Investigation on Time Spent on Caries Prevention in Västerbotten Public Dental Service Clinics
A secondary analysis of data from a longitudinal caries study

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1. Abstract (222 words)

Introduction: Despite being preventable, dental caries is the most widespread noncommunicable disease (NCD) globally. Being the most prevalent condition, and the attempts of dentists and dental auxiliaries to give oral health the right attention, transparent, reliable, and up-to-date data about the type and level of oral health care costs are of significant societal relevance to present feedback about health system–level efficiency.

Methods: Using records from a prospective cohort of 452 12-year-old children from 14 Västerbotten Public Dental Service Clinics an investigation on time spent on caries prevention was done. Time spent on caries prevention per patient per year was used as a proxy for caries prevention costs to understand variation in values in these cohort.

Result: Time spent on caries prevention was associated with individual caries experience, clinics caries prevalence and number of dentists and dental auxiliaries in a 1:2 ratio. Besides, the patient’s caries risk assessment could not explain oral health professionals time spent on caries prevention.

Discussion: Time spent on caries prevention was not evenly distributed (median= 6.8 minutes). As a consequence of improved dental health and scarce resources it has been essential to optimize the efficiency in the dental service. Thus, the amount of individualized preventive intervention offered and given by dentists, hygienists and nurses, to the patients in the various risk groups needs to be further clarified.
2. Introduction

2.1 Global Burden of Dental Caries
Despite being preventable, dental caries is the most widespread noncommunicable disease (NCD) globally. In the 2015 Global Burden of Disease Study, dental caries is ranking first for caries of permanent teeth (2.3 billion people) and 12th for deciduous teeth (560 million children), making it a major public health problem (1). Therefore, joint action between local, regional, national, and international levels among researchers, policy makers, public health practitioners, clinical teams, and the public is needed urgently (2).

Quality of life can be deteriorated when dental caries is left untreated since it can develop difficulties in eating and sleep. In its advanced phases it may result in severe pain and abscesses can progress in chronic systematic infections. Thus, dental caries is also associated with adverse growth patterns as well as a frequent cause of absence from school or work (1).

Moreover, the lack of proper health facilities and the uneven distribution of oral health professionals in most countries translates into low access to primary oral health services. For example, in low-income countries the overall coverage for oral health service in adults ranges from 35%, 60% in lower-middle-income countries, 75% in upper-middle income countries to 82% in high-income countries (3). This results in a high proportion of oral diseases being untreated and leads to significant unmet patient needs. Furthermore, even in high income settings, dental treatment is costly, averaging 5% of total health expenditure (4) and 20% of out-of-pocket health expenditure (5). For example, in 2015 the worldwide average dental expenditure per capita was 413SEK. On the regional level, the highest per capita levels of expenditure were found for High-Income North America (3.095 SEK), Australasia (2.817 SEK), Western Europe (2.016 SEK), High-Income Asia Pacific (1.366 SEK), and Asia East (371 SEK). On the country level, the highest expenditures were found for Iceland (3.863 SEK), followed by Germany (3.517 SEK), Norway (3.213 SEK), Australia (3.188SEK), and the United States (3.121 SEK)(6)(7).

Being dental caries de most prevalent condition, transparent, reliable, and up-to-date data about the type and level of oral health care costs are of significant societal relevance to present feedback about health system–level efficiency (8).
2.2 Aetiology of Dental Caries

Dental caries is caused by two main groups of bacteria, specifically the mutans streptococci and the lactobacilli species, by fermenting carbohydrates, which produce acids and dissolves tooth mineral (9–12). The acids produced include lactic, acetic, formic and propionic, all of which have been shown to easily dissolve the mineral of the enamel and dentine (13–15). These bacteria are known as acidogenic, since they produce acid as a by-product of their metabolism and aciduric, which gives them the ability to live in an acid environment. Once the organic acids are produced by the bacteria in dental plaque on the tooth surface they easily diffuse in all directions through the pores of enamel or dentine (first and second layer of the tooth) and into the underlying tissue. The acid begins to dissolve acid soluble mineral as it diffuses into the tooth (13,16). The final result is a cavity, if this process advances long enough (many months or years). However, before cavitation, in the early stages of the disease, carious lesion progression can be stopped and even reversed with interventions such as high fluoride concentration varnish applied by an oral health professional (17–20).

However, twin (17–20)(21), human experimental (22) and association studies, including genome wide association studies (GWAS) (23), have suggested that genetic factors play a role in caries as well (24). Findings from Esberg et al provided the first evidence for specific adhesin types of S. mutans that match and predict individual caries development in people. This results, provide a rationale for individualized oral care. The presence of SpaP B and Cnm subtypes coincided with more cross-sectional caries but also predicted increased 5-year caries increment in 452 Swedish children. A lack of such evidence for a specific S. mutans caries pathogen has interfered its clinical use and favored the idea of caries resulting from an ecological shift toward various acid-tolerant species by plaque acidification from sugar consumption. However, since children not infected with S. mutans developed caries as well, but to a lesser extent, both, lifestyle and non-mutans bacteria can be assumed to be part of caries development. Moreover, two long standing vaccine candidates involving host-microbe and bacteria-bacteria adhesion events, respectively, may play important roles in caries development depending on S. mutans biotype, disease prevalence, and life style profile in different populations and individuals. These results highlight the importance of developing novel approaches to diagnose high-risk patients and improve prevention and treatment of chronic infectious disease. The findings may also have relevance beyond dental caries and
translate to improved systemic health. For example, missing teeth as a consequence of caries and periodontitis is a reported risk factor for cardio-vascular disease (25,26). Therefore, chronic caries infections and associated inflammation from carriage of high virulence strains would likely contribute to poor outcomes related to systemic disease risk as well as to diminished oral health (27).

Also, Strömberg et al study demonstrates specific human genes that match and predict individual differences in prospective caries development. Taken together with recent report on S. mutans adhesion biotypes with high caries and systemic virulence (27), Strömberg et al findings may be generalized to indicate that many of the high-risk children who do not respond to standard prevention interventions carry highly cariogenic strains or defective innate and adaptive immunity. On the other hand, the many individuals of low-to-moderate genetic risk may develop caries largely from eating sugar and bad oral hygiene and respond to traditional standard prevention. Such results give intriguing insights into the etiology of caries, and a rationale for typing individuals for risk in individualized oral care. This means that high risk individuals could be identified and treated even before caries and other symptoms arise. As a result, these conditions may be more easily cured or prevented than when it develops (28).

2.3 How is caries classified and measured?
Despite novel findings, dental caries is still classified into different types based on affected surfaces (e.g. Root, occlusal, approximal, coronal), dentition (i.e. Primary, permanent) and age group (e.g. Early childhood, adolescents, elderly)(29).

As of today, there are several reference values for caries, individually, among groups and within groups. However, in order for studies to be endorsed by WHO the following age groups and caries prevalence index are recommended for nationwide surveys of the general population. The intention is creating tools that helped inform, plan and develop interventions based on worldwide valid results in order to be applicable from a public health perspective (30)
Reference values

Age

- 5 years

Between the age of 5 and 6 years old, children are expected to have an oral examination. The main reason is to be able to measure caries levels in the primary dentition. Also, in some countries, 5 years is the age at which children begin primary school. Thus, schools are a helpful setting for having access to children. In countries where school entry is at 6 or 7 years of age, these ages can still be used, but the mean age should be reported with the results. In this case, missing primary incisors should not be scored as missing because differentiating between normal exfoliation and lost because of caries or trauma can be difficult (30).

