# Young adults and oral health

## Oral health behaviors and an intervention for better oral health

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Gothenburg 2022

Cover illustration: Oil painting, “Disco 98”, by Daniel Boström.

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ISBN 978-91-8009-783-3 (PRINT)
ISBN 978-91-8009-784-0 (PDF)
http://hdl.handle.net/2077/72051

Printed in Borås, Sweden 2022
Printed by Stema Specialtryck AB

To my family, you are my number 1

# Young adults and oral health—Oral health behaviors and an intervention for better oral health

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## ABSTRACT

Although the oral health among young adults in Sweden is generally good, there are groups where poor oral health remains a problem. The aim of this thesis is to increase our knowledge of oral health and oral health-related behaviors among young adults with caries disease, and to evaluate the ability of a brief form of Acceptance and Commitment Therapy (ACT) to promote oral health and oral health behaviors in this group of individuals at the Public Dental Service Clinics. The studies included are based on a randomized controlled trial carried out in a sample of 18-25-year-olds, with ≥ 2 new approximal dentin caries lesions since their last dental examination. In Study I, we analyzed baseline data to describe oral health, oral health-related quality of life (OHRQoL), oral health behaviors, and the association between different known risk factors for poor oral health and caries severity. The results demonstrate that, in general, the young adults suffered from poor oral health, negatively affected OHRQoL, and they engaged in different oral health risk behaviors. Levels of gingivitis, the frequency of sugary soda consumption, poor OHRQoL and less frequent dental attendance were found to be associated with the caries severity. Study II evaluated the direct effect of ACT on oral health behavior, and Study III evaluated the effect on the levels of gingivitis and plaque at the 9-week and 18-week follow-ups. Study II showed a promising direct effect of ACT on oral hygiene behaviors, in favor of ACT treatment. In Study III, reduced gingivitis and plaque levels were found both in the intervention and the control group. Although slightly lower levels of plaque and gingivitis were maintained in the intervention group at the 18-week follow-up, the improvement was not statistically significantly better than in the control group. The finding in Study I emphasizes the need to develop effective interventions to promote oral health in this subgroup of young adults. Study II and III contribute with important knowledge but also acknowledge the need for further development and evaluation of theory-based interventions in the dental field.

**Keywords**: Behavioral interventions, Acceptance and Commitment Therapy, Oral health, Oral health behaviors, Young adults, Randomized controlled trial

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# SAMMANFATTNING PÅ SVENSKA

I Sverige erbjuds alla kostnadsfri tandvård, med ett fokus på sjukdomsförebyggande insatser, till och med det år man fyller 23. Generellt är munhälsan god i dessa åldersgrupper men det finns fortfarande grupper där dålig munhälsa är ett problem. En bidragande orsak till försämrad munhälsa är ohälsosamma levnadsvanor, som en kost rik på socker, bristande egenvård och rökning. Traditionellt har man inom tandvården försökt påverka patienters munhälsorelaterade beteende genom att ge information om munsjukdomars orsak och förlopp samt genom att ge råd om vilka beteenden patienten behöver ändra för att bibehålla eller förbättra munhälsan. Under de senaste årtiondena har effekten av detta tillvägagångsätt ifrågasatts, och andra interventioner har efterfrågats. Detta avhandlingsarbete bygger på tre delarbeten baserade på en randomiserad kontrollerad studie utförd på unga vuxna (18–25 år) med kariesproblematik, i allmäntandvården Västra Götaland. Studiedeltagarna tilldelades slumpmässigt behandling med antingen en teoribaserad beteendeintervention (baserad på Acceptanc and Commitiment Therapy) av psykolog på kliniken samt standardiserad munhälsoinformation (interventionsgruppen) eller endast standardiserad munhälsoinformation (kontrollgruppen). Syftet med studie I var att öka kunskapen kring munhälsa och munhälsorelaterat beteende, baserat på studiedeltagarnas basundersökning. Syftet med studie II och III var att utvärdera den teoribaserade beteendeinterventionens förmåga att förbättra munhälsorelaterat beteende (studie II) och munhälsan (studie III) vid 3 respektive 9 och 18 veckors uppföljning. Studie I visade att deltagarna hade flertal kariesangrepp samt höga nivåer av plack och gingivit, och att ogynnsamma munhälsovanor var vanligt förekommande. Höga nivåer av gingivit, regelbunden läskkonsumtion, mindre regelbundna besök till tandvården och negativt påverkad munhälsorelaterad livskvalitet ökade sannolikheten för en högre kariesfrekvens. Studie II visade en omedelbar lovande effekt av beteendeinterventionen, då deltagarna i interventionsgruppen statistiskt signifikant förbättrade flera beteenden kopplat till munhygien, jämfört med deltagarna i kontrollgruppen. Studie III visade att båda grupperna minskat sina nivåer av plack och gingivit över tid men däremot var skillnaden mellan grupperna inte statistiskt signifikant. Resultaten visar att det finns ett behov av att utveckla effektiva interventioner för att främja munhälsan samt att teoribaserade beteendeinterventioner har potential att förbättra egenvård samt munhälsa.

# LIST OF PAPERS

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

I. Hagman J, Wide U, Werner H, Hakeberg M. Oral health and oral health behavior in young adults with caries disease. BDJ Open. 2021;7(1):28.

II. Wide U, Hagman J, Werner H, Hakeberg M. Can a brief psychological intervention improve oral health behaviour? A randomised controlled trial. BMC Oral Health. 2018;18(1):163.

III. Hagman J, Wide U, Werner H, Hakeberg M. A psychological intervention for caries active young adults, a randomized controlled trial. Clin Exp Dent Res. 2022;8(1):239-247.

# CONTENT

# ABBREVIATIONS

| | |
|---|---|
| ACT | Acceptance and Commitment Therapy |
| DAS | Dental Anxiety Scale |
| DMFS | The number of Decayed, Missing due to caries, and Filled permanent Surfaces |
| DMFT | The number of Decayed, Missing due to caries, and Filled permanent Teeth |
| e.g. | For example |
| FDI | FDI World Dental Federation |
| GLM | General Linear Model |
| i.a. | Such as/among other things |
| i.e. | That is |
| ITT | Intention-to-treat |
| MeSH | Medical Subject Headings |
| NLM | National Library of Medicine |
| OHIP | Oral Health Impact Profile |
| OHRQoL | Oral Health-Related Quality of Life |
| Partial $\eta^2$ | Partial eta squared |
| PDS | Public Dental Service |
| PP | Per Protocol |
| RCT | Randomized Controlled Trial |
| SD | Standard Deviation |

| | |
|---|---|
| SiC-index | The Significant Caries Index |
| SKaPa | The Swedish quality register for Caries and Periodontitis |
| SPSS | Statistical Package for Social Sciences |
| WHO | World Health Organization |

# 1 INTRODUCTION

I think that everyone in the field of healthcare can recall one or several times when they have tried to make a patient alter a behavior in the pursuit of better health. This sometimes leads to frustration about the perceived reluctance of the patient to implement the desired behavioral change. But the task of changing a behavior—even when it is crucial for obtaining or maintaining health—is not as easy as it might seem. A person's health behavior is not merely the result of their health knowledge but also the outcome of several determinants interacting both on a structural, social and individual level. There is an urgent need for effective health interventions on every level if the goal is to achieve equal health and a healthy lifestyle in a population. One contributing strategy in the pursuit of this goal is to open up for interprofessional collaboration in the field of dentistry.

## 1.1 ORAL HEALTH

The oral cavity is indisputably a part of the human body. It plays a fundamental part in the everyday life functioning of individuals (i.e., chewing, swallowing, communication, conveying a state of mind) and plays an important role for personal identity (1).

It is important to recognize that oral health may have different meaning for different people and that other factors, such as culture, social class and age, will influence their interpretation of what health is (2, 3). This means that the individual's interpretation of oral health and the values, perceptions, and expectations they have will ultimately affect how they act to protect their oral health (3, 4).

## Definition of oral health

Agreeing on a definition of oral health is important, as it will influence how dental healthcare is organized, the allocation of resources, the design of the reimbursement models and how oral health promotion is implemented (4).

Traditionally, the definition of oral health has mainly relied on the biomedical model of health (4, 5), where health is defined as the absence of disease, and where symptoms simply originate from the underlying pathology (3). However, this is a very simplistic way of measuring and defining oral health. In fact, the consequences of oral diseases (such as pain, mobile teeth and tooth loss) may have negative impacts on a person's life; for example, mobile teeth and/or tooth loss may affect the ability to eat, speak and socialize. Other potential consequences of oral disease are anxiety and absenteeism from school or work (6, 7). Clearly, oral diseases have the potential to affect individuals' health in a much broader perspective.

WHO defines oral health as *"a state of being free from chronic mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial well-being."* (8) This underlines the importance of incorporating the subjective experience of oral disease in the definition of oral health and linking oral health to overall health and wellbeing.

In 2016, the General Assembly of the FDI World Dental Federation announced a new definition of oral health (4), accompanied by an associated theoretical framework. The definition of oral health according to FDI is as follows:

*"Oral health is multi-faceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow and convey a range of emotions through facial expressions with confidence and without pain, discomfort and disease of the craniofacial complex. Further attributes of oral health:*

*- is a fundamental component of health and physical and mental wellbeing. It exists along a continuum influenced by the values and attitudes of individuals and communities;*
*- reflects the physiological, social and psychological attributes that are essential to the quality of life;*

*- is influenced by the individual's changing experiences, perceptions, expectations and ability to adapt to circumstances."*

According to the associated framework, there are three core elements of oral health: disease and condition status, physiological function, and psychosocial function. How these three elements define the oral health of an individual is the result of a complex interaction between the core elements and influencing external factors: driving determinants (i.e., factors that affect oral health outcome, such as genetics, social environment, and health behavior), moderating factors (i.e., factors that influence individual perception of oral health, such as age, culture, and expectations), and overall health and wellbeing.

By acknowledging the multifaceted nature, the dynamic attributes and the influence of external factors in the definition of oral health, the FDI takes the definition and concept of oral health one step further compared with previous definitions of oral health.

The conceptual model for health-related quality of life by Wilson and Cleary (9) provides a useful explanatory framework for the relationship between oral diseases and oral health-related quality of life (OHRQoL). Like the framework for oral health provided by the FDI, Wilson and Cleary's model acknowledges the complex and multifaceted relationship between the clinical measure of health status, symptoms, function, general health perception and quality of life, while taking into account mediating factors of environmental and patient characteristics.

**Determinants of oral health and oral health behavior**

Social determinants of health are the structural determinants and conditions of everyday life and the primary cause of inequities in health observed both within and between countries (10). These structural determinants (such as economic, social and welfare polices) create social hierarchies and influence health outcomes through a complex range of intermediary determinants (such as socioeconomic status, living and working conditions, psychosocial factors, lifestyle and age) (11, 12). Dahlgren and Whitehead provided a structural model (Fig 1) illustrating how these different factors eventually affect health outcomes in populations (13, 14).

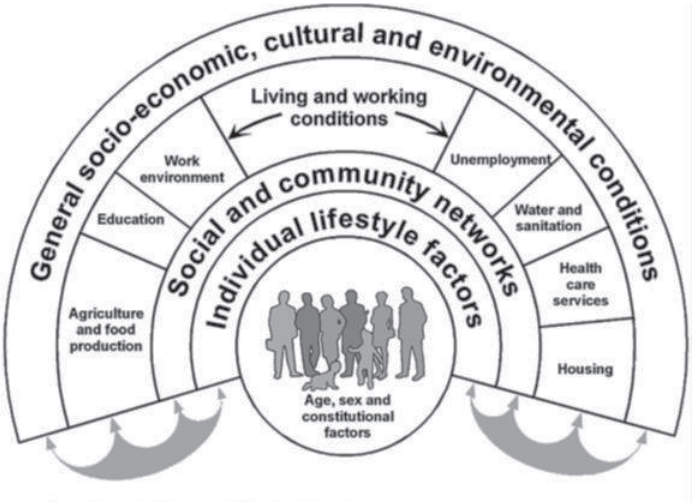


*Figure 1. "The main determinants of health" Reprinted from Public Health, vol. 199 (2021), Dahlgren G, Whitehead M, The Dahlgren-Whitehead model of health determinants: 30 years on and still chasing rainbows, p. 20-24, Copyright (2021), with permission from Elsevier. Originally appeared in: Dahlgren G, Whitehead M. (1991). Policies and Strategies to Promote Social Equity in Health. Stockholm, Sweden: Institute for Futures Studies. Reproduced with permission from the Institute for Futures Studies, Stockholm, Sweden.*

There is increasing research demonstrating the effect of social determinants on oral health outcomes (11, 12, 15-18) and, as for health, a social gradient is evident (11, 15, 17), with increased deterioration of oral health by each step down the "socioeconomic ladder" (15, 17). Furthermore, individuals remain vulnerable to the social determinants of oral health throughout the life course (19-21).

It is important to recognize that even in countries with a generous welfare regime, such as the Scandinavian countries, a social gradient in oral health is still evident (15, 22). Furthermore, it has been reported that despite full dental coverage, free of cost, for children to young adulthood, individuals with low socioeconomic status still experience worse oral health (23, 24).

Unhealthy behaviors tend to cluster among people in socially more deprived groups (25, 26), and may therefore be one factor contributing to the inequalities

observed in oral health. However, the role of oral health behaviors in explaining inequalities in oral health is somewhat inconsistent. For example, in a population study of Finish adults, Sabbah et al. (27) found a gradient relationship between educational level and caries increment over a four-year period. However, when they adjusted for each of the four oral health behaviors assessed, the gradient relationship between education level and caries increments was gradually attenuated and, in the end, only oral health behaviors were found to explain the variation in caries increment. On the contrary, in a population study of Australian adults, oral health behavior (i.e., dental attendance and dental self-care behavior) was not found to explain the observed socioeconomic gradient in oral health (i.e., missing teeth) (28). Other studies have found that oral health behaviors play a more modest role in explaining socioeconomic inequalities in oral health outcomes (29, 30).

Oral health behaviors has been suggested as one explanatory factor that might play a more relevant role in explaining the oral health inequalities observed in countries with the most generous welfare regimes, such as the Scandinavian countries, compared with other European welfare regimes (31, 32). Results from a cross-sectional study by Guarnizo-Herreño et al. (31) yield some limited evidence indicating that this might be the case, as oral health-related behaviors were found to explain relative educational and occupational inequalites to a larger extent in the Scandinavien welfare regiem, compared to the Anglos-Saxon, Bismarckian and Southern regimes. However, as stated by the authors, these findings should be interpreted with caution due to factors related to studydesign. Nevertheless, as further stated by the authors, the findings indicate that potentially different strategies should be applied in different European countries to tackle inequalities in oral health.

Although it is clear that if the goal is to improve oral health across all social groups, actions need to be directed towards the social determinants of oral health. However, behavioral interventions still play a relevant role in tackling inequalities in oral health, as they have been shown to play a part in explaining the observed socioeconomic inequalities in oral health (27, 29-31, 33).

# 1.2 ETIOLOGY OF DENTAL CARIES AND GINGIVITIS

Oral diseases include a range of different diseases and conditions (such as oral cancer, trauma, periodontal disease and dental caries) (34), but in this thesis we will focus on dental caries and gingivitis.

Both caries and periodontal disease are multifactorial diseases and as such, multiple and diverse exposures are responsible for the initiation and progression of these diseases. These exposures or "risk factors" are factors associated with an increased probability of contracting a disease if exposed to those factors (35). However, being exposed to a certain risk factor does not necessarily lead to contracting the disease in question.

One way of explaining the complex multifactorial etiology of dental caries and periodontal disease is the conceptual framework for causes, presented by Rothman (36, 37). According to this framework, the onset of caries or periodontal disease in an individual will only occur when a sufficient set of causes is present. Each sufficient cause is made up by a set of component causes. Each component cause can be thought as one piece of a pie, and the pie as the sufficient cause, i.e., it is the joint action of each component causes that initiate the disease. The component causes that make up a sufficient cause may vary and, as for other multifactorial diseases, multiple sufficient causes exist for caries and periodontal disease. A component cause that constitutes an element of all sufficient causes for a disease is referred to as a necessary cause. For caries and periodontal disease, the dental biofilm should be referred to as a necessary cause. However, according to the framework provided, the necessary cause itself does not equal disease onset.

**Etiology of dental caries**

There is strong evidence of the relationship between consumption of free sugars and dental caries, with sucrose being the foremost cariogenic dietary carbohydrate (38). In accordance with the ecological plaque hypothesis, frequent consumption of fermentable carbohydrates results in repeated decreases in the biofilm pH level, due to the metabolic activities of bacteria resident in the dental biofilm. These changes in the environmental conditions in the biofilm, i.e., prolonged periods of pH below the critical level for enamel

demineralization (approximately pH 5.5), benefit the growth of acidogenic and aciduric bacterial species (for example, but not exclusively, Mutans streptococci) at the expense of bacteria associated with sound teeth. This will result in a shift in the balance of the biofilm's residential microflora, enhancing the dental biofilm's caries-inducing properties and predisposing the covered tooth surface to caries. At some point (if excessive sugar consumption is not stopped), the balance between demineralization and remineralization of the tooth's hard tissue will shift towards demineralization. Eventually, the hard tissue become fragile and irreversible rupture and cavitation occurs (38-40).

