions are the target of fillings in Sweden, there would have been uncertainty about the number of these enamel lesions that would actually have resulted in fillings in the near or distant future. A study by Vidnes-Kopperud et

al. (2011) showed that only 7% of the dentists in Norway reported that they would treat approximal enamel lesions operatively, which means a change in the treatment concept during the last few decades. This is probably also true in Sweden.

In Paper IV, caries data were extracted for the groups aged from 12 to 15 years and these caries data formed the basis of the cost analysis. In addition, an estimate of costs and savings up to the age of 19 was made. This could be discussed, as no caries data were available from 16 to 19 years of age, but several studies have shown long post-treatment benefits after fluoride programmes (Leverett et al., 1985; Leske et al., 1986; Haugejorden et al., 1990; Kobayashi et al., 1995; Moberg Sköld et al., 2001).

As the cost analysis in Paper IV was limited to comparing the cost of the programme with the reduction in costs due to a reduced number of fillings, all other possible benefits of the programme were not evaluated. For the individual, fewer caries lesions mean better dental health, which could be evaluated from many different aspects. Fewer fillings, due to a lower caries prevalence, could perhaps mean less dental fear due to less pain and frightening treatments. No further analysis of these effects was made, but a preventive programme that saves as much as it costs in the very short perspective is inevitably cost effective in a longer perspective, especially if the programme does not have any negative effects on the population.

8.5 Ethics

It may be difficult to strike a balance between the expectation that everyone will participate and the voluntariness of a population programme. The ethical principles of respect for the individual are the same for all ages, but, as adolescents could lack the capacity to understand the benefits or the risks involved in a procedure, they have to depend on their parents as adults to make decisions for them (Dixon-Woods et al., 2007). This means that parents or guardians, who have a duty to protect their child's welfare, are responsible for making a decision for their child. It is therefore important to obtain the parents' consent before the start of a preventive programme. Nevertheless, the children or the adolescents must also have a say and first and foremost be able to refrain from participation if needed. This is seldom a problem, but the opposite could be a potential dilemma, which results in an adolescent wanting to participate in a programme and the parents declining. Although consent from parents or guardians is a requirement, the autonomy of adolescents should be respected and included in the decision-making in accordance with their age and

capability (Ackerman, 2001; Davidson and O'Brien, 2009; World Medical Association, 2008).

Another ethical question that has been raised in population-based programmes considered the fact that all adolescents receive the same treatment irrespective of actual risk. This means that there are individuals who are "over treated", as they would remain caries free regardless of the intervention. This topic is even more in focus when a drug, such as fluoride varnish, is administered in the programme. Nevertheless, as stated by many researchers, those individuals are difficult to find and especially during adolescence when the risk of caries can rapidly change due to many circumstances and the best caries predictor is past caries experience (Mejàre et al., 2014). The use of a drug that is applied to low-risk individuals must therefore be extremely safe and guaranteed not to cause any form of harm in the population and, in this context, Duraphat matches this criterion effectively. Furthermore, to implement a population-based caries-prevention programme without any form of fluoride supply is questionable, as prevention programmes with the use of fluoride have shown a caries-preventive effect in adolescents (SBU, 2002).

Another ethical consideration in a population-based programme such as the fluoride varnish programme is the democracy aspect, as all adolescents are offered the same preventive measures. Even individuals with good health should have access to health promotion. There is also a gain when individuals at risk of caries are not singled out on a negative basis but are treated in groups with their peers.

Not covered in this thesis

The focus in this thesis has been caries, one of the main oral diseases for adolescents. Nevertheless, there are other oral diseases that are important for this age group, such as dental erosions and periodontal diseases. A population-based programme with dietary advice, promoting daily toothbrushing with toothpaste, in addition to fluoride varnish applications, could possibly have a positive effect on these diseases as well.

9 CONCLUSIONS

9.1 Conclusions in Papers I-IV

- When comparing the two fluoride varnishes, Bifluorid 12 and Duraphat, with the same or a higher frequency of application, no statistically significant differences in approximal caries increment among 12- to 16-year-olds after 3.5 years in an area with low caries prevalence were found. Moreover, there were no differences compared to a group, which did not receive any fluoride varnish applications at school (Paper I).

- Adolescents participating in a school-based fluoride varnish programme felt that taking part was positive but had experienced feelings of exposure, peer pressure and a lack of information during the programme (Paper II).

- The dental nurses found that performing a fluoride varnish programme at school was a positive experience, mainly as it meant meeting adolescents where they are comfortable and relaxed, with an opportunity to identify individuals with poor dental health. The work was associated with a high degree of independence and variation, even if it was also a challenge to adapt to the school's conditions and terms, as it meant working in someone else's arena (Paper III).

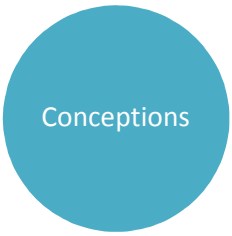
- The approximal caries increment from 12 to 15 years of age was significantly lower after the implementation of a school-based fluoride varnish programme, on a broad scale in field conditions, in the Västra Götaland Region. A break-even between costs and gains due to prevented fillings at the age of 15 was achieved, which suggests that the cost effectiveness of the programme was good (Paper IV).

9.2 Main conclusions

A school-based fluoride varnish programme, implemented on a broad scale in the Västra Götaland Region in Sweden, for all 12- to 15-year-olds, was found to have a caries-preventive effect. Comparing two fluoride varnishes, Bifluorid 12 and Duraphat, no differences in approximal caries increment were found. The participating adolescents and dental nurses had positive experiences of the programme. The reduction in costs, due to prevented fillings, was very similar to the cost of the programme, during the four-year study period, which suggests large-scale cost effectiveness over an extended period of time.