- 12 years old

In many countries, children finish primary school by this age. Therefore, it might be the last reliable sample available easily through the school system. Likewise, at 12 years all the permanent teeth except the third molars will have erupted. Thus, for international comparisons and surveillance of disease trends, age 12 years has been chosen as the global indicator age group (31).

- 15 years

The permanent teeth have been erupted for three to nine years by the time adolescents turn 15 years old. Therefore, the assessment of caries prevalence in adolescents may be relevant. Since adolescence has a major impact, it is important that the age group of 15–19 years has a periodontal assessment. For example, in countries where it is difficult to obtain reliable samples from this age group, individual examinations in two to three areas can be useful, in the capital city or another large town and in one rural area (30).

- 35–44 years (mean = 40 years)

Truly representative sampling in adult patients is difficult, but this age group is the standard age group for surveillance of oral health conditions in adults. Planners and decision-makers can assess the full effect of dental caries, the level of severe periodontal involvement, and the general effects of oral health care provided by sampling this age group. For example, samples can be drawn from organized groups, such as office or factory workers. It is of utmost importance to avoid obvious selection bias, such as sampling patients at health care facilities for this age group (30).
65–74 years (mean = 70 years)

Because population is suffering major demographic changes (i.e. age distribution of populations and the worldwide increase in lifespan), the age group of 65–74 years has become more important. In this age group, it is likely to estimate the manifestation of oral disease from a life course perspective. In order to plan appropriate interventions for elderly people and to measure the ultimate effect of population oral health programs, data for this group are highly needed. Sampling this age group is not considered as difficult as younger age groups. Because older people tend to be in or near their homes, as well as in senior houses or clubs or day centers or institutions it is easier to get a representative sampling (30).

Caries prevalence

Since different populations have different caries values, it is difficult to define a “normal” level of caries. Nevertheless, caries prevalence measures are used as a guide to understand how common caries is in a population at a specific point in time. World Health organization in an attempt to have a global measure to compare between groups recommend the next ones:

- DMFT and DMFS Index

These index are common measures used in longitudinal epidemiology studies of dental caries (32), the prevalence of untreated decay, cumulative decay incidence (33), incidence density (34), and the new caries increment, characteristically expressed as the variation in decayed, missing, or filled permanent teeth from baseline to follow-up (8).

Both, DMFT and DMFS are tools to describe numerically the caries prevalence. DMFT stands for Decayed (D), Missing (M), Filled (F) Teeth (T), while DMFS stands for Decayed (D), Missing (M), Filled (F) Surfaces (S).

In child and adolescent Swedish populations, the M component (missing teeth or surfaces) is omitted because almost no teeth are missing due to caries but instead for orthodontic reasons.
DMFT
It is used to get an estimation illustrating how much the dentition, until the day of examination has become affected by dental caries. The maximum value per individual is 28 (permanent) teeth, excluding teeth 18, 28, 38 and 48 (the "wisdom" teeth).

DMFS
It is a more detailed index because it calculates per tooth surface (in Sweden DFS or DeFS when including enamel caries). Molars and premolars are considered having 5 surfaces, front teeth 4 surfaces. Therefore, the maximum value for DeFS comes to 128 for 28 teeth (35).

Caries Risk Assessment (CRA)
A person’s likelihood of developing or not dental caries is known as caries risk. For this assessment clinicians rely on the available information regarding the level of exposure to caries risk factors and the progression the disease has had during a specified period of time (36). Thus, it is not possible to make caries risk assessment (CRA) with a mathematical exactness. The objective of the caries risk assessment is for clinicians to be able to estimate if a patient is at low, moderate or high risk of caries (36). After the three-levelled risk classification, target preventive measures followed by the implementation of an individualized caries prevention (ICP) program or intervention strategy (37,38) (39).

2.4 Caries Prevention
As of today, according to the World Health Organization (WHO), through simple and cost-effective interventions at population-wide and individual level, dental caries is preventable. More importantly, in the early stages of the disease, before cavitation, carious lesion progression can be halted, and even reversed (17,20). Historically, interventions in oral health have had limited success due to being based on simplistic ideologies regarding the caries process. This means that, emphasis on eliminating specific bacteria such as Streptococcus mutans or the recommendation of the use of fluoride products without consideration of other behavioral factors such as diet and oral hygiene has limited preventive success (17).

For example, fluoride is the main tool for the prevention of dental caries. This protects the tooth against demineralization and supports remineralization by acting as an antimicrobial
agent against cariogenic bacteria (40). Thus, in higher-income countries, broad-scale population interventions of fluoride provision through water supply, salt or milk together with increased access to dental services and tools such as toothpaste, mouthwash and gel (41) have being associated with the massively decrease of caries in the last few decades(42). Also, clinical interventions, such as the use of sealants, have all shown to be effective to reduce caries (43). Additionally, as mentioned before, there is a behavior and lifestyle component to dental caries, mainly related to diet, oral hygiene (41) and tobacco (44) which can be acted on through a preventive rather than curative approach to dentistry (45). This means that burden of dental caries can be reduced through public health interventions by addressing common risk factors (46). A study published about this issue by Jamieson et al highlights the efficacy of a multilayered approach to maintaining oral health (i.e. in Aboriginal children). This means that, the engagement with the local community and provision of information and preventive services in a culturally appropriate manner maximizes the potential impact of an intervention (47). Nevertheless, as described previously, recent studies have shown different types of caries patients respond differently to prevention (24,27). As resources to provide dental services are limited, there is a need to understand what these different groups are and how resources are currently allocated to optimize prevention (48).

2.5 What has been done so far?

Historically, interventions in oral health have had limited success due to being based on simplistic ideologies regarding the caries process. This means that, emphasis on eliminating specific bacteria such as Streptococcus mutans or the recommendation of the use of fluoride products without consideration of other behavioral factors such as diet and oral hygiene has limited preventive success (17).

The World Dental Federation (FDI – Fédération Dentaire Internationale) and the World Health Organization (WHO) established the first Global Oral Health Goals together in 1981. The goal was to achieve an average of not more than 3 DMFT at the age of 12 per children by the year 2000 (49). By the end of this period the goal was achieved or even exceed by many countries. However, for the great majority of the world's population, the goals were limited to be a simple aspiration. Nonetheless, the Oral Health Goals worked as a calling for awareness of oral health amongst national and local governments.
In 2012, the World Federation of Public Health Associations (WFPHA) established an Oral Health Working Group (OHWG) with the objective of raising the profile of oral health as an inseparable part of public health. Since then, the OHWG has, in a series of resolutions passed by the WFPHA General Assembly, advocated for better global oral health (50).

More importantly, the first-ever United Nations High-Level Meeting on Universal Health Coverage (UN HLM on UHC) will take place on 23 September 2019 in New York to secure political commitment from countries on UHC. The meeting will result in a Political Declaration, negotiated by UN Member States, that will form the basis for global efforts to provide universal access to affordable and quality health-care services (51). According to the FDI, integration of oral health into primary healthcare and UHC, strengthen health surveillance systems to monitor oral health, and increase investment in NCDs, must be address as priorities in order to improve oral health and UHC (51).