Factors such as exposure to fluoride and adequate salivary flow have protective properties against caries disease (as they reduce demineralization and promote remineralization of the tooth's hard tissue) (38, 41, 42). However, they will only slow down the progression of dental caries in the event of continued consumption of free sugars (38, 41, 43). Reduced intake of free sugars throughout life is therefore the key preventive strategy for caries disease (7). WHO recommends that less than 10% (and preferably even less than 5%) of the daily energy intake should come from free sugars (7).

**Etiology of gingivitis**

Gingivitis is caused by bacteria that colonize the tooth, epithelial surface of the gingiva or the periodontal pocket (44). Due to the physiological properties of the tooth, the outer layers do not shed and accumulation of bacteria is therefore facilitated (45). The host responds to the bacteria resident in the biofilm with inflammation and other immune reactions in the gingival tissue (46). Although clinical signs of gingivitis are evident in most individuals only after 12-21 days of undisturbed biofilm accumulation, an inflammatory response of the gingival tissue will have occurred already within 2-4 days. However, following removal of the plaque by effective oral hygiene procedures, the inflammatory response in the gingiva will be reversed (46). Hence, one of the main causes of periodontal disease is lack of optimal oral hygiene procedures (47).

## 1.3 YOUNG ADULTS

The age span referred to as young adults varies between studies. For example, in some studies, 18 and 19-year-olds are defined as young adults (48-51) and in other studies as adolescents (52-55). In Sweden, the definition of young adults varies between authorities and in Region Stockholm, different agencies use different age restrictions (56).

It seems clear that there is no consensus regarding the age span that should be referred to as young adults in the literature. This lack of an unambiguous age-related definition makes it difficult to compare results between studies of young adults. Table 1 demonstrates how the age span defined as young adults may differ between studies and settings.

*Table 1. Age span (in years) defined as young adults in different studies and settings.*

| Author and year | Country | Age span |
|---|---|---|
| Carvalho et al., 2020 (51) | Belgium | 16-35 |
| Choi et al., 2015 (48) | Korea | 18-32 |
| Drachev et al., 2018 (49) | Russia | 18-25 |
| Roberts-Thomson et al., 2008 (57) | Australia | 20-25 |
| Sun et al., 2018 (50) | Hong Kong | 18 |
| Settings | | |
| Swedish MeSH (58) | Sweden | 19-24 |
| NLM thesaurus for MeSH (59) | applied by Medline/Pubmed, the NLM Catalog and other NLM databases | 19-24 |
| The Employment service (56) | Sweden, Stockholm | 16-24 |
| Swedish Social Insurance Agency (56) | Sweden | 19-29 |

**Why young adults?**

How individuals act to protect their health in adulthood is often the result of behaviors and routines settled already in childhood to early adulthood. During adolescence, attitudes to health may change as the adolescent seeks independence from their parents, and beliefs, attitudes and values held by peers becomes more important for their own health-related choices (3). During young adulthood, the ability to understand the long-term consequences of one's own actions has become more developed (60). It is also a time of transition, as many young adults start living on their own and become financially independent and have to take responsibility for his/her own health

and health-related decisions. This could make young adults a suitable group to target with behavioral change interventions.

Dental caries and periodontal disease are degenerative diseases and when ineffectively treated, they will continue to deteriorate the individual's oral health. As a result, the individual may suffer from dental pain, loss of function, anxiety and negative effects on social life (7). In addition, poor oral health leads to substantial economic consequences, both at the individual and societal level (11). For example, it has been reported that in the age group 20-39 years old, 4% of all approximal fillings performed on women and 3% of those on men were registered with a new treatment (such as a new restoration, extraction, or endodontic treatment) after one year. Furthermore, in the same report it was also stated that if the proportion of fillings replaced in one year for all adults were 4%, a reduction in replaced fillings by 1% would yield a cost reduction of approximately SEK 30 million (61). Establishing healthy oral conditions in early life is therefore crucial.

There seems to be an inconsistency regarding the effect of dental caries and gingivitis on the OHRQoL of young adults in the literature (48-50, 53-55, 62, 63). Furthermore, reports regarding this matter are limited, as most studies have been performed in populations of adolescents and adults. Nevertheless, associations between poor OHRQoL, gingivitis (53, 54, 62, 63) and caries disease (49, 53, 55, 62, 63) among young adults have been reported, which further stresses the need for effective interventions to treat these oral diseases and improve OHRQoL in those affected.

# 1.4 PREVALENCE OF DENTAL CARIES AND GINGIVITIS

**Prevalence of dental caries and gingivitis globally**

Oral diseases are among the most common diseases in humans, affecting close to 3.5 billion people (11, 47). Among the oral diseases, untreated dental caries in the permanent dentition is the most common condition (47), with peak prevalence generally occurring during young adulthood (11, 64, 65). During the past four decades, a decline in caries prevalence has been noted, especially in high-income countries (11, 66).

Gingivitis is the most prevalent periodontal condition worldwide (67), while severe periodontitis has been reported to affect around 10% of the world's population (65, 68). Periodontal health seems to deteriorate with increasing age, with more individuals showing signs of periodontitis (67) and an increased prevalence of severe periodontitis (66).

Oral diseases have been found to cause considerable economic pressure on society, both due to absence from work resulting in productivity losses and through expenditures on treatments. Oral diseases also result in intangible costs, such as pain, loss in oral function and negative impact on social interactions. In fact, in 2015 oral diseases were ranked the third with respect to expenditures on various diseases in the European union (11).

It is evident that in the global perspective oral diseases constitute a major public health problem, both on a societal and an individual level.

**Prevalence of dental caries and gingivitis in Swedish young adults**

In Sweden, the regions have a legal responsibility to meet its residents' need for dental care, which can be provided both in public and private settings (69). During childhood to adulthood (from 0 to 23 years of age), dental care is free-of-charge and children and young adults are regularly called for dental checkups. The current reimbursement scheme for adults were implemented in 2008, with the aim to further improve the oral health of the adult population by encouraging regular dental care and by subsidizing dental care for those

with greater treatment needs (70). Hence, the reimbursement scheme seeks to counteract any financial obstacles for obtaining dental care.

There are several population studies confirming the improvement in oral health in the Swedish population during the last decades (71-75) and among young adults, oral health is generally good (71, 72, 74). Nevertheless, there are still groups of young adults with poor oral health, more specifically, with severe caries disease (23, 61, 76, 77). Socioeconomic and demographic factors have been identified to explain this inequity in oral health (18, 23, 78, 79). Thus, different prevention and treatment needs are obvious and should be taken into account when planning dental care and resource allocation.

Since 1985, the National Board of Health and Welfare has investigated the caries situation (i.e., manifest caries lesions) among 3, 6, 12 and 19-year-olds in the regions in Sweden, and since 2019, 23-year-old young adults have also been included. According to their report for 2020 (77), the proportion of 19-year-olds with caries was approximately 57%, compared with approximately 68% in 2011, which indicated that dental health had continued to improve in this age group. There were also signs of improved oral health among the one third of the 19-year-olds with the greatest caries experience, with a Significant Caries Index (SiC-index) value of 5.2 in 2020 compared with 5.5 in 2017 (77, 80). Regarding 23-year-olds, the proportion with caries was 65% in 2020 (77).

In their annual report from 2020, The Swedish quality register for Caries and Periodontitis (SKaPa) (61) also reported a marked increase in the proportion of caries-free 19-year-olds between 2011 and 2020. However, for individuals with caries experience, regardless of severity, only modest alterations were found. A similar pattern was found among 20-29-year-olds, where no marked improvement in caries experience was noted between 2010 and 2020.

Cross-sectional studies on oral health have been performed in the city of Jönköping (Sweden) every ten years since 1973 (74). During the past 40 years, a clear and continuous decline in decayed surfaces has been observed among 20-year-olds, from a mean value of 6.5 (i.e., manifest and initial caries lesions) in 1973 to 3.7 in 2013.

Table 2 presents mean values for caries experience from national population data and for sub-populations of young adults in Sweden, according to different caries indices.

*Table 2. Studies on caries experience among young adults in Sweden. Different caries indices are used.*

| Author and year published | Study design | Year examined | Location | Age | Caries index | Mean value |
|---|---|---|---|---|---|---|
| SKaPa annual report 2020 (61) | National quality register | 2020 | Public dental and private dental clinics National data | 19<br>20-29 | DFT<br>DFS<br><br>SiC | 2.2<br>5.1<br><br>5.7females<br>6.0 males |
| National board of health and welfare "Karies bland barn och ungdomar" 2020 (77) | National quality register | 2020 | Public dental clinics National data | 19<br><br>23 | DFT<br>SiC<br><br>DFT | 2.1<br>5.2<br><br>2.9 |
| Norderyd et al., 2015 (74) | Cross-sectional | 2013 | City of Jönköping | 20 | $DS_{i+m}$<br>DFT<br>DFS | 3.7<br>4.3<br>5.9 |
| Edman et al., 2016 (75) | Cross-sectional | 2013 | County of Dalarna | 35 | DS<br>DT<br>DFS | 0.9<br>0.8<br>11.6 |
| Isaksson et al., 2013 (76) | Cross-sectional | 2007 | City of Jönköping | 20 | $DS_m$<br>$DS_i$<br>$DFS_{i+m}$ | 0.5<br>2.3<br>5.8 |
| Julihn et al., 2006 (79) | Cross-sectional | 2001 | City of Stockholm | 19 | DMFT<br>DMFS | 3.9<br>5.1 |

*D, Decayed*
*F, Filled*
*T Teeth*
*S, Surfaces*
*SiC, Significant Caries index*
*$DS_i$, Decayed Surfaces initial*
*$DS_m$, Decayed Surfaces manifest*

In the annual report from SKaPa (61), the prevalence of periodontal disease was found to have increased during the last decade in the adult Swedish population, with approximately 10% experiencing severe periodontitis and approximately 11% moderate periodontitis. The remaining adults were either found to be periodontally healthy, experience mild periodontitis or lacking a periodontal examination. The prevalence of severe periodontitis were further found to increase with age. However, during the last decade a deterioration in periodontal status was especially noted among the younger age groups experiencing severe periodontitis. The observation of deteriorated periodontal health among young adults is not new. In a report by Wahlin et al. (72),

increased numbers of periodontal pockets ≥ 4mm were noted among 20-year-olds between 2003 and 2013, which was claimed to be due to the increased prevalence of gingivitis in this age group.

The clinical status of plaque and gingivitis among young adults has been found to be poor. Among 19-year-olds, mean values around 50% have been reported for plaque and gingivitis scores, and low levels were only found in a minority of study participants in both studies (52, 81). However, more favorable oral conditions have also been reported among young adults, with a mean plaque score of 11.6% and a gingivitis score of 19.4% (74).

## 1.5 ORAL HEALTH BEHAVIOR IN RELATION TO GINGIVITIS AND CARIES DISEASE AMONG YOUNG ADULTS

Important modifiable risk factors for dental caries and periodontal disease are individual oral health behaviors and, in many cases, the disease will not be cured if oral health risk behaviors remain unchanged.

**Oral hygiene behaviors**

Inadequate oral hygiene procedures lead to an accumulation of dental plaque along the gingival margin, which will induce the development of gingivitis. If left untreated, gingivitis may progress with time to periodontal breakdown (i.e., periodontitis) (44). To prevent this negative disease spiral, adequate oral hygiene procedures leading to plaque removal and/or control is crucial (44, 82, 83). Toothbrushing twice a day for at least two minutes is a well-established recommendation for maintaining good oral health, and regular toothbrushing has been found to reduce gingival inflammation (44, 82, 83). Interdental cleaning (floss or interdental brushes) in combination with toothbrushing may reduce plaque levels and gingivitis more than toothbrushing alone, according to a recent Cochrane review (84). However, there was only low certainty of evidence for flossing, and very low certainty of evidence for interdental brushes in reducing gingivitis when added to toothbrushing. In an report on

Japanese young adults, Furuta et al. (85) found an association between oral hygiene behaviors and plaque levels, which, in turn, was associated with gingival inflammation in the study population. Broadbent et al. (86) found that individuals with higher plaque levels from 5 to 32 years of age were more likely to have poorer periodontal health, higher caries experience, and loss of teeth due to caries, than individuals with lower plaque levels from childhood into adulthood. Inadequate toothbrushing behavior and higher levels of gingivitis have also been associated with a higher risk of caries experience (79). Reports on the oral hygiene procedures of Swedish young adults have shown that the vast majority brush their teeth at least twice a day (52, 81, 87). However interdental cleaning habits have not been found to be commonly practiced (52, 81, 87).

### Use of fluorides

In addition to restricting sugar intake, adequate daily oral hygiene procedures with fluoridated toothpaste is an important behavior with respect to caries disease prevention (42). The use of fluoridated toothpaste has been shown to be an effective measure for preventing caries disease in the permanent dentition of children, adolescents and adults when compared with non-fluoridated toothpaste (88). The beneficial association between the use of fluoridated toothpaste and caries experiences has also been demonstrated in a longitudinal study by Bernabé et al. (89). They found that daily use of fluoridated toothpaste reduced the association between the amount of sugar consumed and the caries experience. However, it should be noted that daily use of fluoridated toothpaste did not eliminate the association (89). Additional use of fluoride, administered in the form of fluoridated mouth rinse, has been found to reduce caries in children and adolescents (aged 6-14 years), and likely even if accompanied by fluoridated toothpaste or when living in areas with fluoridated water (90).

### Attending the dental service

Regular dental attendance may be protective of oral health as signs and symptoms of oral disease may be detected and treated early and preventive measures offered (e.g., providing oral health advice, applying fluoride varnish), which may halt the disease progression and its negative effects (91).

Regular dental attendance has been shown to have positive effects on oral health outcome. For example, in a retrospective study among British adults, former and never regular dental attenders were found to have a worse oral health outcome (i.e., more decayed and missing teeth and greater caries experience) than always regular attenders, even after adjusting for socioeconomic and demographic variables (92). When analyzing different patterns of dental care attendance during the life course of the participants in the Dunedin longitudinal cohort study, regular dental attenders were found to have both better clinical (i.e., less caries experience and missing teeth) and subjective (better OHRQoL and self-rated oral health) oral health outcomes than irregular dental attenders (93). Finally, regular dental attendance (i.e., attending dental care once a year) was found to be the strongest predictor of being caries-free (neither enamel, nor dentin caries) among adults in Norway (94).

In 2020, approximately 49% of the Swedish adult population (≥ 24 years) attended dental care, which was 7% less than in 2019, according to The National Board of Health and Welfare (95). The decrease in dental care attendance was argued to be the result of the ongoing Covid-19 pandemic. Nevertheless, a decline in yearly dental care attendance has been noted since 2011 (95). The youngest and oldest adults attend dental care the least (95), which may involve an increased risk of negative effects on the oral health of these age groups.

**Consumption of sugars**

The key preventive measure for dental caries is decreased consumption of free sugar (38). Furthermore, a dose-response relationship between the consumption of sugar and caries experience has been reported in adults (89). According to current recommendations, less than 10% of the total daily energy intake should consist of free sugars, and additional health benefits could be expected with a further reduction to less than 5% (7). To put this recommendation into context, one can of soda typically contains 40-50g of free sugars, which corresponds to 10 teaspoons of table sugar (96, 97). This means that by ingesting one single can of sugary soda, the recommendation of a daily energy intake of less than 5% of free sugars has already been exceeded (98).

According to a report from the Swedish Public Health Agency on school children's health habits in 2017/2018 (99), 3-4% of the 11-year-olds and 6-8%

of the 13 and 15-year-olds consumed sweets every day. Daily consumption of sodas was reported by 2-8 % of the 11, 13 and 15-years-old. When compared to the results from a previous study conducted in 2001/2002, the proportion of 11, 13 and 15-year-olds who reported daily consumption of sweets and sodas had decreased in 2017/2018, except for in 15-year-olds girls where no reduction in soda consumption was observed. In the epidemiological study conducted in Jönköping, Sweden, in 2013, 23% of the 20-year-olds and 27% of the 30-year-olds reported that they consumed sweets ≥ several times/week. Regarding sodas, 26% of the 20-year-olds and 16% of the 30-year-olds reported that they consumed sodas ≥ several times/week (87).