10 FUTURE PERSPECTIVES

For future research it would be of the greatest interest to study whether fluoride varnish programmes have a long-term effect during the caries risk ages of 12 to 15 years. The analysis of the large data set in Paper IV will also continue, as there are several questions that could possibly be answered. It is possible to divide the material into subgroups and study the caries increment in areas, or individuals, with different caries prevalence. In addition, those participating in an extended programme should be analysed separately and compared with those taking part in the general programme.



The voices of the participants in a fluoride varnish programme were heard in this thesis and, for future studies, it is important to include this to a greater extent. More people are involved in a fluoride varnish programme and a group like this comprises the school players and it would be of great interest to know how they experience the programme. A better understanding of their conceptions could possibly improve the co-operation between the dental and school personnel.

Finally, further studies, or more refined health-economy analyses, of the cost effectiveness of the programme would be of the greatest interest. This could provide a more complete knowledge of the costs and benefits of a prevention programme, especially if the analysis focused on a more extended period of time.

ACKNOWLEDGEMENTS

Jag vill tacka alla er som under så många år hjälpt och stöttat mig i mitt avhandlingsarbete.

Ulla Moberg Sköld, min engagerade handledare och medförfattare från start till mål på den här resan. Kunnig, påläst och full av energi. Som tidigare övertandläkare på Tandhälsovården även den som på allvar väckte mitt intresse för tandhälsovård och som jag har att tacka för att jag fick möjligheten att arbeta med dessa frågor idag.

Dowen Birkhed, min förste huvudhandledare och medförfattare, som funnits med under alla år, om än de senaste till viss del på distans från Malmö. Stort tack för all hjälp och stöd.

Margret Lepp, min handledare och medförförfattare från Vårdvetenskapliga institutionen. Tack för att du delat med dig av din stora kunskap om fenomenografi och kvalitativa metoder och tack för all uppmuntran under min doktorandtid.

Peter Lingström, min andre huvudhandledare och medförfattare. Tack för att du trädde in och engagerade dig i min doktorandutbildning likväl som i delarbete IV på ett så utmärkt sätt.

Christina Granlund, radiolog och medförfattare. Tack för alla de timmar du la ner på att tillsammans med mig läsa de drygt 9 500 röntgenbilderna. Utan dig hade jag gett upp redan första förmiddagen vid röntgenbordet. Tack för att du både tog oss igenom det och fick det att bli trevligt.

Lars Gahnberg, min chef på Hälsoodontologiska enheten och medförfattare. Tack för stöd, förtroende och ett roligt arbete.

Magnus Hakeberg, medförfattare och stöd när det gäller statistik.

Vänner och kollegor på Folktandvården Landvetter, Mölnlycke och Hindås, ni har varit ovärderliga och utan er hade det inte blivit många studier gjorda, åtminstone inte i Härryda. Jag hoppas ni vet hur mycket ni har betytt för mig både när det gäller forskning, jobb och vänskap.

Vänner och kollegor på Hälsoodontologiska enheten, en arbetsplats utöver det vanliga. Vill särskilt tacka er som jag jobbat närmast; Anita Alm, Christina

Larsson, Christina Prestgaard, Katharina Wretlind och Ewa Nyström. Alltid stöttande, uppmuntrande och engagerade.

Christer Davidson och Lena Eliasson, ni tog emot mig som en alldeles ny tandhygienist, och lät mig få träda in i tandvårdens förtrollade värld. Utan någon vettig anledning gav ni mig ibland ledigt för att jag skulle kunna fortsätta min fördjupningsutbildning, som kanske någon gång skulle kunna behövas för en forskarutbildning. Tack.

Anders Ljungné, för att du såg att jag behövde en utmaning och gav mig möjligheten att påbörja denna resa. Tack för att du fortsatt att ge mig nya uppdrag, utmaningar och uppmuntran.

Birgit Johansen, ditt stöd och engagemang har betytt så mycket för mig.

Helene Vighagen, tack för all hjälp och allt stöd under alla år. Först med Härrydastudiens alla utmaningar och sedan som min engagerade chef.

Bent Petersén, tack för ditt viktiga stöd från start till mål.

Lotta Sundelin, tack för stöd och uppmuntran.

Avdelningen för Cariologi, som jag är glad att ha fått vara en del av.

Tommy Johnsson, för hjälp med statistik.

Jeanette Kliger, för hjälp med språkgranskning.

José Ferraz-Nunez, för samtal om hälsoekonomi.

Syskon, svägerskor, svågrar och vänner, som motiverat och hjälpt till och distraherat och balanserat på ett helt otroligt sätt under alla dessa år. Tack!

Ingrid och Lasse, mamma och pappa, som är mitt livs kanske allra största vinstlott. Ni är bäst! När man har er i sitt liv så kan man inte misslyckas, för man har redan fått ett försprång.

Henrik, för uppmuntran, hälsosamt intresse i vissa frågor och ett ännu hälsosammare ointresse i andra frågor. Du har fraktat fluorlack och röntgenpärmar, byggt mig ett hemma-kontor, tagit foton, diskat och på det stora hela varit en utmärkt assistent under alla dessa år. Dessutom snygg och snäll, vilket är en oslagbar kombination!

Slutligen vill jag tacka alla mina små älsklingar, mina hönor, tuppar och guldfiskar. Trots att ni saknar tänder har jag har fått använda lite av er tid, det som kanske för andra framstår som min fritid, för att skriva denna avhandling. Ni sätter fokus på det som är viktigt: Att vi alltid har mat hemma.

Studierna har kunnat genomföras tack vare stöd från Folktandvården Västra Götaland, FoU-rådet i Göteborg och Södra Bohuslän, FoU i Västra Götaland och VOCO.

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