However, before de UHC concept exist, some countries across the world have adopted their own versions of universal oral health care, making them a potential model to follow when adopting the commitment to provide universal health care. For example, Austria, Denmark, Germany, Poland, Spain, Sweden, and Mexico are providing basic dental care services through state-sponsored health insurance schemes funded through population’s general taxation mechanisms. In countries such as Greece, Turkey, and Finland, basic dental care services are provided through a mix system of subsidized private practitioners and state-funded health services (52). The last-mentioned examples showed how countries are already making progress towards UHC. Regardless their possible weakness, the characteristic of being different type of economies give health care providers and policymakers hope for such an ambitious goal (UHC that includes oral health care). Nevertheless, it is of outmost importance to point that the dental services provided through country-specific universal oral health care mechanisms might differ in their level of coverage. As well, several challenges might make it difficult to evaluate the oral health care schemes across the different countries. However, looking from a closer perspective at the current global situation, health systems are finding it increasingly difficult to respond to the ever-growing health needs of the populations. The increasing costs of health services has difficult the availability of healthcare services even in countries where it has been conventionally accessible and affordable (53).

For that reason, oral health providers know the difficulty to incorporate successfully oral
health care into the UHC packages. Thus, the need to bring up to date information regarding the cost-effective preventive schemes that have worked to decrease caries prevalence among some countries or within countries (54).

2.6 Dental Care in Sweden

In 1974, Sweden introduced a national dental insurance system that provided every citizen with dental care, including prevention, which was unique at that time (55). However, in 1991 dental insurance coverage was reduced by being replaced by a national subsidized support system. Later this scheme was modified with the aim of benefiting children and elder people (56). Nowadays, this system is considered to be affected by the effects of inflation and the increase in healthcare prices (57,58).

Currently, the healthcare service, which includes the oral healthcare, is delegated to the county or municipality level. In addition, the government mostly distributes budgets based on political priorities. It is the county council that decides how to distribute budgets, including dental care for children and adolescents, which is sometimes affected.

Finally, it is the Dental and Pharmaceutical Benefits Agency, in Swedish Tandvårds- & Läkemedelsförmånsverket (TLV) who is in charge of deciding which dental procedures and products are covered by the state (59).

2.7 Pediatric dentistry

In Sweden, it has always been a priority for the government, the dental prevention and treatment of children. Therefore, maintaining an accessible dental care system has been prioritize throughout the last 40 years. The results can be measure by the decrease of caries prevalence among children, before many other countries did (60). The dental service is given regularly and individually targeted. In fact, it is estimated that in a range of two years, 95% of children and adolescents have had contact with the dental service. Also, the latest legislation reform offers dental care for children, adolescents and young adults up to 23 years of age. This applies to public and private dental care (61).

In Sweden, dental care is given either by a dentist from the public dental service or from the private practice. But the majority of the dental care for children and adolescents is carried out
by the public dental service. Also, the specialized treatment, mainly the orthodontics and other dental pediatric specialties is mainly granted by specialists employed in the dental public service but in some counties or regions also the specialists of the private practice grant the service and is financed by the state. In addition, parents or legal guardians of minors choose the dentist or dental clinic that is responsible for the dental care of their children (62).

2.8 Correct allocation of resources
In Sweden and countries with a low caries prevalence, many children are either free of caries or have a low disease level while 15–20% remains with a high caries burden which accounts for approximately 60% of caries development (63)(29,64). However, those high caries groups have been poorly explained by lifestyle risk factors such as large consumption of carbohydrates, oral hygiene habits, or fluoride or mouthwash use. It seem that some populations do not respond to traditional oral health prevention schemes based on protecting populations with those risk factors (64). Accordingly to those studies, this groups’ life style, saliva, and bacteria, as traditionally known as common risk factors, are poor predictors of caries development (29,65). Thus, in the last decades better etiological models and diagnostic and preventive tools are seemed to be needed. However, socioeconomic factors have been shown to impact the oral health in Swedish children and adolescents, including dental caries. The foremost socioeconomic risk factors for dental caries in children and adolescents in Sweden are family low level of education, low cash funds and being foreign-born (66–68).

Traditionally, the welfare systems and dental services in the Nordic countries were based on population strategies (4, 8). Thus, preventive programs have been developed and offered to the total population or to defined subgroups at risk (9). Nevertheless, in the last decade, individually oriented preventive dental care based on risk assessment has become part of almost every county oral health guidelines (10). This means that length of recall intervals for children has been individualized, based to an individual assessment of caries risk, and different categories of personnel such as dental hygienists and dental nurses have been involved in the delivery of such prevention scheme. As a consequence, caries incidence has been reduced as mentioned before. On the other hand, caries prevalence in Swedish children and adolescents show that populations have not benefit equally from these preventive schemes (5,11).
Wang et al studied the time spent on caries prevention amongst the Nordic countries and results showed that preventive dental care for children and adolescents consumed substantial resources in all the countries participating in the study. According to the dentist’s preventive care absorbed 12 to 25 min per child per year. Then, at the time of the study, prevention was reported to constitute 18% to 50% of the total time for dental care. This adds up to a very large amount of time dedicated to the preventive dental care of children and adolescents (69). In the same study, the time spent on caries prevention per children by dentist was longer in Norway (23 min) than in the other countries (14, 16 and 17 min). Both the maximal and the most frequently used interval between recalls were substantially longer in Norway (17.0 and 13.5 months) and Sweden (17.9 and 13.1 months) than in Denmark (10.8 and 9.2 months) and Iceland (9.9 and 7.4 months) (69).

Recently, a study in Vasterbotten (northern Sweden) adult population receiving dental care at public clinics, presented that adult patients with high or no/low caries are different populations. Each population contain distinctive subpopulations, those who improve/impair or maintained their caries risk and disease progression. Thus, the study concluded that these groups needed different strategies in disease treatment. Also, some preventive measures and non-operative treatments were associated with improvements in caries risk and maintenance, but the level to which dental preventive treatments were given to high caries risk subjects was unacceptably low and not in line with present guidelines (caries risk assessment is mandatory in Västerbotten since 2002) (70).

2.9 Tasks division between oral health professionals

It is necessary that the diverse categories of work are done by healthcare personnel with the appropriate qualifications, in order to guarantee the provision of health care in a most cost-effective way. For example, if complex procedures are left to unqualified personnel, patients could be at risk. Contrariwise, if basic tasks are done by over-qualified personnel, efficiency will likely fail. For instance, in the case of the dental service, cost-effectiveness could improve if dental hygienists did more of the work for which they are actually trained, such as examining and screening patients and performing basic forms of treatment (71–75) as well as dental nurses.

Compared with other European countries, the Nordic countries have relatively more dental hygienists per dentist (6, 36). However, Norway has relatively fewer dental hygienists per
dentist than the other Nordic countries, and considerably fewer than Canada, Japan and the United States, when comparing globally where there is almost one dental hygienist per dentist (6, 36).