**Smoking**

Smoking is a well-known risk factor for periodontal disease and smoking cessation plays an important part in reducing the risk of periodontitis and may even result in a beneficial outcome of non-surgical periodontal treatment (100). When it comes to smoking and dental caries, the association is less clear. In a systematic review by Benedetti et al. (101), the authors found that although results from the included studies indicated that smoking was associated with an increased risk of caries, the overall quality of the studies was low; hence, there was not enough evidence for such a conclusion. Findings from a more recent systematic review and meta-analysis indicated an association between smoking and dental caries, but the evidence of smoking being a risk factor involved in the dental caries process was insufficient (102).

According to The Swedish Public Health Agency (103), 4% in the age group 16-29 years reported daily smoking in 2020. In 2014-2016, the corresponding proportion was 8%. Moreover, in the same age group in 2020, 82% reported that they had never smoked, while in 2014-2015, the corresponding proportion was approximately 70%, indicating that a decrease in smoking has taken place among 16-29-year-olds on a population level.

## 1.6 HEALTH PROMOTION AND PREVENTION IN DENTISTRY

**Oral health promotion**

Health promotion seeks to strengthen people's ability to take control of and improve their health. This is achieved through a combination of strategies addressing social, environmental, and economic determinants of health, but also actions promoting personal skills and capabilities (104). One of the key elements in health promotion is to increase people's ability and opportunities to make healthy choices (105).

During the seventies it was recognized that environmental factors, lifestyle, and individual behaviors were the main causes of death and disease. This led to an international health promotion conference being organized by the WHO in Ottawa in 1986, and the formulation of the Ottawa charter. Since then, several more conferences on the same subject have been organized by the WHO, resulting in the development and practice of a health promotion movement worldwide. The five key elements for action according to the Ottawa charter is as follows: Create supportive environments, build healthy public policy, strengthen community action, develop personal skills, and reorient health services (2). These five elements demonstrate the width and diversity of actions needed in health promotion (2).

Developing personal skills is one action that could be targeted in the clinical dental setting through health education. Health education has been defined in the WHO Health Promotion Glossary of Terms 2021(104) as follows:

*"Health education is any combination of learning experiences designed to help individuals and communities improve their health by increasing knowledge, influencing motivation and improving health literacy."*

Health education aims at providing individuals and/or communities with the knowledge, attitudes, beliefs, values, and skills to be able to make informed decisions about their health-related behaviors and thereby maintain or improve their health (2). Health education may include providing individuals with information about individual risk factors, task-based communication supporting health-related behavior change, and skills-based communication strengthening people's ability to make more autonomous health-related choices (104). However, it should be noted that health education is not the same thing as health promotion, but should rather be viewed as one of several supporting strategies for health promotion (2).

**Disease prevention**

Prevention involves strategies to reduce exposure to determinants of disease and thereby prevent the onset of disease, but also strategies to arrest disease progression and reduce the consequences of already established disease (104).

Preventive strategies can be divided into two types of main approaches: "The whole population approach" and "The risk approach". In the whole population approach, preventive actions aim to reduce exposure to the causes of disease for everybody in the population. Preventive strategies in the risk approach can be divided into one of two sub-categories, "The targeted population approach" and "The high risk approach". The targeted population approach is directed towards subgroups of the population identified to be at greater risk of contracting a disease, whereas the high risk approach is directed towards individuals identified as having a greater risk (2). It has been advocated in the literature that combinations of these three approaches should be applied to prevent oral disease (64).

Preventive measures and health education are important tools for the dental staff in everyday clinical practice to promote oral health (2). In an article by Watt et al. (106), the authors highlight various opportunities for health equity promotion activities that the dental team could engage in. One of these actions is that the dental team should provide their patients with individually tailored, up-to-date evidence-based preventive measures, to prevent oral disease and promote oral health. They further state that patients belonging to a specific dental clinic and identified as having an increased risk of future disease should be targeted with supportive and preventive care to reduce oral health inequalities.

## The Swedish national guidelines for dentistry

In the Swedish national guidelines for dentistry (107, 108), the National Board of Health and Welfare emphasizes the need to promote oral health and prevent oral disease. They further acknowledge the dental staff's responsibility to explore the underlying causes of disease or the risk of disease, and target and treat these causal factors and not just the symptoms of disease. In addition, they call for collaboration between the dental care and general health care to tackle unhealthy lifestyles. The national guidelines make the following recommendations to promote oral health in individuals with an unhealthy lifestyle (note that reproduced recommendations are abbreviated):

*Health-promoting and disease-preventive feedback:* Essentially standardized counselling regarding oral health conditions and health-promoting measures. It also includes positive feedback on existing protective oral health behaviors. The time consumed is generally very short.

*Counselling:* Consists of individually adapted, patient-centered dialogue, including information and advice regarding self-care. Sometimes it also includes motivational strategies and may or may not include follow-up. The counselling can be delivered by dental staff or other health care providers. In most cases, a counseling session last 5-15 minutes.

*Qualified counselling:* Qualified counselling, contrary to counselling, is based on theory. This means that the persons delivering the treatment need to have knowledge about the current disease as well as knowledge, education and training in the theory and method on which the counselling is based. Qualified counselling sessions often last longer than counselling and always include follow-up.

## Approaches to behavioral change in a clinical dentistry setting

In the WHO Health Promotion Glossary of Terms, 2021 (104), the WHO defines health behavior as follows:

*"Any activity undertaken by an individual for the purpose of promoting, protecting, maintaining or regaining health, whether or not such behaviour is objectively effective towards that end."*

Health behavior is the result of complex interactions of different influencing factors that work on different structural levels. The social and environmental determinants of health play a fundamental part in shaping health behaviors. On a more individual level, health behaviors are influenced by factors such as emotions, cognition, and personal skills for health. Related health behavior tends to cluster in individuals and different populations and may act for or against health. Behavioral change is an important part of health promotion, either because it may benefit health directly or by providing increased control of the determinants of health (104).

The approach to oral health interventions in a clinical dental setting ranges from providing health information and/or give health advice and support changes in lifestyle, to behavioral interventions based on strategies for behavioral change (including elements such as identifying barriers to behavior change, strategies to reduce relapse, specifying behaviors that should be altered) and psychological interventions based on psychological theories regarding behaviors (109).

Historically, it was thought that if patients were given information and/or advice regarding oral health, with the intention to increase the patient's oral health knowledge and awareness, they would automatically change their risk behaviors. However, this has proven to be an ineffective way to promote good oral health behavior (2). In a review by Watt et al. (110), exploring the evidence base for health promotion interventions in reducing plaque and gingival inflammation, it was found that all the studies included contained educational interventions. The authors concluded that although reduction in plaque and gingival bleeding could be expected after educational interventions, the evidence conforming the long-term sustainability of these changes was lacking. They further stated that the clinical and public health significance of these short-term improvements were questionable. In a systematic review by Lingström et al. (111), no studies were identified that evaluated the effect of information given to reduce sugar consumption at preventing caries disease. Thus, there is no evidence supporting this as an effective strategy.

In a recent Cochrane review by Soldani et al. (112) on one-to-one oral hygiene advice, 19 RCTs that evaluated individual counselling in a dental setting were included. The interventions applied varied greatly, as did the number of sessions provided and populations studied. In addition, three of the studies included were directed towards children and only a minority (5 out of 19 studies) were conducted in general dental practice clinics. The author concluded that there was a lack of evidence to support any of the methods

included as being effective in improving oral health outcomes, nor was any method found to be more effective than the others.

The Cochrane review on one-to-one dietary interventions in the dental setting by Harries et al. (109) found only five studies that met the inclusion criteria. Interventions directed both towards child- and adult populations were included. The authors found weak evidence to support the effect of one-to-one dietary interventions, due to the small number of studies conducted and because many of the studies suffered from poor methodology. In their national guidelines, the Swedish Board of Health and Welfare also acknowledges the lack of studies on dietary interventions regarding sugar intake; thus, the effect of such interventions could not be evaluated (108). Instead, they considered it reasonable to transfer the results from the national guidelines for the prevention and treatment of unhealthy lifestyles to the national guidelines for dentistry. According to the national guidelines for the prevention and treatment of unhealthy lifestyles (113), behavioral interventions (i.e., qualified counselling) were found to be effective at increasing the daily intake of fruits and vegetables. The results were also considered to be potentially clinically relevant, and the interventions to be cost-effective. However, they also state that there was a lack of studies including other food products, such as sweets and sodas, whole grain products and fish (108, 113).

In a systematic review of psychological interventions for poor oral health, Werner et al. (114) reviewed eleven articles, based on nine RCT studies, that met the inclusion criteria. The included RCTs varied with regard to several factors (i.a., psychological intervention and associated framework, profession delivering the intervention, number of sessions given, time to follow-up and outcome measurements), but a common feature was that the study population consisted of adult patients with periodontal disease. Psychological interventions were not found to be more successful than traditional counselling at reducing gingivitis or plaque levels, although a small but statistically significant reduction in plaque index were found in favor of psychological interventions. Psychological interventions were also found to be more effective at altering oral health behaviors and increasing self-efficacy for toothbrushing. However, it was questionable if the statistically significant result had any clinical relevance. Moreover, the certainty of evidence was low, and no long-term effects were evaluated. Other systematic reviews have reported similar results (115, 116). Thus, there seems to be tentative evidence of psychological interventions being more effective at changing oral health behavior and improving oral health than traditional counseling methods.

In summary, it seems reasonable to conclude that in general there is a lack of evidence supporting behavioral change methods provided to patients in clinical dental settings (109, 110, 112, 114-116).

**Knowledge gaps regarding psychological interventions**

Most studies have been conducted in secondary care, which limits the generalizability of the results to the general population seeking and being treated in primary care (114). Moreover, the studies are generally conducted on adult patients with periodontal disease (114). There seems to be a lack of studies on the effect on oral health of theory-based behavioral interventions in adolescents and young adults (114), which is noteworthy as oral diseases are degenerative by nature and, consequently, it is important to target these diseases at an early stage. Furthermore, there seems to be a lack of studies evaluating the effect of theory-based behavioral interventions to reduce sugar intake in the adult population (114, 117), and no studies including adult patients with dental caries disease or peri-implantitis (114).

It seems unclear which profession is best suited to deliver theory-based behavioral interventions (114, 115). As stated in the Swedish National guidelines for dentistry (107), the health care provider delivering qualified counseling needs to have both knowledge, education and training in the theory and method on which the counselling is based. However, it further states that although there are some professionals in dentistry that have the skills required to deliver these interventions, more dental staff needs to be educated and trained in these methods in order to make effective health-promoting strategies accessible to populations. Another possible solution could be that the dental staff collaborates with psychologists, and The National Board of Health and Welfare called for interdisciplinary collaboration between the dental care and general health care in their recent guidelines (107). Psychologists are educated and trained professionals in psychological interventions and therefore a useful resource for this purpose. Although Werner et al. (114) in their systematic review only found one RCT where a psychologist delivered the intervention, interdisciplinary collaboration with psychologists in dentistry is not a new phenomenon, as patients with dental anxiety has been successfully treated in close collaboration with psychologists in some specialized dental clinics for many years now.

In brief, continued improvement in oral health has been noted among young adults, with an increase in the proportion of individuals being caries-free during the last decade (61, 77). However, a group of individuals with poor oral health still remains (23, 61, 77). In contrast to the general improvement concerning the prevalence of caries disease, a deterioration in periodontal health has been found among young adults during the last decade (61). Dental caries and periodontal disease imply a substantial burden on both a societal and individual level (11). Poor oral health can lead to loss of function and negative effects on psychological and social wellbeing; i.e., affect OHRQoL and overall wellbeing negatively (7, 34). There is an urgent need to tackle this highly preventable diseases, and effective oral health interventions are warranted. Furthermore, oral disease shares several behavioral risk factors with other non-communicable diseases (such as cardiovascular disease, diabetes, and cancer) (47). This means that improved oral health behavior will not only benefit people's oral health, but their general health as well. In most cases, children and adults visit the dental care on a regular basis, which makes the dental service a unique and suitable arena to detect and change unhealthy behaviors and thereby promote oral health and potentially also general health (107).

# 2 AIM

**General aim**.

The overall aim of this thesis was to (i) investigate oral health and oral health behaviors among young adults with poor oral health, (ii) and to evaluate the effect of a psychological intervention (Acceptance and Commitment Therapy; ACT) on oral health and oral health behaviors.

**The specific aims**

Study I

To investigate oral health, oral health behaviors, and oral health-related quality of life in relation to the level of caries disease among caries-active young adults.

Study II

To evaluate the effect of a psychological intervention on oral health behaviors (toothbrushing, use of dental floss, toothpicks, and additional fluorides) in young adults with poor oral health.

Study III

To evaluate the effect of a psychological intervention on oral health, measured as gingivitis and plaque levels, at follow-ups at 9 and 18 weeks.

# 3 MATERIAL AND METHODS

All three papers included in this thesis are based on data from a randomized controlled trial, performed at two different Public Dental Service (PDS) clinics in the Region of Västra Götaland, Sweden.

### Study participants

All young adults appointed for a regular dental check-up at two dental clinics between 2013-2014 were screened for eligibility. Young adults that met the inclusion criteria (i.e., ≥ two manifest approximal caries lesions diagnosed since the last regular dental examination and aged between 18 to 25 years) and not the exclusion criteria (i.e., psychiatric/neuropsychiatric diagnosis and not fluent in Swedish) were consecutively asked if they would like to participate in a study to promote oral health. This resulted in 186 eligible patients, 51 of whom declined participation. The remaining 135 young adults all gave written and informed consent to participate before they went through the baseline examination.

### Design and procedure

A parallel group randomized controlled trial design was applied. All study participants received the same standardized oral health information, from a brochure used for this purpose at all PDS clinics in the Region of Västra Götaland at the time of the study. The information was provided both verbally and in writing by the study coordinator at the respective clinic. Before being allocated to either the intervention or control group, the study participants had gone through the baseline examination and received the standardized oral health information.

For the randomization strategy, a block randomization procedure was applied, with an allocation rate of 1:1. The blocks were stratified for gender and smoking habits using randomly permuted blocks (118). The allocation sequence was withheld from the clinical coordinators.

In addition to standard oral health information, the study participants allocated to the intervention group received a psychological intervention (brief form of

ACT), including two individual 45-minute sessions, at the respective dental clinics. The first session was provided shortly after the baseline examination and the second two to three weeks later. The study participants, irrespective of treatment allocation, were followed up at 3, 9, and 18 weeks from baseline.

**Intervention**

Acceptance and Commitment Therapy (119) is a form of cognitive behavioral therapy (120). Moreover, it is not a disease-specific intervention and therefore a useful treatment method in many situations where behaviors may need to be changed (120). Furthermore, ACT is a so-called contextual therapy, which means that ACT puts the individual in its internal (such as thoughts, emotions and memories) and external context (such as family, friends and cultural meaning) (120).

The overall aim in ACT is to increase the individual's psychological flexibility. This is accomplished through six key processes (acceptance, mindfulness, defusion, self as context, values, committed action) and different exercises. During these processes and exercises, the individual is trained to recognize ongoing inner events (such as thoughts, memories, sensations, and emotions) but to not let them direct their behavior. This enables the individual to change unfavorable behaviors, while maintaining functional behaviors, and live a life in accordance with their chosen life values (3, 120, 121).

ACT interventions have demonstrated positive effects on the treatment of different conditions, such as depression, substance abuse and chronic pain, which was recently demonstrated in a review of meta-analyses by Gloster et al. (122). There are also promising results for ACT interventions in managing behaviors related to general health. In their systematic review, Lawlor et al. (123) found promising results of ACT on weight management. In another systematic review by Yıldız et al., (124) promising results of ACT were also found for behavior change related to substance abuse and physical inactivity, in addition to weight management. Moreover, brief forms of ACT also exist and have been reported to have similar effects as longer interventions (125). To our knowledge, ACT has not previously been used in a dental setting.

For the purpose of this study, a brief form of ACT was developed by the psychologists Helene Werner (HW), Ulla Wide (UW) and ACT expert Celia Young (CY), in collaboration with the dentist Magnus Hakeberg (MH), (for more information, see the treatment manual (126)). The intervention was based

on a brief form of ACT by Strosahl et al., (127) developed particularly for primary care settings and health-related behavior change. This was considered reasonable, as the organizational structure of the primary health care and primary dental care are somewhat similar. Furthermore, brief therapy entails lower costs and may be more appealing to young adults as fewer sessions are needed. To ensure treatment fidelity, the psychologist delivering the intervention (HW) followed predeveloped work sheets for each session and was supervised by CY during the whole study period.

**Data collection and measures**

Clinical measures of plaque and gingivitis were registered at the mesial, distal, buccal, and lingual/palatinal surfaces of the six index teeth: 16, 21, 24, 44, 41 and 36 (128). Gingivitis was considered present when bleeding occurred after gentle probing of the gingival sulcus (129), and plaque was recorded according to the Silness-Löe plaque index system (130) with each surface given a score between 0 and 3. According to the Silness-Löe plaque index (130), a score of 0 = no plaque, 1= plaque detectable only after the probe has been drawn along the tooth surface at the gingival margin, 2 = moderate accumulation of plaque detectable by the naked eye, and 3 = rich accumulation of plaque. For each study participant, the sum of tooth surfaces diagnosed with gingivitis and tooth surfaces with visible plaque (score 2-3, according to the Silness-Löe plaque index) was calculated.

A review of the criteria for the recording of plaque and gingivitis was given to the two examiners prior to the first examination at baseline and was repeated regularly during the study period in order to keep the examiners calibrated during the study trial. To further secure fidelity to the study protocol, the study monitors regularly visited each clinic.

Data of dental caries for mesial, distal, buccal, occlusal and lingual/palatinal surfaces of all teeth, were retrieved from the participants last clinical examination. The diagnosis of initial and manifest caries was according to general practice in the PDS, Region Västra Götaland (D1- D2 initial caries (caries in enamel), D3 manifest caries (caries in dentine), and secondary caries (caries adjacent to a restoration or a previously restored tooth surface) and based on both clinical and radiographic examinations. For each study participant, the sum of all recorded initial caries lesions (D1 + D2), manifest caries lesions (D3 + secondary caries), and the total number of caries lesions (D1-D3 + secondary caries) were calculated.

To assess the inter-examiner reliability for the diagnosis of manifest caries lesions on bite-wing radiographs, an inter-examiner reproducibility test was conducted between one of the investigators (JH) and one of the clinical coordinators (CS). The distal surface of tooth 34 and the mesial surface of tooth 16, from 31 study participants, were classified as sound or with manifest caries. Kappa analysis was applied, resulting in a kappa value of 0.82.

Information regarding background characteristics, oral health behavior, self-rated oral health, OHRQoL and dental anxiety were collected through the participants responding to questions on a touch-screen computer. Table 3 shows which questions regarding background characteristics and oral health behavior with associated response options, that were assessed in Study I-III. Table 3 further shows which variables were dichotomized, and in which studies the dichotomization was applied.

OHRQoL was captured using the five-item version of Oral Health Impact Profile (OHIP-5) (131). The Swedish version of the OHIP-5 is derived from the German language short form developed by John et al. (132). The five items address problems related to the four dimensions of OHRQoL: oral function, orofacial pain, orofacial appearance, and psychosocial impact (132, 133). Each item has the same five possible response alternatives (never, hardly ever, occasionally, fairly often, very often), graded on a five-point Likert scale from zero to four. This gives a possible total sum of scores between 0-20, where a higher score indicates poorer OHRQoL. The total sum score was calculated for each participant. Furthermore, the participants were categorized as experiencing good OHRQoL (scoring never or hardly ever on all items) or poor OHRQoL (scoring occasionally to very often on at least one item) (49, 134, 135). The psychometric properties of the Swedish version of the OHIP-5 have been evaluated in a nationally representative random sample (≥ 18 years). The results indicated satisfactory validity and reliability of the scale. In the same study, normative values for the OHIP-5 score were also provided, with 50% of the population reporting a score of 1 or less. Moreover, the 90$^{th}$ percentile was found to be equal to a sum score of 5 (131).

*Table 3. Questions, response options and dichotomization of background characteristics and oral health behavior.*

| Variable | Response options | Dichotomized into |
|---|---|---|
| Age | In years | |
| Sex | Female/Male | |
| Do you smoke? | Yes/No | |
| Country of birth ϕ<br>Parents' country of birth ϕ | Born in Sweden<br>Born in another Nordic country | Born in Nordic country/Swedish-born |
| | Born in other country | Born in other country |
| Occupation * | Employed<br>Student | Employed/student |
| | Unemployed | Unemployed |
| Housing | Rental flat<br>Own flat/house<br>Other | |
| Parents' educational achievements | Primary school<br>Secondary school<br>University studies | |
| How often do you brush your teeth? * | Three times a day or more<br>Twice a day | ≥ twice a day |
| How often do you use fluoridated toothpaste? * | Once a day<br>Several times a week<br>Once a week<br>More seldom or never | ≤ once a day |
| How often do you use additional fluoride? *<br>How often do you use dental floss? * | Three times a day or more<br>Twice a day<br>Once a day<br>Several times a week | ≥ several times a week |
| How often do you use toothpicks? | Once a week<br>More seldom or never | ≤ once a week |
| How often do you consume sugary sodas? * | Several times a day<br>Once a day<br>Several times a week | Often |
| How often do you consume sweets? * | Once a week<br>Seldom<br>Never | Seldom |
| How often do you attend dental care ϕ | Twice a year<br>Once a year | ≥ once a year/often |
| | Once every second year<br>Less than every second year<br>Only for acute dental need<br>Never | ≤ once every second year/seldom |

**Dichotomization was applied in Study I, ϕdichotomization was applied in Study I-II*

Self-rated oral health was captured with a single question: "How do you rate your oral health?" with the following response options: 'Very good', 'good', 'fair' and 'poor'.

Dental anxiety was captured using the Dental Anxiety Scale (DAS) (136). It consists of four items, each with five possible answers rated 1-5 on a Likert scale. This gives a total sum of scores ranging between 4 and 20, where a sum of ≥ 13 indicates dental anxiety (137). The DAS has been found to be a reliable and valid instrument for measuring dental anxiety (138).

Table 4 presents the questions and clinical variables that were assessed in Study I-III, and at which time point during the study period.

*Table 4. Each time point when questions and clinical variables were measured in Study I-III.*

| Variables | Baseline | + 3 weeks | + 9 weeks | + 18 weeks |
|---|---|---|---|---|
| Clinical variables | | | | |
| Dental caries | X | | | |
| Gingivitis | X | | X | X |
| Plaque | X | | X | X |
| Background characteristics | X | | | |
| Oral health behaviors | | | | |
| Toothbrushing | X | X | | |
| Use of dental floss | X | X | | |
| Use of toothpicks | X | X | | |
| Use of fluoridated toothpaste | X | | | |
| Use of additional fluorides | X | X | | |
| Consumption of sugary sodas | X | | | |
| Consumption sweets | X | | | |
| Dental care attendance | X | | | |
| Smoking habit | X | | | |
| Self-rated oral health | X | | | |
| OHIP-5 | X | | | |
| DAS | X | | | |

*X = when measured*

## Statistics

A power analysis was conducted to estimate the number of patients needed to be recruited if a 20% reduction in mean gingivitis were to be detected between treatment groups, with a power of 80% and the significance level of 5%. When taking dropouts into account, the needed sample size per treatment group was 65 participants. In addition, power analyses for oral health behavior and plaque were also conducted, but neither indicated that a larger sample size was needed.

Descriptive statistics were analyzed according to means, medians, standard deviations and frequencies.

In Study I, the dependent outcome variable of manifest caries was trichotomized into three caries groups based on the 33 and 67 percentiles, creating a moderate (2-3 manifest caries lesions), high (4-6 manifest caries lesions) and very high (≥ 7 manifest caries lesions) caries group. For group comparisons, the Chi-square test was applied for categorical variables, and the Kruskal-Wallis test and the Mann-Whitney test for continuous variables. To reveal associations between theoretically important independent variables and caries severity (based on the three caries groups), multinomial logistic regression analyses were performed.

In Study II and III, analyses were performed according to intention-to-treat (ITT) and per protocol (PP), which is in line with the CONSORT principles (139). To handle missing data due to dropouts at follow-up, the last observation carried forward was applied to the ITT analyses.

In Study II, the Mann-Whitney test and the Chi-square test were applied to explore if any statistically significant difference existed between the baseline measure of the intervention and the control group. The Wilcoxon Signed Rank test was applied to analyze behavior change from baseline to follow-up at week 3. Effect sizes were calculated using the z value obtained from the Wilcoxon Signed Rank test analyses, divided by the square root of the number of observations over the two time points (140). Due to multiple comparisons, the Bonferroni corrections was applied, which gave a p value for statistical significance of $p < 0.005$ for the baseline comparison, and $p < 0.003$ for the analysis of behavioral change.

In Study III, the effect of the ACT intervention compared with standard treatment was evaluated for gingivitis and plaque scores using the General Linear Model (GLM) for repeated measures. To analyze if gender or smoking habits had any impact on the outcome, explorative sub-analyses (applying the

GLM) were conducted for the intervention and control groups, separately. Partial eta squared (partial $\eta^2$) was applied to the calculation of the effect size, where a value of 0.01 is interpreted as a small effect size, 0.06 as moderate and 0.14 as a large effect size (140).

The Statistical Packages for Social Sciences (SPSS), version 27.0, was used for all the statistical analyses. A p value of $< 0.05$ was considered to demonstrate statistical significance.

# 4 RESULTS

The flow chart (Fig. 2) displays the allocation of study participants and drop-outs during the studied trial period.

**Baseline characteristics**

The final sample consisted of 64 females and 71 men, with a mean age of 21 years. Most of the participants were born in a Nordic country (76.3%). Little less than 50% reported having a mother born outside of the Nordic countries and the same was true regarding the father's country of birth. In general, the study participants' parents had secondary school as their highest educational achievement (48.9% of the mothers and 50.4% of the fathers).

The clinical oral health status of the study participants at baseline is shown in Table 5.

*Table 5. Clinical oral health status for the total study sample at baseline, according to initial, manifest, and total number of dental caries lesions, gingivitis and plaque scores.*

| Variables | Mean (SD) | Median | Minimum | Maximum |
|---|---|---|---|---|
| Initial caries lesions | 15.8 (13.6) | 11.0 | 0.0 | 54.0 |
| Manifest caries lesions | 5.6 (4.6) | 4.0 | 2.0 | 28.0 |
| Total number of caries lesions | 21.4 (13.8) | 19.0 | 2.0 | 60.0 |
| Gingivitis score | 16.4 (6.9) | 17.0 | 0.0 | 24.0 |
| Plaque score | 7.6 (6.4) | 6.0 | 0.0 | 24.0 |

*Standard deviation (SD), Initial caries (D1+D2), Manifest caries (D3+secondary caries), Total number of caries lesions (D1-D3+secondary caries).*

The vast majority of the study participants rated their oral health as poor (38.5%) or fair (45.9%), and no one as very good. Poor OHRQoL was reported by 73.3% and the mean and median score on the OHIP-5 was 5.2 and 5.0, respectively.

Around 60% reported that they brushed their teeth at least twice a day and almost 40% flossed at least several times a week. Around 60% used toothpaste at least twice a day and additional fluorides at least several times a week. Little less than 60% consumed sugary sodas at least several times a week, and approximately 40% reported the same consumption pattern for sweets. The vast majority attended dental care at least once a year. Smoking was reported by 34.8%.

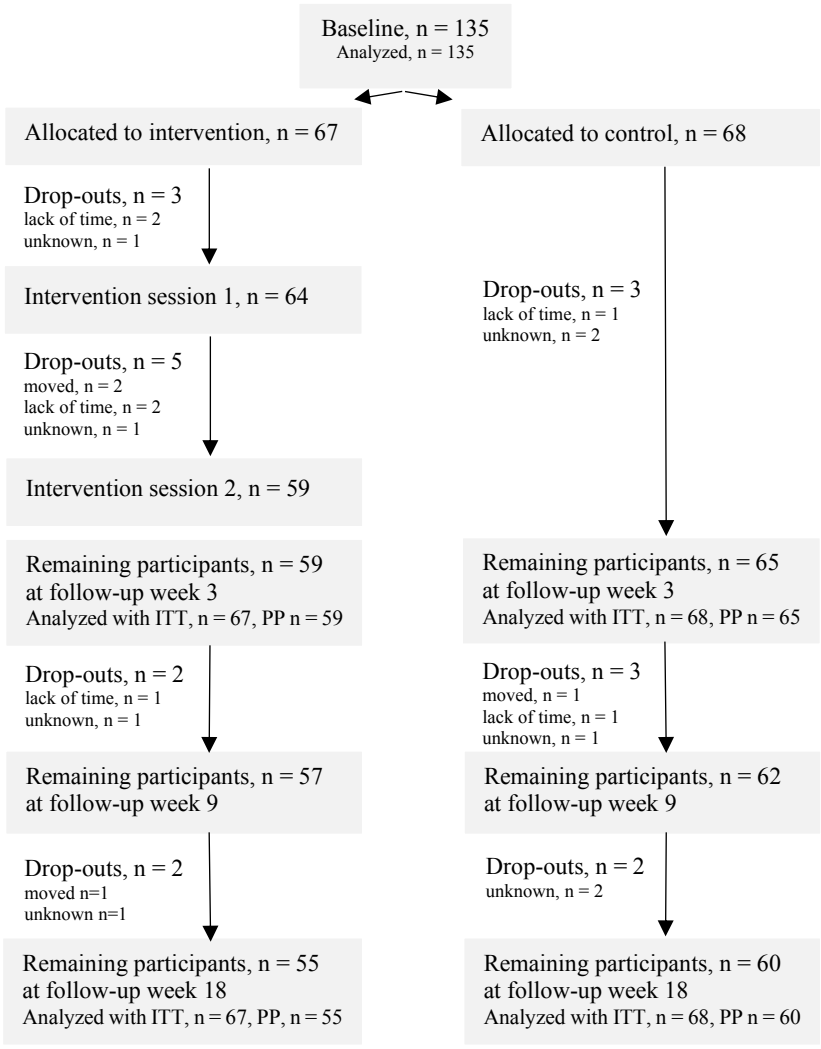


*Figure 2. Flow chart displaying the flow of participants during the studied trial period, and the number of participants remaining at each follow-up occasion*

The were no substantial differences between the two treatment groups regarding oral hygiene behavior, socioeconomic status and clinical measures at baseline (Study II). However, a slightly larger proportion of the participants allocated to the control group than to the intervention group reported being

employed (30.9% versus 14.9%) and that their mother was not Swedish born (60.3% versus 44.8%) (Study III).

**Study I**

The moderate (2-3 caries lesions), high (4-6 caries lesions) and very high (≥ 7 caries lesions) caries groups consisted of 54, 46 and 35 of the study participants, respectively.

In the bivariate analyses, consumption of sugary sodas ($p = 0.003$), dental care attendance ($p = 0.019$), self-rated oral health ($p = 0.001$), OHRQoL ($p = 0.016$), DAS ($p = 0.049$), father's ethnicity ($p = 0.034$), gingivitis ($p = 0.002$) and plaque score ($p = 0.022$) were found to differ statistically significantly between the three caries groups. Furthermore, the proportion of study participants that reported frequent consumption of sugary sodas, poor oral health, poor OHRQoL, father born in a non-Nordic country, less frequent dental care attendance and higher dental anxiety scores increased with caries severity. The same gradient pattern was also noted for the gingivitis score.

The multinomial logistic regression analysis revealed that belonging to the high caries group or very high caries group rather than the moderate group was more likely if experiencing poor OHRQoL and higher levels of gingivitis. It was also more likely to belong to the very high caries group rather than the moderate group if reporting dental care attendance ≤ once a year or consuming sugary sodas often.

**Study II**

Immediately after the intervention, analyses according to ITT and PP revealed that the intervention group had improved statistically significantly on all four behaviors (toothbrushing, flossing, toothpick use, and additional fluoride) since baseline. Regarding the control group, statistically significant improvement was found since baseline for the use of flossing and additional fluorides, according to both the ITT and PP analyses. However, after the Bonferroni correction for multiple comparisons was applied, the behavioral change of the control group no longer reached statistical significance.

For the intervention group, the behavior change for toothbrushing and flossing reached a medium effect size in the PP and ITT analyses (effect size between 0.30-0.32). In the PP analysis, the effect size for the use of additional fluorides

was medium (effect size 0.30), but low in the ITT analysis (effect size 0.28) . The effect size for the use of toothpicks was low in both the PP and ITT analyses (effect size 0.28 and 0.26, respectively). Regarding the control group, the behavior changes of flossing and additional fluorides had a low effect size, according both to the ITT and PP analysis (effect size between 0.22 and 0.24).

**Study III**

During the approximately 16 weeks that had passed since the last ACT session and the nine weeks since the last follow-up visit, both the intervention and control group had reduced their gingivitis ($p < 0.001$, partial $\eta^2 = 0.22$) and plaque score ($p < 0.001$, partial $\eta^2 = 0.28$) statistically significantly, with large effect sizes (analyses by ITT). However, although the intervention group had reduced their gingivitis and plaque score slightly more than the control group, no statistically significant difference was observed between the two groups.

Table 6 presents gingivitis and plaque scores expressed as percentages of the surfaces diagnosed with bleeding or visible plaque, divided by the total number of investigated surfaces (24 surfaces in total) at baseline and at the 18-week follow-up, and the mean change between the two measuring occasions, according to both the ITT and PP analyses.