For example, between Nordic countries, despite the similarities, the provision of dental care for children differs. Different personnel provide preventive services. In Iceland, examinations and prevention are mainly performed by dentists, in Denmark and Norway by dentists and hygienists, while in Sweden in addition specially trained dental nurses perform preventive care (69). Therefore, the dynamic work done between the full-time personnel in public dental clinics could help understand better what happens inside doors.

Also, a retrospective analysis of caries management and risk in adults in Västerbotten County found that despite improvement on the prevention scheme deliver for high-risk patients, the rates at which it was given was very low and did not match with the real need for each patient. Therefore, in order to use resources in a cost-effective way a better and earlier identification of caries risk is needed (27).

Similarly, a cost analysis evaluation made in 2018(48), from a prospective cohort study in Västerbotten County, showed that the amount spent on prevention cost per child was only a fraction of the annual budget available per child. Therefore, further investigation on the possible reasons of the negligible amount spent on prevention was suggested. In the cost analysis, clinics with higher caries levels among children and adolescents and those with higher costs did not match. This is surprising as Västerbotten clinic uses a caries risk assessment guideline since 2002. Thus, it would be expected that cost via estimated risk drive dental practitioners to allocate dental caries prevention (48). Since, salaries were estimated to represent > 99% of the total costs per prevention session and results showed, that after covering rent, salaries and consumables in the Dental Public Health System there is very little funding left for prevention, this cohort was analyzed from the time spent on prevention perspective (48). Based on some limitations that the author mentioned in the study, new variables were introduced in this study dataset in order to investigate which patients’ characteristics and which clinics’ characteristics drive oral health professionals to allocate time on caries prevention.
Aim
The aim of this study is to investigate time spent on caries prevention for patients from Västerbotten Public Dental Service clinics and the reasons for variation in values in these patients. As time spent on caries prevention is used as a proxy for caries prevention costs, the study will also try to explain why cost differ between clinics by answering the following questions:

Research question
Is there an association between time spent on caries prevention and participants baseline characteristics such as caries score and caries risk?
Could characteristics from clinics such as size, personnel, or caries prevalence explain time spent on caries prevention?

3.1 Study design
The present study is a prospective cohort study.

3.2 Study setting
The study was led by the Department of Cariology of Umeå University and took place in 14 public dental clinics in Västerbotten county located in Northern Sweden.

3.3 Study population
The study cohort included patients who regularly attended Public Dental Service clinics from the year 2005 to 2011.
Patients from the county statistic records were randomly selected among low/high caries 12-year-old patients born in 1996 and 1998. The only criteria for exclusion was unwillingness to participate (24,27).

3.4 Sample size
Two independent samples of 12-year-old children were recruited with a total of 452 children. The first sample were children born in 1996 which at the age of 12 years old had caries ($\geq 1$ Decayed and Filled Surfaces (DFS) in the permanent dentition) and caries-free controls (DFS= 0 in 2007) were also included. For the second sample, participants born in 1998 with caries at 12 years old ($\geq 2$ DFS lesions) and controls (DFS = 0 in 2009) were included to increase the proportion caries cases in the total sample of 452 children (24,27).
3.5 Prevention
Participants received standard dental care at Public Dental Service Clinics. Risk information was recorded at baseline and information about the prevention treatments performed was collected throughout the follow up examination (24,27). The recall intervals were based on risk assessments performed by the dentist or the dental hygienist and, consequently, may have differed between individuals.

3.6 Data collection
Clinical data collection was done by the research team dentist, dental nurse and laboratory assistant (24).

Measurement of caries
The participants were examined for caries at baseline and again after approximately four to five years later. Caries was recorded using a mirror, probe and two bitewing radiographs. The primary caries outcome measure was the mean number of Decayed (enamel caries included), Filled Surfaces in the permanent dentition (64,65).

Other data
Clinics’ size, full time personnel (number of full-time dentists, dental hygienists and dental nurses), and caries prevalence where acquired from the county records in order to answer the research questions. Number of caries preventive interventions per patient and the time allocated for each session were also introduced in the dataset.

3.7 Variables
Outcome variable
1. Minutes for caries prevention per year per patient was used as the outcome variable. Each “routine dental check-up” could involve preventive interventions such as information and/or application of fluoride varnish, chlorhexidine mouth rinse, and sodium fluoride (NaF), lifestyle advice relating to oral hygiene and diet, as well as simple and/or extensive prophylaxis by a dentist, dental hygienist or a dental nurse. Each preventive intervention required a specific number of minutes. The total number
of minutes of preventive interventions were divided by the participants’ total number of years in the study.

Predictor variables

1. Clinic: each clinic was coded with a number between one and fourteen. Umeå University Dental Clinic (Clinic 1) was used as a reference since it is the university having conducted the initial study. Also, it was assumed to follow procedures consistently to a high standard and be up-to-date with the latest recommendations for being the teaching hospital. For the statistical analysis each clinic’s number was used as a factor.

2. Individual Caries Prevalence (DeFS): the total number of Decayed (including enamel) and Filled Surfaces (De+F+S) was calculated for each patient at baseline. For the statistical analysis this variable stayed as numerical, continuous.

3. Clinic Caries Prevalence (DFT): the total number of permanent Decayed and Filled Teeth (D+F+T) due to dental caries was recorded for each participant. Then, the overall mean DFT score was computed by dividing the sum of the individuals DFT value by the total number of clinics’ patients. For the statistical analysis, a median cut-off was used. Patients with median= 0.65 and below were classified as low, while patients above the median were classified as high. Low category was used as reference.

4. Estimated Caries Risk: participants were classified into three mutually exclusive categories (0, 1, and 2) based on clinical assessment of the presence, location and progression of carious lesions by the dental practitioner at the first consultation. (See Annex 1, Table 1). For the statistical analysis this variable was converted into factors (0=Low, 1=Moderate, and 2=High). Low caries risk was used as reference.

5. Size: each clinic was classified as big or small. A big clinic was located in the city, have more staff and received more patients. Small clinics were located in small municipalities or localities, with a smaller number of staff. They were mutually exclusive. For the statistical analysis this variable used size big as reference.

6. Dentist ratio: the total number of full-time dentists, dental hygienists, and dental nurses were individual variables. A ratio between dentists and dental auxiliaries was used in order to analyze the possible effects of time on prevention depending on combination of the full-time personnel. The first step was to put together dental
hygienist and dental nurses in one group named: dental auxiliaries. The second step was to add the total amount of dental hygienists and dental nurses per clinic. Finally, a ratio was created by comparing the full-time dentists working with the full-time dental auxiliaries per clinic. Thus, every clinic with a ratio of 1 dentist per 2 dental auxiliaries (1:2) was classified as high ratio of dentist, while a clinic with a ratio of 1 dentist per 3 dental auxiliaries (1:3) was classified as low ratio of dentist. Low dentist ratio was used as reference for the statistical analysis.

3.8 Statistical Analysis

Data was reported using descriptive and inferential statistics. Means, standard deviations and frequency distribution for all the variables are presented in table 3.

Since the outcome variable presented a skewed distribution, the univariate and bivariate analyses were done with non-parametric tests. Wilcoxon rank-tests were used to check for differences between minutes use on prevention distribution among numerical variables and Kruskal-Wallis was used for categorical variable. Alpha level of $P < 0.05$ was applied for statistical significance.