*Table 6. Mean gingivitis and plaque proportions at baseline and follow-up at week 18, and mean change in proportions between baseline and follow-up at week 18 for analyses according to ITT and PP.*

| | Intervention | | | Control | | |
|---|---|---|---|---|---|---|
| | Baseline | Week 18 | Changes in mean % | Baseline | Week 18 | Changes in mean % |
| Mean % Gingivitis | | | | | | |
| ITT | 70.4 | 55.4 | - 15.0 | 66.3 | 60.4 | - 5.9 |
| PP | 72.1 | 55.0 | - 17.1 | 66.3 | 59.2 | - 7.1 |
| Mean % Plaque | | | | | | |
| ITT | 32.9 | 20.4 | - 12.5 | 30.4 | 22.9 | - 7.5 |
| PP | 35.8 | 20.0 | - 15.8 | 30.4 | 22.1 | - 8.3 |

*Number of participants analyzed according to ITT: intervention 67, control 68*
*Number of participants analyzed according to PP: intervention 55, control 60*

The explorative analyses according to gender revealed that in the intervention group, the females had improved their gingivitis ($p = 0.025$, partial $\eta^2 = 0.08$) and plaque scores ($p = 0.013$, $\eta^2 = 0.09$) statistically significantly, with a moderate effect size, compared with the male participants (Figure 3 and 5). Interestingly, the same pattern was not observed between genders in the control group (Figure 4 and 6).

The explorative analyses according to smoking behavior did not reveal any statistically significant differences between smoking behavior and reduction in gingivitis or plaque score, neither in the intervention group nor in the control group.

No adverse events were reported by the study participants during the trial.

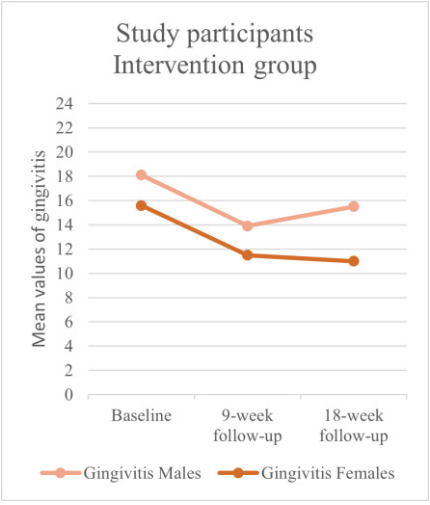


*Figure 3. Change in mean gingivitis scores between baseline and follow-up week 18 according to gender (ITT analysis)(141)*

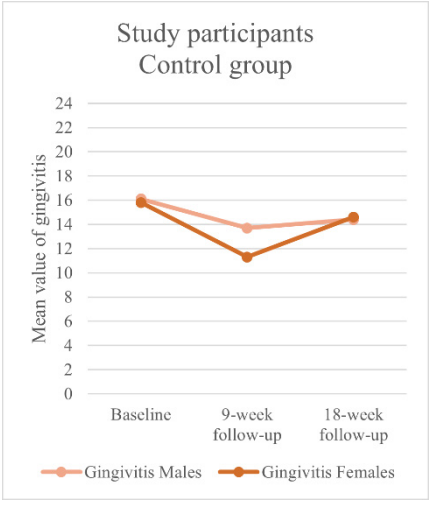


*Figure 4. Change in mean gingivitis scores between baseline and follow-up week 18 according to gender (ITT analysis)*

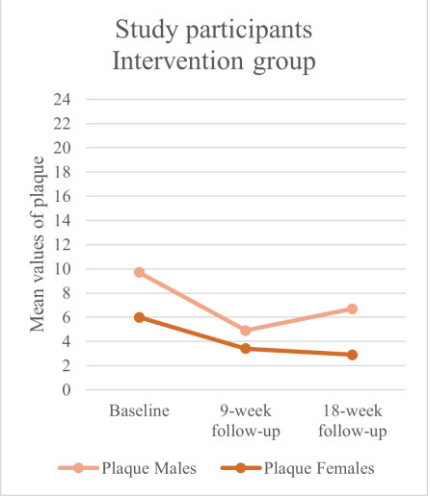


*Figure 5. Change in mean plaque scores between baseline and follow-up week 18 according to gender (ITT analysis)(141)*

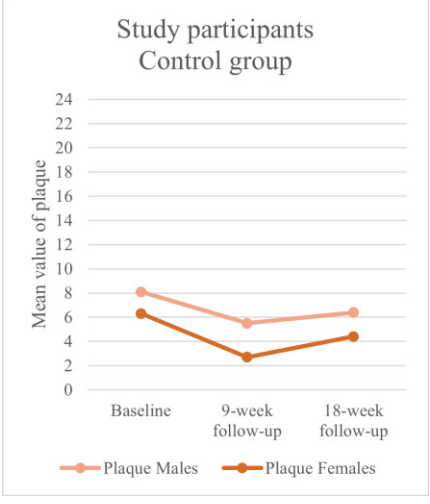


*Figure 6. Change in mean plaque scores between baseline and follow-up week 18 according to gender (ITT analysis)*

# 5 DISCUSSION

**Study I**

Young adults suffering from poor oral health and oral health risk behaviors were common in the sample. With respect to dental caries disease, the prevalence of dental caries lesions was high, and caries severity was found to be associated with poor OHRQoL. Furthermore, dental caries severity was found to be associated with frequent consumption of sugary sodas, higher levels of gingivitis and less frequent dental care attendance, indicating that behavioral variables seemed to have an important influence on oral health in the present study sample.

Previous studies reporting on the prevalence of both enamel and dentin caries lesions in populations of young adults, have found the prevalence to be much lower than in the present study (57, 74, 76, 94); however, they used slightly different diagnostic criteria, which limits the possibility to compare the results. There are several studies demonstrating a skewed distribution of dental caries in populations of young adults, with the highest burden found in a minor proportion of the population (23, 57, 76, 78, 94). For example, in a Norwegian study, only 16 % of 20-29-year-olds were found to have > three dentin caries lesions (142). As dental caries diseases have been found to remain a problem for a minor portion of the population (23, 77), and as present caries experience remains the best predictor of future caries increment (23, 76, 143), continued deterioration in oral health can be expected among these young adults if not effectively treated.

Toothbrushing twice a day with fluoridated toothpaste is a well-established recommendation. It seems likely that the young adults had received this information on repeated occasions during their visits to the dental service. Nevertheless, there was still a substantial proportion who reported less desirable behavior. When comparing our results with previous reports on young adults living in the Nordic countries, the behavior of brushing one's teeth twice a day was less common in the present study (52, 81, 87, 142, 144). Poor oral hygiene behaviors were further reflected by high gingivitis and plaque scores in the sample. Appropriate plaque removal is a fundamental part in preventing and/or treating gingivitis, while managing gingivitis is a primary preventive strategy for periodontitis (82, 83). Hence, there is a risk of continued deterioration of periodontal health among these young adults.

Frequent consumption of sugary sodas was common in the present sample, as was consumption of sweets. Previous studies have found these behaviors to be less common among young adults (87, 144). Reduced intake of free sugars is the key preventive strategy for caries disease, and any reduction in intake may be of value (89). In addition, sugary sodas and food items high in free sugars has been recognized as particularly important dietary sources of excessive calories among young adults (98). A high intake of unnecessary calories may lead to overweight, obesity and type 2 diabetes (47, 97, 98), which further stresses the need to find effective interventions to decrease the consumption of these food items.

Compared with national data on tobacco habits among 16-29-year-olds (8% and 10% reporting daily smoking in 2014 and 2013, respectively (103)), the prevalence of smokers was overrepresented in the present sample, with more than 30% reporting to be smokers. Smoking in particular has been found to be a risk behavior that seldom exists in isolation (145, 146); rather, it tends to cluster with other risk behaviors, such as excessive alcohol consumption, physical inactivity and low consumption of fruits and vegetables (145-147). Cluster of multiple risk behaviors are more common during young adulthood than later in life (145-147), and more prevalent in men (146, 147). Hence, it is possible that young adults who smoke also engage in other risk behaviors, which could affect their oral health negatively.

Regular dental attendance has been shown to be protective of oral health (92, 93). However, in the present sample, the majority reported attending dental care at least once a year but still suffered from poor oral health. This might reflect an inability of dental health care to prevent and/or halt disease progression and to promote health-protective behaviors among some people in the population. According to the annual report by SkaPa (61), the dental health service has difficulties in preventing disease progression among adults already affected with caries disease. They further reported that although the proportion receiving preventive treatments for dental caries disease has increased during the last decade, restorative treatments still dominate in the age groups above 20 years. Moreover, the proportion receiving preventive treatment in connection with restorative treatment due to dental caries, decreased with increasing age. In the age group of 20-49-year-olds, only 29% received preventive treatment in connection with restorative treatment, compared with 67% in the age group 6-11-year-olds, and 57% in the age group 12-19-year-olds, in 2019. According to a report by Hänsel Petersson et al. (148) on preventive treatment delivered after caries risk assessment in 19-year-olds attending the PDS in Region Skåne, Sweden, preventive measures were more commonly carried out in the two lower caries risk groups, compared with the

two higher risk caries groups. In addition, the individuals categorized as belonging to one of the two low risk caries groups were twice as likely to receive additional preventive measures than those in the two higher caries groups. Hence, caries risk assessments were not accompanied with desirable individually tailored preventive efforts. There is also a lack of evidence to support the provision of health information as an effective method to induce behavioral change and improved oral health outcomes (109-112). To make informed choices about lifestyle, some patients may need more than just knowledge and advice. The professional needs to accompany the information with efforts to equip the patient with attitudes and beliefs that support the information provided. But most importantly, the professional needs to assist the patient in identifying their own priorities and health concerns and equip the patient with the confidence and skills to make healthy lifestyle choices (2). However, findings from the annual report by SKaPa (61) seems to indicate that these more complex behavioral interventions (i.e., qualified counselling) rarely are provided in the Swedish dental health care.

Although socioeconomic position and demographic factors are well known to influence the distribution of oral disease in the population, they were not found to be associated with caries severity in the present sample (except for father's ethnicity in the bivariate analysis). Rather, behavioral factors (consumption of sugary sodas, dental care attendance and oral hygiene behaviors, as measured by gingivitis levels) affected the odds of having a higher caries burden. Similar findings have been reported among adults in Norway, where behavioral variables seemed to influence the probability of being caries-free more than socioeconomic variables (94). However, as young adulthood is associated with a time of transition, measuring socioeconomic position is somewhat complicated. For example, educational achievements are difficult to appreciate, as many young adults may not yet have finished or enrolled in higher educational studies. The same applies to households, as some young adults may still live with their parents while others may live in student accommodation. Thus, the socioeconomic measures used in the present study are not necessarily representative of the participants' socioeconomic position. On the other hand, parental education and ethnicity can be considered as fixed measurements for socioeconomic positioning and may provide the most reliable measure in this context. However, they only offer an approximate estimate. Hence, the way socioeconomic position was measured in the present study may have attenuated the possibility to find associations between socioeconomic variables and caries severity in Study I.

Almost 40% reported their oral health to be poor and the proportion increased with increasing caries severity, demonstrating that the young adults were aware

of their compromised oral health status. The result from the OHIP-5 questionnaire indicated that the young adults experienced a substantial negative impact on their OHRQoL when compared with normative values for the adult Swedish population (131). This finding was further confirmed by the higher proportion with poor OHRQoL in the present sample compared with previous studies of young adults (49, 135). Another important finding was that the higher the caries severity, the poorer the OHRQoL. Thus, one may conclude that the OHIP-5 measure was able to discriminate for caries severity in the population.

**Study II and III**

Compared with oral health information given alone, the addition of ACT treatment demonstrated promising direct effects on oral hygiene behaviors. Although these promising behavioral changes resulted in better oral health status in the form of lower gingivitis and plaque levels at the nine-week follow-up, with minor relapses approximately four months after the last ACT session, the differences were not statistically significantly better in the intervention group than in the control group. This might imply that there was a need for additional sessions or a booster session of ACT for the study participants to maintain their initially improved oral hygiene behaviors. This may have been especially necessary among the male participants, as the results from the explorative analysis indicated that the ACT treatment was more successful among the female than the male participants in the intervention group. Does this mean that it is easier to change behavior in women?

Study II revealed promising direct effects of the intervention with ACT, as the participants in the intervention group had improved statistically significantly on all four oral health behaviors measured, which was not the case in the control group. This is in line with previous reports evaluating the effect of theory-based interventions in improving oral hygiene behavior in adult patients with periodontitis (149, 150).

At the 18-week follow-up, both the intervention and the control group had improved their gingivitis and plaque levels statistically significantly, but no statistically significant differences were found between the two treatment groups. Gingivitis and plaque levels of ≤ 20% have been reported to be an acceptable level for infection control in patients treated for periodontitis (151) and levels of ≤ 30 % to reflect good oral hygiene conditions among adolescents (52). Considering these cutoff levels, the desired plaque levels were obtained

in both the intervention and control group at the 18-week follow-up. However, the levels of gingivitis were still high, although now more in line with previous studies reporting on gingivitis among young adults, and more so in the intervention group (52, 81).

In a recent report evaluating the effect of a theory-based behavioral intervention delivered to16-17-year-olds with poor oral hygiene conditions, the intervention was found to be statistically significantly more effective than conventional therapy at reducing gingivitis and plaque scores. The intervention was delivered by dental hygienists and, like the present study, conducted in general Public Dental Service Clinics in Region Västra Götaland, Sweden. According to the per protocol analysis, the study participants in the intervention group had a mean reduction in gingivitis levels of 19.6 %, whereas the mean reduction in the control group was 11.2%, at six months (152). Although the participants in the present study did not reach the desired levels of gingivitis on a group level, as the adolescents studied by Dimnäs et al. (152), the mean reduction in gingivitis did not differ considerably between the two studies. One possible explanation why Dimnäs et al. found the effect of their intervention to be statistically significant and we did not, is that they had a much larger study sample, resulting in less probability of type II errors compared with our study. Another factor that might explain the greater risk of type II errors in Study III was the possibility for participants in the intervention group to choose which behavior that they were willing to change. Hence, behaviors that would not result in reduced plaque and gingivitis levels may have been altered. Although comparison between the study by Dimnäs et al. and others evaluating theory-based behavioral interventions should be made with caution, due to factors related to the study design, it raises the question of what should be considered a clinically meaningful result of theory-based behavioral interventions.

The way patients respond to treatment can be attributed to the content of the treatment, but it also depends on the context in which the treatment is given (153). Treatment outcome is therefore the result of an interaction between treatment content and factors such as the recipient's expectations of the treatment, conditioning (connecting treatment with improvement), numbers of meetings with the clinician, and the potential desire to please the clinician (153, 154). Thus, the improved oral hygiene behaviors in Study II and the oral health outcome in Study III might be explained, in part, by these contextual factors, and most likely this is the case for the improvements noted in the control group. The reason for this point of view is the lack of evidence supporting the provision of oral health information and/or advice as effective strategies to improve oral health (109-112). The effect of context for the treatment outcome

is also one of the reasons why longer follow-up periods have been called for in several reviews (114-116). In Study III, nine weeks and approximately 16 weeks had passed since the last follow-up occasion and the second ACT session, respectively. Although this is a much longer time than in most previous reports on theory-based behavioral intervention, more time need to have passed for a full evaluation of the long-term effects of the ACT intervention.

The explorative analyses in Study III indicated that female patients had maintained their improved oral hygiene behaviors to a greater extent, reflected by sustained improved gingival health and reduced plaque levels at the 18-week follow-up, compared with the male participants in the intervention group. In addition, no such gender differences were evident in the separate analysis of the control group. To the best of our knowledge, no previous studies on theory-based behavioral interventions in the dental field have explored the effects of gender on the outcome in the intervention and control group *per se*. The association between gender and oral health outcome has been evaluated in a few other studies; however, independently of treatment group affiliation. In a study evaluating motivational interviewing for improved adherence with periodontal infection control, Stenman et al. (151) found that being a female patient was associated with the desired outcome of a marginal bleeding score of 20 % or below. However, Gorda et al. (155) found no association between gender and improved oral hygiene behavior in their study evaluating the effect of an intervention based on self-regulation theory and motivational interviewing. There are several reports in the literature indicating gender differences in oral health and oral health behaviors in young adults, with better oral health and oral health behaviors among female participants (23, 52, 81, 85). Furthermore, male gender has been associated with unfavorable oral health-related knowledge, attitudes, beliefs, and perceptions, which has been suggested to account for these gender differences in oral health and oral health behavior (52, 85). To some extent, these differences could most likely be attributed to psychosocial aspects related to gender norms (156) and contribute to the males in the intervention group failing to sustain their improved oral health 16 weeks after the last ACT session, compared with female participants in the intervention. To conclude, there seems to be a need for further studies of how gender differences might affect the outcome of oral health behavior interventions and oral health outcome, and whether or not male participants, in particular, would benefit from additional sessions of theory-based behavioral interventions.

The incidence and progression rate for caries lesions have been found to be lower during young adulthood than during adolescence (157), and even if the

caries incidence may vary according to previous caries experience (158, 159), it was also found to decrease with higher age regardless of previous caries experience (158). Hence, dental caries as an outcome was not included in Study III, as more time would have needed to pass for the evaluation to be meaningful. However, we plan to conduct a study including caries data three and five years since baseline to evaluate the effectiveness of the ACT intervention in reducing caries disease.

There are mixed results in the literature on the ability of theory-based behavioral interventions to improve oral health behaviors and, consequently, oral health (149-151, 155, 160-162). Several systematic reviews evaluating their effectiveness in adult populations (114-117, 163) have been carried out and offer tentative evidence of theory-based interventions being more effective than treatment as usual (114-116). In addition, several limitations, knowledge gaps, and areas that need future research have been pointed out, including the need to study the effect of interventions in populations other than adult patients with periodontitis (114) and in other contexts than specialist clinic settings (149, 151).

Another implication for future research addresses the question of the number of sessions needed to attain and/or maintain behavior change obtained through treatment with theory-based behavioral intervention (115, 151, 161). Carra et al. (115) suggested that future studies should assess outcome at multiple short and longer time points, to provide knowledge regarding the possible need for behavioral reinforcement sessions and at which intervals they should be delivered. As previously mentioned, the ACT intervention demonstrated direct promising effects on oral hygiene behaviors, with reduced levels of plaque and gingivitis noted at the nine-week follow-up. However, at the 18-week follow-up, the levels of plaque and gingivitis had increased, indicating that participants in the intervention group might have benefited from a booster session with ACT some time after six weeks in order to maintain, or potentially further improve, their plaque and gingivitis levels.

Another question is which profession (dentist, dental hygienist, counselor, or licensed psychologist) is most effective at delivering theory-based behavioral interventions in dentistry (114, 115, 151). It has been acknowledged that the health care provider delivering these interventions is required to have specific knowledge and training in the theory and method on which the theory-based behavioral interventions are based (107, 115). According to the Swedish national guidelines for dentistry, there is a need of more professionals in dentistry with the required skills (107), which is reflected in that the dental care rarely charges their patients for theory-based behavioral treatments (61). One

solution to this problem is to educate and train dental personnel in these theories and methods. On the other hand, psychologists could be introduced in dentistry as they already have both extensive knowledge and training in these theories and methods. In recent years, psychologists have become a common feature in primary care settings (164), so why not in dental care? The distinction between health care and dentistry and the structural difference with regard to the health insurance policies and the cost of treatment between them, might constitute an obstacle for the integration of other professionals in dental care. Nevertheless, several regions are investigating the possibility to introduce new professionals in dental care, for example, psychologists and dietitians (107). Moreover, psychologists have the skills and the theoretical knowledge to recognize different psychological conditions and have diagnostic abilities that would broaden their usefulness in general dental care. In addition, they have the ability and knowledge to use different behavioral techniques and thus provide more tailored treatment.

## 5.1 GENERAL METHODOLOGICAL CONSIDERATIONS

In the present study, data on dental caries were collected from patient records and, for this reason, several different dentists and dental hygienists had performed the examination and, consequently, the registration in the patients' charts. Due to administrative difficulties, no formal calibration exercise was conducted prior to the initiation of the study, which could be considered a limitation of the study. However, according to a Finnish study, caries data retrieved from public dental health service records are not inferior to those based on examination by calibrated examiners (165). In addition, dental caries lesions were recorded according to a standard procedure in public dental care. Thus, the dentist and dental hygienist were very familiar with the diagnostic system used.

In Study I and III, plaque and gingivitis were recorded at six index teeth (16, 21, 24, 44, 41 and 36) corresponding to the Ramfjord index teeth, which might have resulted in over or underestimation of the gingivitis and plaque score. However, recording of gingivitis using the index has only been shown to result in a slight underestimation of the degree of gingivitis in the remaining dentition, and in a slight loss of precision of the mean value. Furthermore, in the same study, the index was also found to provide an excellent representation

of the remaining dentition when tracking changes in gingivitis over time (128). The index has also been found to provide mean plaque scores that are highly correlated with the mean plaque scores for the whole dentition. In addition, over and underestimation due to plaque registration only at the index teeth compared with registration for the whole dentition was found to be non-significant (166). It therefore seems reasonable to argue that only recording gingivitis and plaque at the six index teeth did not jeopardize the estimation of the study participants' gingivitis and plaque levels in the present trial. Furthermore, the less time needed due to registration at only six teeth may also have contributed to fewer study participants dropping out as the examination was less demanding.

The present study was conducted at two PDS clinics in Region Västra Götaland, which is one of the larges regions in Sweden. In addition, most young adults are listed at the PDS and are regularly invited to receive dental check-ups. This means that the external validity of the results could be considered as high.

This study used a randomized controlled trial design, which is considered the best study design for evaluation of interventions. The reason for this assumption is attributed to the randomization procedure, resulting in all other factors (known or unknown) than the treatment *per se* being equally distributed between treatment groups, according to chance. Hence, any difference in outcomes between treatments could be assigned to the treatment itself (167). Another strength of the present study design is that the RCT design makes it possible to evaluate the efficacy, while the setting (general dental clinics) for the delivery of the intervention makes it possible to evaluate the effectiveness of ACT.

One important factor for the quality of an RCT is the level of blinding. For some types of studies (e.g., lifestyle, surgery, and psychotherapy interventions), blinding is difficult to achieve. In the present study, blinding was not possible due to the study design. The dropout rate in the present study was low (15 %), considering that young adults are at a stage in life where relocation is common due to factors such as enrollment in university studies, work opportunities or traveling. It is also a stage in life where some may have started a family of their own, restricting their ability to participate in a research study. Previous studies on theory-based behavioral interventions have reported similar dropout rates (between 11-14%) and, as in the present study, somewhat higher dropout rates were found among study participants belonging to the intervention rather than the control group (151, 152, 155). Overall, the treatment acceptability seems to have been high.

Finally, this was the first study evaluating a behavioral intervention based on Acceptance and Commitment Therapy in dental care. Although, the study showed some promising effects of ACT for behavioral change, it also identified some areas of concern. Further studies should explore the number of sessions needed and whether other theory-based methods for behavioral change are more effective at promoting oral health.

## 5.2 ETHICAL CONSIDERATIONS

The study was approved by the Regional Ethical Review Board in Gothenburg, Sweden (reg. no. 840-12) and followed The Declaration of Helsinki protocols. All participants gave their informed consent in writing to participate in the study prior to enrollment.

There is a risk that psychological treatment or answering questionnaires may cause negative emotions and/or stress reactions in the study participant. Great care was therefore taken by the psychologist to detect any adverse events during the ACT sessions, and the study coordinators were always present when the participants filled out the questionnaire, ready to assist the respondent if needed. However, no adverse events were reported.

# 6 CONCLUSION

The present study explored oral health, oral health behavior and OHRQoL, as well as the effect of a theory-based behavioral intervention, based on ACT, on improving oral hygiene behavior and oral health outcomes among young adults with active dental caries disease.

Study I revealed poor oral health conditions, a high prevalence of oral health-related risk behaviors and poor OHRQoL in this sample of young adults. In addition, the results indicated that especially oral health risk behaviors were associated with caries severity in the present sample. Moreover, the high levels of dental caries lesions, gingivitis, plaque, and oral health risk behaviors indicate that preventive action in dentistry has probably not been effective in this subgroup of young adults. This implies that existing preventive programs may need to be evaluated and further adopted to individual needs, but more importantly, it signals the need for the development and evaluation of new effective behavioral interventions in the dental field, to improve oral health and OHRQoL, especially among those most affected.

Study II and III evaluated the effect of a theory-based behavioral intervention among young adults with active dental caries disease, provided by a psychologist in PDS clinics, thereby contributing important knowledge to the scientific field of theory-based interventions in dental care.

The promising direct effects of ACT on oral hygiene behavior seen in Study II, and the decreased levels of plaque and gingivitis noted in Study III, imply that a brief form of ACT with some modifications might be an effective treatment to achieve behavioral change and better oral health among young adults.

Study II and III further demonstrate that interprofessional collaboration in PDS clinics is feasible, and that the young adults with poor oral health were willing to meet a psychologist and receive treatment for behavioral change to gain better oral health.

# 7 FUTURE PERSPECTIVES

To be able to confirm our findings in Study I, future research should explore the association between oral health behaviors and additional risk factors for poor oral health among young adults with dental caries disease. Applying theoretical modeling to explore the complex pathways through which different risk factors work to affect oral health outcomes and OHRQoL would bring important insights and be useful in the pursuit of developing effective interventions for young adults.

There is a continued need for high quality research in the field of theory-based behavioral intervention in dentistry, especially in the context of general dental settings, directed to patients of different ages, with dental caries disease, erosions, and behaviors of relevance (especially diet) for these diseases. Outcome measures should also include OHRQoL to enable evaluation of the ability of interventions to improve the patients' overall wellbeing. To improve the study design, elements such as longer periods of follow-up should be applied (to be able to evaluate the sustainability of the behavioral changes observed), and outcomes should be assessed both in the short and longer term (to be able to detect a possible need for booster sessions and when they may be needed).

There are several different theories for behavioral change that are or could be applied in dental care (108, 168). To the best of our knowledge, there are no studies comparing the effect of one theory-based behavioral intervention with another in the dental field; i.e., there is a lack of knowledge regarding which theory-based intervention/interventions should be recommended, and whether different interventions perform better in different populations and/or settings. Against this background, there is a need to perform randomized controlled trials exploring these issues.

To the best of our knowledge, there are no studies to date examining which profession is the most effective at delivering theory-based behavioral interventions in the field of dentistry. This knowledge would be of value when deciding on the allocation of resources in dentistry; i.e., is it more cost-effective to incorporate a psychologist in the dental clinic or should we educate and train the dental personnel in psychological theories and methods to enable them to perform qualified counselling for behavioral change in dental patients?

In general, there is a need to replicate previous studies on theory-based behavioral interventions, as factors such as the population studied, the context

and relations between the provider and the recipient may have influenced the outcome. To be able to confirm and strengthen the generalizability of existing results, the intervention methods previously applied, as well as the brief form of ACT applied in this thesis, need to be evaluated in other populations, settings and by different providers. In addition, during the evaluation of the brief form of ACT in Study II and III, some limitations of the format were recognized. Future studies using brief forms of ACT should evaluate the effect of a booster session, preferably some time after six weeks since the last initial sessions, and the long-standing effect of the intervention also needs to be more thoroughly examined. Furthermore, a qualitative study exploring how different components of the intervention were received by the participants might share some light on which elements of the ACT treatment that were especially effective and where improvements could be made.

# ACKNOWLEDGEMENT

To Professor Magnus Hakeberg and Professor Ulla Wide. I am forever grateful to you for believing in me and giving me this opportunity! It has been an incredible journey and I have loved every second of it, even when things have been tough. Thank you for all commitment, your support, sharing of knowledge and everything you have taught me over the years.

I would like to thank all study participants for taking the time to participate in this study. A special thanks to the research coordinators Erika Udvari Hargitai and Camilla Svanberg for taking the time and effort to answer all my questions regarding the ACT-project.

Lisa and Helen. What had this journey been without the two of you? Thank you for always being there for me. To Lisa, a special thank you for letting me tag along with you and your sister´s adventures during our research trips. It has given me precious memories for life. To Helene, I am so thankful that I got to share this research project and all the excitement and enthusiasm over research result with you. I hope we will be able to research together in the future as well.

To my former and present doctoral student colleagues; we share the insight to what life as a doctoral student can be, and as such, your sharing of experiences, knowledge and advice have been extra valuable to me. I am very grateful to have had you all as PhD-student colleagues. Astera, a special thank you for your encouragement and your sense of humor. Negin, a special thank you for all interesting discussions about different scientific matters and life in general.

To all the staff on the fifth floor, thank you for all nice chats and for making me feel so included. I specially thank you Carina for all help with schedules, problems with Primula etc. and Anki for your kindness. Thank you Johan for always taking the time to help me out with all computer related matters and Birgitta for being so supportive and dedicated to us doctoral students and for sharing your knowledge regarding research founding and applications.

Thank you, Anita and Lena, for being the best dental nurses there is, for all that you have taught me and all the support during hectic times. Working with you have made such a difference!

To my parents, thank you for always believing in me and all the support and love you given me through life. I would not have come this far if it wasn't for

you. To my siblings, Cecilia and Lina, you are my best friends! Thank you for always encouraging me and supporting me in your own special ways.

To Aisha and Salim, my children, thanks for all the joy you bring me and for giving me such an important perspective of what really matters in life. You mean the world to me!

To Yashin, my husband, thank you for giving me perspective and keeping me grounded. Your ability to see everything from a positive perspective and that nothing is a problem has been very helpful. I am very grateful for your support during these years.

To Leila, my mother-in-law, thank you for all your support and encouragement during my doctoral studies. I am very grateful to have you as a part of my life.

To Jelena. You have been such a support to me both during our studies to become dentist and then during my doctoral studies. Thank you for always being there for me and I am very lucky to have you in my life.

To Rebecca, one of my oldest friends. We have shared so much during the years. I am sure that our friendship has taken a part in making me who I am today. Thanks for all your support and all lovely memories during the years.

## Funding:

The Health Care Subcommittee, Region Västra Götaland, Sweden

The Public Dental Service of Region Västra Götaland, Sweden

# REFERENCES


1. Sheiham A. Oral health, general health and quality of life. Bulletin of the World Health Organization. 2005;83(9):644-.
2. Daly B, Batchelor P, Treasure ET, Watt RG. Essential Dental Public Health. 2 ed. Oxford, United Kingdom: Oxford University Press; 2013.
3. Morrison V, Bennett P. An introduction to health psychology. 3 ed. Essex, England: Pearson Education; 2012.
4. Glick M, Williams DM, Kleinman DV, Vujicic M, Watt RG, Weyant RJ. Reprint of: A new definition for oral health supported by FDI opens the door to a universal definition of oral health. J Dent. 2017;57:1-3.
5. Brondani MA, MacEntee MI. Thirty years of portraying oral health through models: what have we accomplished in oral health-related quality of life research? Qual Life Res. 2014;23(4):1087-96.
6. World Health Organization. Newsroom/ Fact sheets. Sugars and dental caries [Internet]. World Health Organization; 2017. [cited 2021 Sep 26]. Available from: www.who.int/news-room/fact-sheets/detail/sugars-and-dental-caries.
7. World Health Organization. Guideline: Sugars intake for adults and children [Internet]. Geneva: World Health Organization; 2015 [cited 2021 Okt 06]. Available from: https://www.who.int/publications/i/item/9789241549028.
8. World Health Organization. Health topics/ Oral Health [Internet]. Brazzaville: World Health Organization, Regional office for Africa; [cited 2022 July 22]. Available from: https://www.afro.who.int/health-topics/oral-health.
9. Wilson IB, Cleary PD. Linking clinical variables with health-related quality of life. A conceptual model of patient outcomes. Jama. 1995;273(1):59-65.
10. World Health Organization. Closing the gap in a generation: health equity through action on the social determinants of health [Internet]. Geneva: World Health Organization; 2008. [cited 2022 April 11]. Available from: https://www.who.int/publications/i/item/WHO-IER-CSDH-08.1.
11. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. Lancet. 2019;394(10194):249-60.
12. Watt RG, Sheiham A. Integrating the common risk factor approach into a social determinants framework. Community Dent Oral Epidemiol. 2012;40(4):289-96.
13. Dahlgren G, Whitehead M. Policies and Strategies to Promote Social Equity in Health. 1991.