In addition to the univariate analysis and bivariate methods used, a multinomial logistic regression analysis was performed. The outcome variable “Minutes for caries prevention per year per patient” was transformed into two tertials to split data into three groups (Low, Moderate and High level of prevention), due to the clear skewed distribution mentioned before. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated from the model and are reported in Table 4 and 5, in crude and adjusted analysis respectively. The significance level was set at $p < 0.05$. Significant test results are marked in the tables in the results section.

Data handling was done by Microsoft Excel version 16.23 while descriptive analyses, and regression modelling were performed using R computer software with R commander interface version R 3.5.3 GUI 1.70.
Outliers and influential points
The dataset presented several outliers, nevertheless the values described the real number of minutes received on prevention. Thus, there was no justification found to remove the influential observations or outliers from the data set provided in the final model.

Potential confounders
Demographic variables that could be confounding such as gender, socioeconomic status or ethnicity were not available.

3.9 Ethical considerations
The study was approved by the Ethics Committee for Human Experiments at Umeå University, Sweden (Dnr 08-047M, Addendum Dnr 2019-253-32M). Before participation, informed consent was acquired from the participants and their parents, as well as a parental signed consent due to the underage status of the participants. The study could be leaved at any time by the adolescent without giving any reason. Data was treated confidentially and stored in a secure data environment with each participant assigned a number at enrolment that cannot be linked to the patient by anyone other than the primary investigator (PI)(24,27).

Descriptive data
From the dataset, participants that had number of years in the study in the records were included in this thesis. Therefore, from the total of 452 participants who were included at baseline, 390 participants remained, resulting in a drop- out rate of 14% (n=62).
The range of years between baseline and follow up in the records were 3.44 - 7.50 years with a mean of 5.25 years, a median of 5.37 years (mode of 4.13 years).

The caries prevention received per year per participant was between 0 to 200.7 minutes. It had a clear right skewed distribution with a mean of 12.5 minutes, a median of 6.8 minutes and a mode of 0 minutes per year per participant.

The number of participants from each clinic were not evenly distributed. Clinic 1 had the biggest number of participants n=88 which represent 23% from the total. In second and third place were clinics 4 and 5 with 78 (20%) and 45 (12%) participants respectively. This showed that 50% of the participants came from just 3 of the 14 clinics. On the other hand, clinics 9 and 10 had 3 participants which represented less than 1% from the total cohort with 3 participants each one.

The individual caries prevalence at baseline (DeFS) followed a skewed distribution with a mean of 2.4, a median of 5.1 and a mode of 0. The range amongst participants was between 0 and 15 DeFS. From the total, 70% had a caries score equal or below the median=3. The other
30%, which represent the high caries score group (>3 DeFS), had a mode of 4 DeFS. Three participants outstand with 13, 14 and 15 DeFS each one.

The clinic’s caries prevalence (DFT) range between 0.59 (clinics 1, 5 and 8) and 0.84 (clinic 13). Among participants there was a mean caries prevalence of 0.68 and a median of 0.65. Participants above the median compromise 47% (n=183) of the total. Regarding caries risk assessment, from the total cohort, 46% were classified as low, 23% as moderate, and 31% as high caries risk.

Frequency between big and small clinics was almost the same. There was a 2% difference of participants between big (51%) and small (49%) clinics.

Similarly, participants distribution amongst clinics considered of having a low or high density of dentists was close to evenly distributed with a 4% difference. From the total, 52% of the participants received prevention in a clinic with low density of dentist (compared to dental auxiliaries), while 48% received prevention in a clinic with a high density of dentists.

**Bivariate analysis**

1. **Clinics**

   The clinics receiving the highest mean number of minutes per year where clinics number 10 and 12 with 29 and 25.6 minutes respectively. On the other hand, clinics 9 and 13 received the least mean number of prevention per year 5.6 and 4.3 minutes respectively. Clinics were significantly associated with time on prevention. The difference between the highest median (27.3 minutes) of prevention per year per participant and the lowest (4.2 minutes) was 23.1 minutes, which belong to clinic 12 and clinic 13 respectively.

2. **Individual caries prevalence at baseline (DeFS)**

   Patients with 0 DeFS received from 0 to 60 minutes of prevention per year. The participant with the highest number of DeFS n=15, received 5.9 minutes on prevention per year. The patient receiving the highest number of minutes for prevention per year was a patient with 11 DeFS. Meanwhile, participants receiving 0 minutes of prevention per year had a range of 0 – 7 DeFS. Nevertheless, individual caries prevalence (DeFS, median=5.12) was significantly associated with minutes on caries prevention per year.
3. **Estimated Caries Risk**

The mean number of minutes of caries prevention received by low caries risk patients was 8.71 minutes, 13.2 minutes for moderate caries risk, and 17.8 minutes for high caries risk patients. The median increasing 4 minutes between low (median=5.2) and moderate (median=9.2) caries risk and increasing 3 minutes between moderate and high (median=12.07) was significantly associated.

4. **Clinic caries prevalence at baseline (DFT)**

Participants from clinics with the lowest caries prevalence which represent the 39% (n=151) received between 0 to 200.7 minutes of prevention per year. Meanwhile the participants from clinics with the highest prevalence which represent 1% (n=4) received between 1 to 7.7 minutes of caries prevention per year. When classifying participants in low or high prevalence groups according to the median, the median increasing by 0.52 minutes between low (median = 6.5) and high (median= 7.3) clinics’ caries prevalence was not significantly associated.

5. **Clinic Size**

Big clinics allocated a mean of 11.8 minutes (median= 6.7) per year per patient, while small clinics allocated a mean of 12.3 (median= 6.8) minutes per year per patient. The difference between big and small clinics was not significant.

6. **Dentist Ratio**

52% of participants belong to a clinic with low ratio of dentist, which received a mean number of minutes of prevention of 11.7 per year. The median number of minutes of prevention in low ratio was of 6.6 minutes while high ratio clinics had 7.1 minutes. The difference was not significant.

<table>
<thead>
<tr>
<th>Table 2. Univariate and bivariate analysis of the study population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency (%) or M (SD)</strong></td>
</tr>
<tr>
<td>Total of patients</td>
</tr>
<tr>
<td>Total at follow up</td>
</tr>
<tr>
<td>Drop outs</td>
</tr>
<tr>
<td>Years in the study</td>
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</table>
### Clinics

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>88 (23)</td>
<td>14.3 (25.1)</td>
<td>**</td>
</tr>
<tr>
<td>2</td>
<td>40 (10)</td>
<td>11.0 (10.0)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28 (7)</td>
<td>8.8 (14.3)</td>
<td></td>
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<tr>
<td>4</td>
<td>78 (20)</td>
<td>8.6 (9.5)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>45(12)</td>
<td>9.9 (9.5)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>26 (7)</td>
<td>20.9 (8.0)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>25(6)</td>
<td>14.72 (16.3)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>18 (5)</td>
<td>14.7 (21.5)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>3 (1)</td>
<td>5.6 (1.9)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3 (1)</td>
<td>29.0 (32.6)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>12 (3)</td>
<td>8.9 (7.3)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>13 (3)</td>
<td>25.6 (15.1)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>4 (1)</td>
<td>4.3 (2.6)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>7 (2)</td>
<td>11.1 (11.2)</td>
<td></td>
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</tbody>
</table>