14. Dahlgren G, Whitehead M. The Dahlgren-Whitehead model of health determinants: 30 years on and still chasing rainbows. Public Health. 2021;199:20-4.
15. Guarnizo-Herreño CC, Watt RG, Stafford M, Sheiham A, Tsakos G. Do welfare regimes matter for oral health? A multilevel analysis of European countries. Health Place. 2017;46:65-72.
16. Costa SM, Martins CC, Pinto MQC, Vasconcelos M, Abreu M. Socioeconomic Factors and Caries in People between 19 and 60 Years of Age: An Update of a Systematic Review and Meta-Analysis of Observational Studies. Int J Environ Res Public Health. 2018;15(8).
17. Petersen PE. Sociobehavioural risk factors in dental caries - international perspectives. Community Dent Oral Epidemiol. 2005;33(4):274-9.
18. André Kramer AC, Petzold M, Hakeberg M, Östberg AL. Multiple Socioeconomic Factors and Dental Caries in Swedish Children and Adolescents. Caries Res. 2018;52(1-2):42-50.
19. Broadbent JM, Zeng J, Foster Page LA, Baker SR, Ramrakha S, Thomson WM. Oral Health-related Beliefs, Behaviors, and Outcomes through the Life Course. J Dent Res. 2016;95(7):808-13.
20. Peres MA, Peres KG, Thomson WM, Broadbent JM, Gigante DP, Horta BL. The influence of family income trajectories from birth to adulthood on adult oral health: findings from the 1982 Pelotas birth cohort. Am J Public Health. 2011;101(4):730-6.
21. Thomson WM, Poulton R, Milne BJ, Caspi A, Broughton JR, Ayers KM. Socioeconomic inequalities in oral health in childhood and adulthood in a birth cohort. Community Dent Oral Epidemiol. 2004;32(5):345-53.
22. Guarnizo-Herreño CC, Watt RG, Pikhart H, Sheiham A, Tsakos G. Socioeconomic inequalities in oral health in different European welfare state regimes. J Epidemiol Community Health. 2013;67(9):728-35.
23. Östberg AL, Petzold M. A longitudinal study of the impact of change in socioeconomic status on dental caries in the permanent dentition of Swedish children and adolescents. Community Dent Oral Epidemiol. 2020;48(4):271-9.
24. Verlinden DA, Reijneveld SA, Lanting CI, van Wouwe JP, Schuller AA. Socio-economic inequality in oral health in childhood to young adulthood, despite full dental coverage. Eur J Oral Sci. 2019;127(3):248-53.
25. Huijts T, Gkiouleka A, Reibling N, Thomson KH, Eikemo TA, Bambra C. Educational inequalities in risky health behaviours in 21 European countries: findings from the European social survey (2014) special module on the social determinants of health. Eur J Public Health. 2017;27(suppl_1):63-72.
26. Kino S, Bernabé E, Sabbah W. Socioeconomic inequality in clusters of health-related behaviours in Europe: latent class analysis of a cross-sectional European survey. BMC Public Health. 2017;17(1):497.

27. Sabbah W, Suominen AL, Vehkalahti MM, Aromaa A, Bernabé E. The role of behaviour in inequality in increments of dental caries among Finnish adults. Caries Res. 2015;49(1):34-40.
28. Sanders AE, Spencer AJ, Slade GD. Evaluating the role of dental behaviour in oral health inequalities. Community Dent Oral Epidemiol. 2006;34(1):71-9.
29. Guarnizo-Herreño CC, Scholes S, Heilmann A, O'Connor R, Fuller E, Shen J, et al. Dental attendance and behavioural pathways to adult oral health inequalities. J Epidemiol Community Health. 2021;75(11):1063-9.
30. Sabbah W, Tsakos G, Sheiham A, Watt RG. The role of health-related behaviors in the socioeconomic disparities in oral health. Soc Sci Med. 2009;68(2):298-303.
31. Guarnizo-Herreño CC, Watt RG, Garzón-Orjuela N, Tsakos G. Explaining oral health inequalities in European welfare state regimes: The role of health behaviours. Community Dent Oral Epidemiol. 2019;47(1):40-8.
32. Bambra C. Health inequalities and welfare state regimes: theoretical insights on a public health 'puzzle'. J Epidemiol Community Health. 2011;65(9):740-5.
33. Åstrøm AN, Lie SA, Özkaya F. Influences of behaviour and attitude on education related inequality in tooth loss: findings from Norway and Sweden over 5 years of follow- up. Acta Odontol Scand. 2021;79(2):81-8.
34. World Health Organization. Health topics/ Oral health [Internet]. Geneva: World Health Organization; [cited 2022 Jan 24]. Available from: https://www.who.int/health-topics/oral-health#tab=tab_1.
35. Fletcher RH, Fletcher SW, Wagner EH. Clinical Epidemiology The essentials. 3 ed. Pennsylvania, USA: Williams & Wilkins; 1996.
36. Rothman KJ. Causes. Am J Epidemiol. 1976;104(6):587-92.
37. Rothman KJ. Epidemiology An Introduction. 2 ed. Madison Avenue, New York: Oxford University Press; 2012.
38. Sheiham A, James WP. Diet and Dental Caries: The Pivotal Role of Free Sugars Reemphasized. J Dent Res. 2015;94(10):1341-7.
39. Manji F, Dahlen G, Fejerskov O. Caries and Periodontitis: Contesting the Conventional Wisdom on Their Aetiology. Caries Res. 2018;52(6):548-64.
40. Marsh PD, Takahashi N, Nyvad B. Biofilms in caries development. In: Fejerskov O, Nyvad B, Kidd E, editors. Dental caries : The Disease and Its Clinical Management. 3 ed. Oxford: Wiley Blackwell; 2015. p. 125-9.
41. Bardow A, Vissink A. Saliva and caries development. In: Fejerskov O, Nyvad B, Kidd E, editors. Dental caries: The Disease and Its Clinical Management. 3 ed. Oxford: Wiley Blackwell; 2015. p. 83-105.
42. Fejerskov O, Cury JA, Tenuta LM, Marinho VC. Fluorides in caries control. In: Fejerskov O, Nyvad B, Kidd E, editors. Dental caries: The

Disease and Its Clinical Management. 3 ed. Oxford: Wiley Blackwell; 2015. p. 245-72.
43. Nyvad B, Fejerskov O. The caries control concept. In: Fejerskov O, Nyvad B, Kidd E, editors. Dental caries: The Disease and Its Clinical Management. 3 ed. Oxford: Wiley Blackwell; 2015. p. 242.
44. Mariotti A. Plaque-Induced Gingival Diseases. In: Lang NP, Lindhe J, editors. Clinical Periodontology and Implant Dentistry, 2 Volume Set. 6 ed. Hoboken, United Kingdom: John Wiley & Sons, Incorporated; 2015. p. 366-76.
45. Marsh PD. Dental Biofilms. In: Lang NP, Lindhe J, editors. Clinical Periodontology and Implant Dentistry, 2 Volume Set. 6 ed. Hoboken, United Kingdom: John Wiley & Sons, Incorporated; 2015. p. 169.
46. Seymour GJ, Trombelli L, Berglundh T. Pathogenesis of Gingivitis. In: Lang NP, Lindhe J, editors. Clinical Periodontology and Implant Dentistry, 2 Volume Set. 6. ed. Hoboken, United Kingdom: John Wiley & Sons, Incorporated; 2015. p. 241-6.
47. World Health Organization. Newsroom/Fact sheets/ Oral health [Internet]. Geneva: World Health Organization; 2020 [cited 2021 Oct 8]. Available from: https://www.who.int/news-room/fact-sheets/detail/oral-health.
48. Choi SH, Kim BI, Cha JY, Hwang CJ. Impact of malocclusion and common oral diseases on oral health-related quality of life in young adults. Am J Orthod Dentofacial Orthop. 2015;147(5):587-95.
49. Drachev SN, Brenn T, Trovik TA. Oral Health-Related Quality of Life in Young Adults: A Survey of Russian Undergraduate Students. Int J Environ Res Public Health. 2018;15(4).
50. Sun L, Wong HM, McGrath CPJ. The factors that influence oral health-related quality of life in young adults. Health Qual Life Outcomes. 2018;16(1):187.
51. Carvalho JC, Mestrinho HD, Guillet A, Maltz M. Radiographic Yield for Clinical Caries Diagnosis in Young Adults: Indicators for Radiographic Examination. Caries Res. 2020;54(2):154-64.
52. Ericsson JS, Östberg AL, Wennström JL, Abrahamsson KH. Oral health-related perceptions, attitudes, and behavior in relation to oral hygiene conditions in an adolescent population. Eur J Oral Sci. 2012;120(4):335-41.
53. da Cunha IP, Pereira AC, Frias AC, Vieira V, de Castro Meneghim M, Batista MJ, et al. Social vulnerability and factors associated with oral impact on daily performance among adolescents. Health Qual Life Outcomes. 2017;15(1):173.
54. da Fonseca RCL, Antunes JLF, Cascaes AM, Bomfim RA. Analysis of the combined risk of oral problems in the oral health-related quality of life of Brazilian adolescents: multilevel approach. Clin Oral Investig. 2020;24(2):857-66.

55. Amilani U, Jayasekara P, Carter HE, Senanayake S, Kularatna S. Key factors associated with oral health-related quality of life in Sri Lankan adolescents: a cross sectional study. BMC Oral Health. 2021;21(1):218.
56. Samordningsförbundet Stockholms stad. Unga vuxna 16-29 år boende i Stockholms stad - En kartläggning av insatser och behov av insatser [Internet]. Stockholm: Samordningsförbundet Stockholms stad; 2017 [cited 2021 Oct 15]. Available from: https://samordningstockholm.se/wp-content/uploads/2017/04/Rapport-unga-vuxna.pdf.
57. Roberts-Thomson K, Stewart JF. Risk indicators of caries experience among young adults. Aust Dent J. 2008;53(2):122-7; quiz 86.
58. Svensk MeSH [Internet]. Stockholm: Karolinska institutet. Universitetsbiblioteket; [cited 2021 Oct 16]. Available from: https://mesh.kib.ki.se/term/D055815/young-adult#:~:text=A%20person%20between%2019,and%2024%20years%20of%20age.
59. Medical Subject Headings (MeSH) [Internet]. Bethesda: National Library of Medicin; [cited 2021 Oct 16]. Available from: https://meshb-prev.nlm.nih.gov/record/ui?ui=D055815.
60. Christie D, Viner R. Adolescent development. Bmj. 2005;330(7486):301-4.
61. The Swedish Quality Registry for caries and periodontal disease (SKaPa). Annual report 2020 [Internet]. Karlstad: Svenskt kvalitetsregister för Karies och Parodontit (SKaPa); 2020 [cited 2021 Oct 11, 2022 Feb 27]. Available from: http://www.skapareg.se/wp-content/uploads/2021/06/SKaPa_2020-%C3%A5rsrapport.pdf.
62. Alwadi MAM, Vettore MV. Are school and home environmental characteristics associated with oral health-related quality of life in Brazilian adolescents and young adults? Community Dent Oral Epidemiol. 2017;45(4):356-64.
63. Carvalho JC, Mestrinho HD, Stevens S, van Wijk AJ. Do oral health conditions adversely impact young adults? Caries Res. 2015;49(3):266-74.
64. Kassebaum NJ, Smith AGC, Bernabé E, Fleming TD, Reynolds AE, Vos T, et al. Global, Regional, and National Prevalence, Incidence, and Disability-Adjusted Life Years for Oral Conditions for 195 Countries, 1990-2015: A Systematic Analysis for the Global Burden of Diseases, Injuries, and Risk Factors. J Dent Res. 2017;96(4):380-7.
65. Bernabe E, Marcenes W, Hernandez CR, Bailey J, Abreu LG, Alipour V, et al. Global, Regional, and National Levels and Trends in Burden of Oral Conditions from 1990 to 2017: A Systematic Analysis for the Global Burden of Disease 2017 Study. J Dent Res. 2020;99(4):362-73.
66. Frencken JE, Sharma P, Stenhouse L, Green D, Laverty D, Dietrich T. Global epidemiology of dental caries and severe periodontitis - a comprehensive review. J Clin Periodontol. 2017;44 Suppl 18:S94-s105.

67. Petersen PE, Ogawa H. The global burden of periodontal disease: towards integration with chronic disease prevention and control. Periodontol 2000. 2012;60(1):15-39.
68. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of severe periodontitis in 1990-2010: a systematic review and meta-regression. J Dent Res. 2014;93(11):1045-53.
69. Tandvårdslagen (SFS 1985:125) [Internet]. Stockholm: Socialdepartementet; [cited 2021 Oct 1]. Available from: https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/tandvardslag-1985125_sfs-1985-125.
70. Socialdepartementet. Ett tandvårdstöd för alla-Fler och staraker patienter (SOU 2015:76) [Internet] Stockholm: Fritze; 2015 [cited 2021 Oct 11]. Available from: https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2015/08/sou-201576/.
71. Socialstyrelsen [Natonal Swedish Board of Health and Welfare]. Tillståndet och utveklingen inom hälso- och sjukvården samt tandvården Lägesrapport 2020 [Internet]. Stockholm: Socialstyrelsen; 2020 [cited 2021 Oct 9]. Available from: https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/ovrigt/2020-3-6667.pdf.
72. Wahlin Å, Papias A, Jansson H, Norderyd O. Secular trends over 40 years of periodontal health and disease in individuals aged 20-80 years in Jönköping, Sweden: Repeated cross-sectional studies. J Clin Periodontol. 2018;45(9):1016-24.
73. Edman K, Ohrn K, Holmlund A, Nordström B, Hedin M, Hellberg D. Comparison of oral status in an adult population 35-75 year of age in the county of Dalarna, Sweden in 1983 and 2008. Swed Dent J. 2012;36(2):61-70.
74. Norderyd O, Koch G, Papias A, Köhler AA, Helkimo AN, Brahm CO, et al. Oral health of individuals aged 3-80 years in Jönköping, Sweden during 40 years (1973-2013). II. Review of clinical and radiographic findings. Swed Dent J. 2015;39(2):69-86.
75. Edman K, Öhrn K, Nordström B, Holmlund A. Prevalence of dental caries and influencing factors, time trends over a 30-year period in an adult population. Epidemiological studies between 1983 and 2013 in the county of Dalarna, Sweden. Acta Odontol Scand. 2016;74(5):385-92.
76. Isaksson H, Alm A, Koch G, Birkhed D, Wendt LK. Caries prevalence in Swedish 20-year-olds in relation to their previous caries experience. Caries Res. 2013;47(3):234-42.
77. Socialstyrelsen [National Swedish Board of Health and Welfare]. Karies bland barn och ungdomar Epidemiologiska uppgifter för år 2020 [Internet]. Stockholm: Socialstyrelsen; 2020 [cited 2022 Feb 18]. Available from: https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/ovrigt/2021-12-7697.pdf.

78. Kramer AC, Hakeberg M, Petzold M, Östberg AL. Demographic factors and dental health of Swedish children and adolescents. Acta Odontol Scand. 2016;74(3):178-85.
79. Julihn A, Barr Agholme M, Grindefjord M, Modéer T. Risk factors and risk indicators associated with high caries experience in Swedish 19-year-olds. Acta Odontol Scand. 2006;64(5):267-73.
80. Socialstyrelsen [National Swedish Board of Health and Welfare]. Karies bland barn och ungdomar Epidemiologiska uppgifter för år 2018 [Internet]. Stockholm: Socialstyrelsen; 2018 [cited 2022 Feb 18]. Available from: https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/ovrigt/2020-2-6629.pdf.
81. Abrahamsson KH, Koch G, Norderyd O, Romao C, Wennström JL. Periodontal conditions in a Swedish city population of adolescents: a cross-sectional study. Swed Dent J. 2006;30(1):25-34.
82. van der Weijden F, Slot DE, Echeverria JJ, Lindhe J. Mechanical Supragingival Plaque Control. In: Lang NP, Lindhe J, editors. Clinical Periodontology and Implant Dentistry, 2 Volume Set. 6 ed. Hoboken, United Kingdom: John Wiley & Sons, Incorporated; 2015. p. 677-703.
83. Chapple IL, Van der Weijden F, Doerfer C, Herrera D, Shapira L, Polak D, et al. Primary prevention of periodontitis: managing gingivitis. J Clin Periodontol. 2015;42 Suppl 16:S71-6.
84. Worthington HV, MacDonald L, Poklepovic Pericic T, Sambunjak D, Johnson TM, Imai P, et al. Home use of interdental cleaning devices, in addition to toothbrushing, for preventing and controlling periodontal diseases and dental caries. Cochrane Database Syst Rev. 2019;4(4):Cd012018.
85. Furuta M, Ekuni D, Irie K, Azuma T, Tomofuji T, Ogura T, et al. Sex differences in gingivitis relate to interaction of oral health behaviors in young people. J Periodontol. 2011;82(4):558-65.
86. Broadbent JM, Thomson WM, Boyens JV, Poulton R. Dental plaque and oral health during the first 32 years of life. J Am Dent Assoc. 2011;142(4):415-26.
87. Norderyd O, Kochi G, Papias A, Köhler AA, Helkimo AN, Brahm CO, et al. Oral health of individuals aged 3-80 years in Jönköping, Sweden, during 40 years (1973-2013). I. Review of findings on oral care habits and knowledge of oral health. Swed Dent J. 2015;39(2):57-68.
88. Walsh T, Worthington HV, Glenny AM, Marinho VC, Jeroncic A. Fluoride toothpastes of different concentrations for preventing dental caries. Cochrane Database Syst Rev. 2019;3(3):Cd007868.
89. Bernabé E, Vehkalahti MM, Sheiham A, Lundqvist A, Suominen AL. The Shape of the Dose-Response Relationship between Sugars and Caries in Adults. J Dent Res. 2016;95(2):167-72.
90. Marinho VC, Chong LY, Worthington HV, Walsh T. Fluoride mouthrinses for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2016;7(7):Cd002284.