**Individual caries prevalence (DeFS)**: 2.4 (2.6) ** ***

### Clinic caries prevalence (DFT)

<p>| | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>207 (53)</td>
<td>12.9 (19.9)</td>
<td>0.42</td>
</tr>
<tr>
<td>High</td>
<td>183 (47)</td>
<td>12.1 (12.6)</td>
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</table>

### Caries risk

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</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>180 (46)</td>
<td>8.71 (10.5)</td>
<td>***</td>
</tr>
<tr>
<td>Moderate</td>
<td>89 (23)</td>
<td>13.2 (14.2)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>121 (31)</td>
<td>17.8 (23.8)</td>
<td></td>
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</tbody>
</table>

### Clinic Size

<p>| | | | |</p>
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<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Big</td>
<td>198 (51)</td>
<td>12.7 (18.7)</td>
<td>0.70</td>
</tr>
<tr>
<td>Small</td>
<td>192 (49)</td>
<td>12.3 (14.8)</td>
<td></td>
</tr>
</tbody>
</table>

### Dentist Ratio

<p>| | | | |</p>
<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Low (1:3)</td>
<td>203 (52)</td>
<td>11.7 (13.4)</td>
<td>0.74</td>
</tr>
<tr>
<td>High (1:2)</td>
<td>187 (48)</td>
<td>13.3 (19.9)</td>
<td></td>
</tr>
</tbody>
</table>

*P-value <0.05  
**P-value <0.001  
***P-value <0.0001

### Main results

1. **Individual Caries Prevalence (DeFS)**

Crude analysis (Table 3) shows that individual caries prevalence (DeFS) has an impact on the level of prevention allocated, being higher the odd for receiving high prevention (OR 1.44, CI
1.28-1.63) than receiving moderate prevention (OD 1.25, CI 1.11-1.41), over low prevention, both being significant.

2. **Estimated Caries Risk**
The odds of receiving moderate (OD 1.5, CI 0.80-2.83) and high (OD 3, CI 1.56-5.78) prevention increase for moderate caries risk participants compared to low risk. Similarly, high caries risk participants odds increase for moderate (OD 1.1 CI 0.62-2.02) and high (OD 3.5, CI 1.96-6.29) prevention compared to low risk. In both risk levels, moderate and high, high level of prevention was significant.

3. **Clinic Prevalence (DFT)**
Crude analysis showed that the odds for patients from high caries prevalence clinics compared to low, increase from moderate prevention (OD 1.06, CI 0.65-1.73) to high prevention (OD 1.24, CI 0.76-2.02) compared to low prevention. Nevertheless, these results were not significant.

4. **Size of Clinic**
Small clinics odds compared to clinics from the city, seem to decrease of receiving moderate prevention (OD 0.69 CI 0.42-1.12) and high prevention (OD 0.91, CI 0.56-1.48) compared to low prevention. None of the results were significant.

5. **Dentist Ratio**
The odds of patients from clinics with high dentist ratio decrease (OD 0.91, CI 0.56-1.48) for receiving moderate prevention, compared to low. On the contrary, the odds of patients from clinics with high dentist ratio increase (OD 1.03, CI 0.63-1.67). But none of the results were significant.
Table 3. Bivariate (crude) analyses of the relationship between clinical factors and prevention time

<table>
<thead>
<tr>
<th></th>
<th>Moderate Prevention (Ref. Low)</th>
<th>High Prevention (Ref. Low)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Individual Caries Score</td>
<td>1.25</td>
<td>1.11-1.41*</td>
</tr>
<tr>
<td>(DeFS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caries risk Moderate</td>
<td>1.5</td>
<td>0.80 – 2.83</td>
</tr>
<tr>
<td>(Ref. Low)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caries risk High (Ref.</td>
<td>1.1</td>
<td>0.62 – 2.02</td>
</tr>
<tr>
<td>Low)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic Caries Prevalence</td>
<td>1.06</td>
<td>0.65 – 1.73</td>
</tr>
<tr>
<td>(DFT)(Ref. Low)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of Clinic (Ref.</td>
<td>0.69</td>
<td>0.42- 1.12</td>
</tr>
<tr>
<td>Big)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dentist Ratio (Ref. Low)</td>
<td>0.91</td>
<td>0.56 - 1.48</td>
</tr>
</tbody>
</table>

* Asterisk indicates statistical significance.

Adjusted analysis

On the adjusted analysis, individual caries prevalence (DeFS) odds of receiving moderate prevention (OD 1.44, CI 1.20-1.73) and high prevention (OD 1.52, CI 1.27-1.81) increase and remained significant for both, compared to the odds of receiving low prevention.

The moderate caries risk odds of receiving moderate prevention (OD 0.60, CI 0.26-1.33) and high prevention (OD 0.89, CI 0.39-2.03), compared to low prevention, decrease but were not significant.

Similarly, high caries risk odds for receiving moderate prevention (OD 0.32, CI 0.13-0.77) and high prevention (OD 1.04, CI 0.44-2.43) decrease compared to low prevention, but only the results for moderate prevention were significant.

High clinic caries prevalence odds increase for both, moderate prevention (OD 1.23, CI 0.58-2.60) and high prevention (OD 2.23, CI 1.03-1.81), but the results were only significant for the latter.
Even when all predictors are held constant, clinic size was not significant. Nevertheless, odds decrease for both, moderate prevention (0.56, CI 0.30-1.03) and high prevention (0.74, CI 0.39-1.39), compared to low prevention.

The odds for participants from clinics with high dentist ratio of receiving moderate prevention (OD 0.85, CI 0.42-1.75) decrease and remained not significant as crude analysis. Meanwhile, the odds of receiving high prevention from a clinic with high dentist ratio increase (OD 2.07, CI 1.00-4.29) and became significant.

Table 4. Adjusted analyses of the relationship between clinical factors and prevention time

<table>
<thead>
<tr>
<th></th>
<th>Moderate prevention (Ref: Low)</th>
<th>High prevention (Ref Low)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Individual Caries Prevalence (DeFS)</td>
<td>1.44</td>
<td>1.20-1.73 *</td>
</tr>
<tr>
<td>Caries risk Moderate (Ref: Low)</td>
<td>0.60</td>
<td>0.26-1.33</td>
</tr>
<tr>
<td>Caries risk High (Ref: Low)</td>
<td>0.32</td>
<td>0.13-0.77 *</td>
</tr>
<tr>
<td>Clinic Caries prevalence (DFT) (Ref: Low)</td>
<td>1.23</td>
<td>0.58-2.60</td>
</tr>
<tr>
<td>Clinic Size (Ref: Big)</td>
<td>0.56</td>
<td>0.30-1.03</td>
</tr>
<tr>
<td>Dentist Ratio (Ref: Low)</td>
<td>0.86</td>
<td>0.42-1.75</td>
</tr>
</tbody>
</table>

* Asterisk indicates statistical significance.

Based on the analysis made with the information available of this cohort study, data provided evidence differences in the input of resources. The average minutes on prevention was 12.5 minutes with a median of 6.7 minutes and a mode of 0 per year per participant which is extremely low. For perspective, previous studies in the Nordic countries showed that the mean total time used for prevention per child per year by dentists was longer in Denmark (21 min) and Iceland (25 min) than in Norway (13 min) and Sweden (12 min) (69). In comparison
with that study, the mean number of minutes allocated for prevention in Sweden has not varied (69).

Regarding individual caries prevalence, there is a strong association between patients DeFS and the minutes use for caries prevention. This is not necessarily a positive result, because high score of DeFS not necessarily means that the patient needs more time for caries prevention than a low DeFS score patient. The objective of the caries risk assessment is to determine the strategy and the amount of time in prevention needed, while DeFS score is only one of the several tools an oral health professional use to estimate the caries risk of the patient. Actually, a high score of DeFS can mean a high level of access to the dental care service (but still a high experience of caries in the past). For example, as DeFS score also counts the number of filled surfaces (not just caries) it means that if a patient has a DeFS score of 15, the patient could have 1 Decayed and 14 Filled Surfaces. On the other hand, another patient could have a DeFS score of 5 which could be the sum of 3 Decayed and 2 Filled surfaces. Therefore, after evaluating other risk factors as dietary habits, oral care habits and good attendance to dental care appointments it is possible for a patient to have a DeFS score of 15 and be a low risk patient. Similarly, it is possible to be a high-risk patient with a DeFS score of 2. Several factors in close relationship with time will give the assessment. For example, if the patient developed 3 Decayed in a relatively short period of time combined with having bad dietary habits, as well as bad oral hygiene habits and low level of attendance to checkups it would be considered high risk patient according to the criteria stated on the guideline. See annex 1, Table1.

Assuming that health practitioners are deciding the time on recall depending on the caries risk assessment, low risk patients could be expected to receive even 0 minutes per year since being low risk assigned them a longer period until the next checkup, which can vary up to 1.5 years to 2 years. But statistical analysis by the patient caries risk was not significant, confirming their prevention was not based on their caries risk. Low risk patients (n=180) actually receive a mean of 8.7 minutes (median 6.6 minutes) per year compared to the mean 13.3 minutes for moderate risk patients (median 6.8 minutes) and the mean 17.7 minutes for high risk patients (median 7.7). It would be expected that patients with low caries risk will received low level of prevention (between 0-4.3 minutes per year). Surprisingly, patients with high caries risk received low level of prevention per year. Some high caries risk patients received between 0
to 4.2 minutes on caries prevention per year. Therefore, time allocated on prevention for moderate and high level is considered to be extremely low. Specially knowing that only 15% to 20% of patients are considered of high risk in Sweden and Västerbotten county is using a caries risk assessment according to a guideline, the time that is not being used yearly on low risk patients (because they have checkups with a larger spans of time) the rest of the time should be expected to be invested for moderate and specially to high risk patients. This translates into caries risk not explaining the differences of prevention time allocation among clinics. Nevertheless, the caries risk does not seem like if it drives health professionals to allocate time on caries prevention on their patients in this cohort. Actually, the association of high risk (compared to low) shifts from being positively associated with much prevention in the crude model to being negatively associated with it in the adjusted model. Using the available information, this can be explained from the fact that health professionals in this cohort are mainly driven from de number of DeFS putting in disadvantage high risk patients with low DeFS score as explained previously. Comparing to Wang et al study among Nordic countries regarding caries experience and time spend on caries prevention. Results showed no association between DeFS score in the 12-year-olds in the clinics and time spent on preventive care two decades ago (69). It seems that a change has occurred on the process of decision making within oral health professionals.

High level of prevention was associated by the clinic’s caries prevalence. This was significant just for patients in clinics with caries prevalence above the median (median = 0.71). This reflects the knowledge on the population the oral health professional might have. Since dietary habits are a risk factor for developing caries, knowing the community general habits and being aware of a higher prevalence of caries among patients can also explain how health professionals could decide when and how allocate caries prevention. Previous investigations in Sweden, which have followed individuals from 3 to 20 years of age, highlights the relationship between caries experience during childhood and adolescence and caries in young adulthood. The same study also revealed that individuals with clinical caries at preschool age but caries-free at 15 years of age have a low caries prevalence as young adults, highlighting the importance of controlling the prevalence of caries as early as possible (76). Those findings suggest connection between early and late caries prevalence. Therefore, studies analyzing the difference between baseline and follow up prevalence of caries after allocation of time on prevention would help understand better the cost-effectiveness of prevention.
Regarding clinics characteristics, such as size, time allocated on prevention could not been 
explained by this predictor. Even though results suggest bigger odds for participants in the 
cities to receive moderate or high level of prevention, their marginal significance could not 
confirm this. So, a better analysis on the exact location of the clinic could bring interesting 
results on how the location of the clinic actually affect the amount of prevention given to the 
patients.

Regarding the dynamic between dentists, dental hygienist and dental nurses, it is important to 
point out that Sweden has a unique characteristic of having also dental nurses that provide 
prevention along with dental hygienists and dentists. This is not common among other 
countries. Just introducing hygienists as an extra auxiliary to promote and deliver oral health 
prevention faces its barriers and is taking time to adjust for several dentists (77). Thus, 
moving towards the implementation of dental nurses in the oral healthcare system could take 
time. But it seems that the combination of having this 3 different oral healthcare professionals 
in the system has helped to decrease caries prevalence, so it is extremely important to 
understand how they work together. Therefore, the most cost-effective way of combining the 
manpower is important to be studied. The high dentist ratio of clinics predicted the high level 
of prevention (OD 2.07, CI 1.00-4.29) allocated in those clinics with a 1:2 ratio of dentists- 
dental auxiliaries compared to low level of prevention. This results are extremely important to 
take in consideration. Because, based on this results, it can be assumed that having a balance 
combination of dentists and dental auxiliaries reflects a higher allocation of time on caries 
prevention.

This study reports that only 7.3% of high caries risk patients did not receive any prevention at 
all (0 minutes during the study), from which 5.3% could be explained because they moved 
from their city or miss frequently their checkups. So, the 2.3% of high-risk participants that 
did not receive any prevention that actually had follow up : how can be explained? Perhaps it 
could be considered a small number, but it could be interesting knowing why this occurred. 
One assumption could be that they were receiving prevention in a private clinic. Nevertheless, 
how come they did not receive prevention during all the study participation but had follow up 
checkup? The optimal length of the recall interval for the preventive maintenance of oral 
health in both children and adults has been the subject of constant debate between countries 
(78,79). This debate has been driven by contradictory evidence from observational
epidemiological studies on the beneficial and harmful effects of regular attendance and by conflicting interpretations of the data.

In summary, the data collected from each participant is expected to be useful to evaluate their caries experience (DeFS), assess their caries risk, and measure the clinic caries prevalence in order to evaluate the individual need of caries prevention. Nevertheless, with the results in the adjusted model (Table 4) it seems that the decision on the amount of time on prevention was according to the number of individual caries experience (DeFS), caries prevalence of their clinic, but not on their estimated caries risk. Therefore, the more caries lesions or filled surfaces a patient had; the more prevention was given. It seems that preventive treatment of caries was weakly or only moderately in accordance with patients’ individual needs and risk of developing caries. Although, patients with more caries lesions tended to receive more prevention than those with none or only a few DeFS. In general, the majority of preventive treatment given were simple and extensive prophylaxis while applications of fluoride varnish remained weak.