91. Fee PA, Riley P, Worthington HV, Clarkson JE, Boyers D, Beirne PV. Recall intervals for oral health in primary care patients. Cochrane Database Syst Rev. 2020;10(10):Cd004346.
92. Aldossary A, Harrison VE, Bernabé E. Long-term patterns of dental attendance and caries experience among British adults: a retrospective analysis. Eur J Oral Sci. 2015;123(1):39-45.
93. Crocombe LA, Broadbent JM, Thomson WM, Brennan DS, Poulton R. Impact of dental visiting trajectory patterns on clinical oral health and oral health-related quality of life. J Public Health Dent. 2012;72(1):36-44.
94. Oscarson N, Espelid I, Jönsson B. Is caries equally distributed in adults? A population-based cross-sectional study in Norway - the TOHNN-study. Acta Odontol Scand. 2017;75(8):557-63.
95. Socialstyrelsen [National Swedish Board of Health and Welfare]. Statistik om tandhälsa [Internet]. Stockholm: Socialstyrelsen; [cited 2021 Oct 16]. Available from: https://www.socialstyrelsen.se/statistik-och-data/statistik/statistikamnen/tandhalsa/.
96. Apovian CM. Sugar-sweetened soft drinks, obesity, and type 2 diabetes. Jama. 2004;292(8):978-9.
97. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. Am J Clin Nutr. 2006;84(2):274-88.
98. World Health Organization. WHO urges global action to curtail consumption and health impacts of sugary drinks [Internet]. Geneva: World Health Organization; 2016 [cited 2022 Jan 30]. Available from: https://www.who.int/news/item/11-10-2016-who-urges-global-action-to-curtail-consumption-and-health-impacts-of-sugary-drinks.
99. Folkhälsomyndigheten [Public Health Agency of Sweden]. Skolbarns hälsovanor i Sverige 2017/18- Grundrapport [Internet]. Stockholm: Folkhälsomybdigheten; 2018 [cited 2021 Oct 16]. Available from: https://www.folkhalsomyndigheten.se/publicerat-material/publikationsarkiv/s/skolbarns-halsovanor-i-sverige-201718---grundrapport/.
100. Duarte PM, Nogueira CFP, Silva SM, Pannuti CM, Schey KC, Miranda TS. Impact of Smoking Cessation on Periodontal Tissues. Int Dent J. 2021.
101. Benedetti G, Campus G, Strohmenger L, Lingström P. Tobacco and dental caries: a systematic review. Acta Odontol Scand. 2013;71(3-4):363-71.
102. Jiang X, Jiang X, Wang Y, Huang R. Correlation between tobacco smoking and dental caries: A systematic review and meta-analysis. Tob Induc Dis. 2019;17:34.
103. Folkhälsomyndigheten [Public Health Agency of Sweden]. Statestik inom folkhälsa-Tobaksbruk [Internet]. Stockholm: Folkhälsomyndigheten; [cited 2021 Oct 16]. Available from:

https://www.folkhalsomyndigheten.se/folkhalsorapportering-statistik/statistik-a-o/ovrig-statistik-a-o/tobaksbruk/.
104. World Health Organization. Health promotion glossary of terms 2021 [Internet]. Geneva: World Health Organization; 2021. Licence: CC BY-NC-SA 3.0 IGO [cited 2022 Jan 26]. Available from: https://www.who.int/publications/i/item/9789240038349.
105. World Health Organization. Newsroom/ Questions and answers/ Health promotion [Internet]. World Health Organization; 2016 [cited 2021 Oct 17]. Available from: https://www.who.int/news-room/q-a-detail/health-promotion.
106. Watt RG, Williams DM, Sheiham A. The role of the dental team in promoting health equity. Br Dent J. 2014;216(1):11-4.
107. Socialstyrelsen [National Swedish Board of Health and Welfare]. Nationella riktlinjer för tandvård-Stöd för styrning och ledning [Internet]. Stockholm: Socialstyrelsen; 2021 [cited 2021 Oct 18]. Available from: https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/nationella-riktlinjer/2021-9-7549.pdf.
108. Socialstyrelsen [National Swedish Board of Health and Welfare]. Nationella riktlinjer för tandvård-Rekomendationer med tillhörande kunskapsunderlag (Bilaga) [Internet]. Stockholm: Socialstyrelsen; 2021 [cited 2021 Oct 18]. Available from: https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/nationella-riktlinjer/2021-9-7549-tandvard-kunskapsunderlag.pdf.
109. Harris R, Gamboa A, Dailey Y, Ashcroft A. One-to-one dietary interventions undertaken in a dental setting to change dietary behaviour. Cochrane Database Syst Rev. 2012;2012(3):Cd006540.
110. Watt RG, Marinho VC. Does oral health promotion improve oral hygiene and gingival health? Periodontol 2000. 2005;37:35-47.
111. Lingström P, Holm AK, Mejàre I, Twetman S, Söder B, Norlund A, et al. Dietary factors in the prevention of dental caries: a systematic review. Acta Odontol Scand. 2003;61(6):331-40.
112. Soldani FA, Lamont T, Jones K, Young L, Walsh T, Lala R, et al. One-to-one oral hygiene advice provided in a dental setting for oral health. Cochrane Database Syst Rev. 2018;10(10):Cd007447.
113. Socialstyrelsen [National Swedish Board of Health and Welfare]. Nationella riktlinjer för prevention och behandling vid ohälsosamma levnadsvanor-Stöd för styrning och ledning [Internet]. Stockholm: Socialstyrelsen; 2018 [cited 2021 Oct 18]. Available from: https://www.socialstyrelsen.se/kunskapsstod-och-regler/regler-och-riktlinjer/nationella-riktlinjer/riktlinjer-och-utvarderingar/levnadsvanor/.
114. Werner H, Hakeberg M, Dahlström L, Eriksson M, Sjögren P, Strandell A, et al. Psychological Interventions for Poor Oral Health: A Systematic Review. J Dent Res. 2016;95(5):506-14.

115. Carra MC, Detzen L, Kitzmann J, Woelber JP, Ramseier CA, Bouchard P. Promoting behavioural changes to improve oral hygiene in patients with periodontal diseases: A systematic review. J Clin Periodontol. 2020;47 Suppl 22:72-89.
116. Renz A, Ide M, Newton T, Robinson PG, Smith D. Psychological interventions to improve adherence to oral hygiene instructions in adults with periodontal diseases. Cochrane Database Syst Rev. 2007(2):Cd005097.
117. Al Rawahi SH, Asimakopoulou K, Newton JT. Theory based interventions for caries related sugar intake in adults: systematic review. BMC Psychol. 2017;5(1):25.
118. Pocock SJ. Clinical trials: a practical approach. Chichester: John Wiley & Sons; 1983.
119. Hayes SC, Strosahl K, Wilson KG. Acceptance and Commitment Therapy: An experiential approach to behavior change. New York London: Guilford Press; 1999.
120. Hayes SC, Pistorello J, Levin ME. Acceptance and commitment therapy as a unified model of behavior change. The Counseling Psychologist. 2012;40(7):976-1002.
121. Hayes SC, Luoma JB, Bond FW, Masuda A, Lillis J. Acceptance and Commitment Therapy: Model, processes and outcomes. Behaviour research and therapy. 2006;44(1):1-25.
122. Gloster AT, Walder N, Levin ME, Twohig MP, Karekla M. The empirical status of acceptance and commitment therapy: A review of meta-analyses. Journal of contextual behavioral science. 2020;18:181-92.
123. Lawlor ER, Islam N, Bates S, Griffin SJ, Hill AJ, Hughes CA, et al. Third-wave cognitive behaviour therapies for weight management: A systematic review and network meta-analysis. Obes Rev. 2020;21(7):e13013.
124. Yıldız E. The effects of acceptance and commitment therapy on lifestyle and behavioral changes: A systematic review of randomized controlled trials. Perspect Psychiatr Care. 2020;56(3):657-90.
125. Powers MB, Zum Vorde Sive Vording MB, Emmelkamp PM. Acceptance and commitment therapy: a meta-analytic review. Psychother Psychosom. 2009;78(2):73-80.
126. Werner H, Young C, Hakeberg M, Wide U. A behavioural intervention for young adults with dental caries, using acceptance and commitment therapy (ACT): treatment manual and case illustration. BMC Oral Health. 2020;20(1):233.
127. Strosahl K, Robinson P, Gustavsson T. Brief interventions for radical change: Principles and practice of focused acceptance and commitment therapy. Oakland, CA: New Harbinger Publications; 2012.
128. Fleiss JL, Park MH, Chilton NW, Alman JE, Feldman RS, Chauncey HH. Representativeness of the "Ramfjord teeth" for epidemiologic studies of gingivitis and periodontitis. Community Dent Oral Epidemiol. 1987;15(4):221-4.

129. Mühlemann HR, Son S. Gingival sulcus bleeding--a leading symptom in initial gingivitis. Helv Odontol Acta. 1971;15(2):107-13.
130. Silness J, Loe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condtion. Acta Odontol Scand. 1964;22:121-35.
131. Larsson P, John MT, Hakeberg M, Nilner K, List T. General population norms of the Swedish short forms of oral health impact profile. J Oral Rehabil. 2014;41(4):275-81.
132. John MT, Miglioretti DL, LeResche L, Koepsell TD, Hujoel P, Micheelis W. German short forms of the Oral Health Impact Profile. Community Dent Oral Epidemiol. 2006;34(4):277-88.
133. John MT, Hujoel P, Miglioretti DL, LeResche L, Koepsell TD, Micheelis W. Dimensions of oral-health-related quality of life. J Dent Res. 2004;83(12):956-60.
134. Brennan DS, Spencer AJ. Life events and oral-health-related quality of life among young adults. Qual Life Res. 2009;18(5):557-65.
135. Lu H-X, Wong MCM, Lo ECM, McGrath C. Oral health related quality of life among young adults. Applied Research in Quality of Life. 2015;10(1):37-47.
136. Corah NL. Development of a dental anxiety scale. J Dent Res. 1969;48(4):596.
137. Corah NL, Gale EN, Illig SJ. Assessment of a dental anxiety scale. J Am Dent Assoc. 1978;97(5):816-9.
138. Newton JT, Buck DJ. Anxiety and pain measures in dentistry: a guide to their quality and application. J Am Dent Assoc. 2000;131(10):1449-57.
139. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, et al. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. Int J Surg. 2012;10(1):28-55.
140. Pallant J. SPSS survival manual : a step by step guide to data analysis using IBM SPSS. 6. ed. England: Maidenhead : Open University Press : McGraw-Hill; 2016.
141. Hagman J, Wide U, Werner H, Hakeberg M. A psychological intervention for caries active young adults, a randomized controlled trial. Clin Exp Dent Res. 2022;8(1):239-47.
142. Hadler-Olsen E, Jönsson B. Oral health and use of dental services in different stages of adulthood in Norway: a cross sectional study. BMC Oral Health. 2021;21(1):257.
143. Mejàre I, Axelsson S, Dahlén G, Espelid I, Norlund A, Tranæus S, et al. Caries risk assessment. A systematic review. Acta Odontol Scand. 2014;72(2):81-91.
144. Mulic A, Skudutyte-Rysstad R, Tveit AB, Skaare AB. Risk indicators for dental erosive wear among 18-yr-old subjects in Oslo, Norway. Eur J Oral Sci. 2012;120(6):531-8.

145. Morris LJ, D'Este C, Sargent-Cox K, Anstey KJ. Concurrent lifestyle risk factors: Clusters and determinants in an Australian sample. Prev Med. 2016;84:1-5.
146. Poortinga W. The prevalence and clustering of four major lifestyle risk factors in an English adult population. Prev Med. 2007;44(2):124-8.
147. Silva DA, Rinaldi AEM, Azeredo CM. Clusters of risk behaviors for noncommunicable diseases in the Brazilian adult population. Int J Public Health. 2019;64(6):821-30.
148. Hänsel Petersson G, Ericson E, Twetman S. Preventive care delivered within Public Dental Service after caries risk assessment of young adults. Int J Dent Hyg. 2016;14(3):215-9.
149. Jönsson B, Ohrn K, Oscarson N, Lindberg P. The effectiveness of an individually tailored oral health educational programme on oral hygiene behaviour in patients with periodontal disease: a blinded randomized-controlled clinical trial (one-year follow-up). J Clin Periodontol. 2009;36(12):1025-34.
150. Kakudate N, Morita M, Sugai M, Kawanami M. Systematic cognitive behavioral approach for oral hygiene instruction: a short-term study. Patient Educ Couns. 2009;74(2):191-6.
151. Stenman J, Lundgren J, Wennström JL, Ericsson JS, Abrahamsson KH. A single session of motivational interviewing as an additive means to improve adherence in periodontal infection control: a randomized controlled trial. J Clin Periodontol. 2012;39(10):947-54.
152. Dimenäs SL, Jönsson B, Andersson JS, Lundgren J, Petzold M, Abrahamsson I, et al. A person-centred, theory-based, behavioural intervention programme for improved oral hygiene in adolescents: A randomized clinical field study. J Clin Periodontol. 2022.
153. Finniss DG, Kaptchuk TJ, Miller F, Benedetti F. Biological, clinical, and ethical advances of placebo effects. Lancet. 2010;375(9715):686-95.
154. Hesser H, Weise C, Rief W, Andersson G. The effect of waiting: A meta-analysis of wait-list control groups in trials for tinnitus distress. J Psychosom Res. 2011;70(4):378-84.
155. Godard A, Dufour T, Jeanne S. Application of self-regulation theory and motivational interview for improving oral hygiene: a randomized controlled trial. J Clin Periodontol. 2011;38(12):1099-105.
156. Heise L, Greene ME, Opper N, Stavropoulou M, Harper C, Nascimento M, et al. Gender inequality and restrictive gender norms: framing the challenges to health. Lancet. 2019;393(10189):2440-54.
157. Mejàre I, Stenlund H, Zelezny-Holmlund C. Caries incidence and lesion progression from adolescence to young adulthood: a prospective 15-year cohort study in Sweden. Caries Res. 2004;38(2):130-41.

158. Stenlund H, Mejàre I, Källestål C. Caries rates related to approximal caries at ages 11-13: a 10-year follow-up study in Sweden. J Dent Res. 2002;81(7):455-8.
159. Mejàre I, Källest l C, Stenlund H. Incidence and progression of approximal caries from 11 to 22 years of age in Sweden: A prospective radiographic study. Caries Res. 1999;33(2):93-100.
160. Stenman J, Wennström JL, Abrahamsson KH. A brief motivational interviewing as an adjunct to periodontal therapy-A potential tool to reduce relapse in oral hygiene behaviours. A three-year study. Int J Dent Hyg. 2018;16(2):298-304.
161. Brand VS, Bray KK, MacNeill S, Catley D, Williams K. Impact of single-session motivational interviewing on clinical outcomes following periodontal maintenance therapy. Int J Dent Hyg. 2013;11(2):134-41.
162. Philippot P, Lenoir N, D'Hoore W, Bercy P. Improving patients' compliance with the treatment of periodontitis: a controlled study of behavioural intervention. J Clin Periodontol. 2005;32(6):653-8.
163. Newton JT, Asimakopoulou K. Managing oral hygiene as a risk factor for periodontal disease: a systematic review of psychological approaches to behaviour change for improved plaque control in periodontal management. J Clin Periodontol. 2015;42 Suppl 16:S36-46.
164. Socialdepartementet. God och nära vård-En primärvårdsreform (SOU 2018:39) [Internet] Stockholm: Norstedts Juridik; 2018 [Available from: https://www.regeringen.se/49c941/contentassets/85abf6c8cfdb401ea6fbd3d17a18c98e/god-och-nara-vard--en-primarvardsreform_sou-2018_39.pdf.
165. Hausen H, Kärkkäinen S, Seppä L. Caries data collected from public health records compared with data based on examinations by trained examiners. Caries Res. 2001;35(5):360-5.
166. Silness J, Røynstrand T. Partial mouth recording of plaque, gingivitis and probing depth in adolescents. J Clin Periodontol. 1988;15(3):189-92.
167. Statens beredning för medicinsk och social utvärdering [Swedish Agency for Health Technology Assessment and Assessment of Social Service]. Utvärdering av metoder i hälso- och sjukvården och insatser i socialtjänsten: En handbok. 3 ed. [Internet]. Stockholm: Statens beredning för medicinsk utvärdering (SBU); 2017 [cited 2022 March 18]. Available from: https://www.sbu.se/sv/metod/tidigare-versioner-av-metodboken/.
168. Al Rawahi SH, Asimakopoulou K, Masood M, Al Bulushi NM, Al Yaqoobi KH, Newton JT. The Psychological Models of Health-related Behavior in Understanding Sugars Intake in Adults: A Review. Oman Med J. 2020;35(2):e114.