Finally, the significant results among the poor association of caries risk and time spend on prevention is not a surprise as previous studies carried out have found a poor association, as well, between risk grouping and individualized prevention (80,81). This findings are in line with Varsiö & Vehkalahti whom found in Finland that the preventive treatment of caries was related only weakly to the patients’ risk of developing caries (82). Which means it is a characteristic of the dental care system that it is not exclusive for Swedish oral health system.

**Weakness**

This study had a few limitations that should be noted. Demographic information about the patients such as gender, socioeconomic status, ethnicity and time living in Sweden was not available. This information could be interesting to be included since socioeconomic risk factors such as family level of education, with low cash fund and being foreign born has been shown to impact negatively oral health in children and adolescents in Sweden (60,64,65).

Besides, there was no record of which health professional (dentists, hygienist or nurse) was involve on the preventive interventions such as information and/or application of fluoride varnish, chlorhexidine mouth rinse, and sodium fluoride (NaF), lifestyle advice relating to oral hygiene and diet, and simple dental prophylaxis. Thus, analysis on who use which preventive intervention was no possible to made. This would have given a different value to
the time spent on prevention since not all patients necessarily need more time on prevention but specific preventive treatments according to their risk assessment. So, evaluating the quality of prevention each health professional (dentists, hygienists and nurses) allocate could help evaluate the process of decision making within oral healthcare professionals.

Also, the number of prevention treatments per dental checkups were not available so knowing how much time on prevention was allocated per checkup was not possible to obtain. From a healthcare perspective, consumables during the preventive sessions, fluoride varnish, chlorhexidine mouthwash might expect to have a cost but from the county council perspective it was not considered in the cost of prevention.

The score of decayed surfaces (DS) and decayed teeth (DT) at baseline were not available. Thus, using only individual DeFS score and caries prevalence at clinic level make it difficult to judge the allocation of time on caries prevention. Knowing the exact number of decayed surfaces or teeth would help understand the decision of healthcare professionals on how they allocated prevention.

**Strengths**

The sample of children studied is a convenience sample. The loss to follow-up was 14% (n = 62), which should be considered low. In general, the results could be considered representative of Swedish adolescents.

Caries was recorded by three dentists (intra- and inter-examiner kappa ≥0.979) in the entire sample at baseline. Thus, the available information recorded can be judge as strong. Also, the caries risk assessments were done according to the guidelines used in Västerbotten county since 2002, making it easy to access to the guidelines that driven clinicians to evaluate a patient regarding its caries risk.

The record of years between the baseline examination and follow up examination was really specific which helped when measuring the specific time allocated on prevention per year per patient.
The record of the minutes that involve each preventive session for each preventive treatment were carefully done. Thus, the sum of the number of minutes use on prevention per children were calculated with precision.

**Generalizability**

As global oral health moves towards UHC it is required the strengthening of health systems in all countries with robust financing structures as well (53). Emphasizes not only on which services are covered, but also how they are funded, managed, and delivered (51) is needed. Each country is unique, and each country may focus on different areas, or develop their own ways of measuring progress towards UHC. But there is also value in a global approach that uses standardized measures that are internationally recognized so that they are comparable across borders and over time (53).

Each situation will be different not only in so far as the epidemiology of oral diseases, but also with regard to the political, socio-economic, cultural and legislative context. Therefore, it is required detailed knowledge of the prevailing circumstances and the significant determinants of oral health. This knowledge is crucial to the development of policies, which address not only the immediate known risk factors but also help create a social, legislative and economic environment that is conducive to good oral health (49).

As dental services everywhere are under pressure to contain or reduce costs, the absence of evidence that dental disease prevention is effective could lead politicians and administrators to consider eliminating the expense of preventive care. Unless the dental profession addresses the issue of the effectiveness of preventive dental care, politicians and administrators in a cost-containment context will easily conclude that least is best (83).

**Moving forward**

Naturally, if the main etiological factors could be identified, suitable treatment for that particular individual can be carried out with good results. Thus, research on novel assessment of caries risk must keep going. New models to diagnose caries based on etiology exists (24,27) and recent findings will help prevent and treat caries in a whole new direction. Sadly, it could take a lot of years to make it accessible to the entire population. Meanwhile, caries risk assessment should keep being carried out at the child’s first dental visit and reassessments
should be done during childhood. Further quantitative and qualitative studies are therefore needed to identify the barriers among parents, their children, as well as dental professionals, to perform caries risk assessment and deliver a risk-based preventive care that could bridge the social inequalities in dental health.

The rationale behind individualized recall intervals is to deliver dental care based on each child’s need, and thereby obtain good oral health for all children, not to allocate equal amount of dental services to all. The length of recall intervals has significance for policymakers, clinicians and patients.

In conclusion, the time spent on caries prevention (proxy for cost of caries prevention) by the Public Dental Service clinics in the study, relied basically on the individual caries prevalence (DeFS), and the composition of the team (1:2 dentist- dental auxiliaries’ ratio) and not by the caries risk assessment as could be expected. As a consequence of improved dental health and scarce resources it has been essential to optimize the efficiency in the dental service. Thus, the amount of individualized preventive intervention offered and given by dentists, hygienists and nurses, to the patients in the various risk groups needs to be further clarified.


44. Holmén A, Strömberg U, Magnusson K, Twetman S. Tobacco use and caries risk among adolescents – a longitudinal study in Sweden. BMC Oral Health [Internet]. 2013 Dec


Annex 1

Table 1. Overview of risk categories and criteria for risk assessment used in the County Council of Västerbotten, Sweden (48).

<table>
<thead>
<tr>
<th>Caries development</th>
<th>Caries Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (0)</td>
</tr>
<tr>
<td></td>
<td>Moderate (1)</td>
</tr>
<tr>
<td></td>
<td>High (2)</td>
</tr>
<tr>
<td>No new caries</td>
<td>1-2 new caries</td>
</tr>
<tr>
<td>lesions and/or no</td>
<td>lesions on caries</td>
</tr>
<tr>
<td>caries activity</td>
<td>susceptible surfaces</td>
</tr>
<tr>
<td>Previous initial</td>
<td>Moderate</td>
</tr>
<tr>
<td>caries-lesions</td>
<td>progression of</td>
</tr>
<tr>
<td>completely stopped</td>
<td>initial caries lesions</td>
</tr>
<tr>
<td></td>
<td>&gt;3 new caries</td>
</tr>
<tr>
<td></td>
<td>lesions and/or</td>
</tr>
<tr>
<td></td>
<td>caries on non-</td>
</tr>
<tr>
<td></td>
<td>susceptible carious</td>
</tr>
<tr>
<td></td>
<td>surfaces</td>
</tr>
<tr>
<td></td>
<td>Clear progression</td>
</tr>
<tr>
<td></td>
<td>of several initial</td>
</tr>
<tr>
<td></td>
<td>caries lesions</td>
</tr>
</tbody>
</table>