



JÖNKÖPING UNIVERSITY
School of Health and Welfare

Doctoral Thesis

The multifaceted concept of oral health

– studies on a Swedish general population
and perspectives of persons with
experience of long-term CPAP-treated
obstructive sleep apnea

Hanna Ahonen



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To those we love who left us too soon.

“Forty-two”

Deep Thought (Douglas Adams)

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Abstract

Oral health is a multifaceted and changeable part of our overall health and well-being as it contributes to important everyday functions such as eating, talking, and conveying feelings. Our oral health can be affected by a range of determinants, one of which is obstructive sleep apnea [OSA] treated with continuous positive airway pressure [CPAP]. Even though xerostomia has been frequently reported upon, the possible relationship between oral health and CPAP-treated OSA is not clearly understood. The World Dental Federation [FDI] recently proposed a definition and theoretical framework of oral health, intended to be globally applicable and to move dentistry toward a more promotive approach. By using the FDI's framework as a basis for exploration, studies in a general population can increase the understanding of different aspects of oral health and set the frame of reference for whether and how CPAP-treated OSA can be experienced to affect a person's oral health.

The overall aim of this thesis was to gain a deeper understanding of how the FDI's theoretical framework of oral health can be applied in a general population and how oral health is experienced in a specific population of persons with increased risk for adverse oral health.

The FDI's framework was explored with empirical data from a general population (N=630) and a population of persons with experience of CPAP-treated OSA (N=18). In papers I and II, the FDI framework was tested and evaluated with quantitative methods (principal component analysis and structural equation modeling), using cross-sectional data from the Jönköping studies. In papers III and IV, qualitative methods (directed content analysis and critical incident technique) were used where personal views and experiences were explored using individual semi-structured interviews.

The findings in paper I showed that factors such as dental caries, periodontal disease, experience of xerostomia, and aesthetic satisfaction can be included in the FDI's component *the core elements of oral health*. In paper II, *driving determinants* and *moderating factors* were found to have direct effects on all core elements of oral health except aesthetic satisfaction. Three of *the core elements of oral health* (oral health-related quality of life, aesthetic

satisfaction, and xerostomia) had direct effects on the latent variable *overall health and well-being*. *Driving determinants* and *moderating factors* had no direct effect on *overall health and well-being*, and no indirect effects were found. In paper III, the study participants' views on oral health determinants were described and could be categorized into all the FDI framework dimensions. The component *driving determinants* could include a range of determinants affecting a person's oral health such as CPAP treatment, age, the influence of family and social surroundings, interdental cleaning, willingness to change when needed, and relationship with oral healthcare professionals. In paper IV, the study participants described both negative and positive experiences occurring with or without their CPAP. The negative experiences included increased xerostomia, pain or discomfort, tooth wear, and negative feelings. The positive experiences included decreased xerostomia and improved oral health habits due to improved sleep. Many of the difficulties could be managed by easily accessible facilitators. The experiences the study participants described could be included in all the FDI framework components.

In conclusion, the FDI's framework can be applied in a general population to describe different components of oral health, and is also useful to describe a person's views and experiences of oral health in a specific population. CPAP treatment could be considered an oral health determinant as it can affect a person's oral health. Both positive and negative experiences can contribute to CPAP adherence as negative experiences often can be successfully managed.

Abbreviations

AHI	Apnea Hypopnea Index
AOHSS	The minimum Adult Oral Health Standard Set
CIT	Critical Incident Technique
CPAP	Continuous Positive Airway Pressure
DMFT/DFS	Decayed Missed Filled Teeth/Decayed Filled Teeth
FDI	The World Dental Federation
HRQOL	Health-Related Quality of Life
OA	Oral Appliances
OHIP	Oral Health Impact Profile
OHRQOL	Oral Health-Related Quality of Life
OSA	Obstructive Sleep Apnea
OSAS	Obstructive Sleep Apnea Syndrome
PAP	Positive Airway Pressure
PCA	Principal Component Analysis
QOL	Quality of Life
REM	Rapid Eye Movement
SEM	Structural Equation Modeling
WHO	World Health Organization

Original papers

The following papers are enclosed with permission from the respective journal in which they were published.

Paper I

Clinical and self-reported measurements to be included in the Core elements of World Dental Federation's theoretical framework of oral health.

Ahonen H, Kvarnvik C, Norderyd O, Broström A, Fransson EI, and Lindmark U. International Dental Journal. 2020; 71(1): 53-62. DOI: 10.1111/idj.12614

Paper II

Applying the FDI's theoretical framework for oral health in a general population.

Ahonen H, Pakpour A, Norderyd O, Broström A, Fransson EI, and Lindmark U. International Dental Journal. 2021. DOI: 10.1016/j.identj.2021.09.001 (preprint online)

Paper III

Views about oral health determinants as described by persons with continuous positive airway pressure-treated obstructive sleep apnea: a qualitative study.

Ahonen H, Neher M, Fransson EI, Broström A, and Lindmark U. (Submitted)

Paper IV

"The terrible dryness woke me up, I had some trouble breathing"- critical situations related to oral health as described by CPAP-treated persons with obstructive sleep apnea.

Ahonen H, Broström A, Fransson EI, Neher M, and Lindmark U. (Submitted)

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1. Preface

Even though I have worked in clinical oral healthcare (private sector) as a registered dental hygienist (graduated in 2006) and as a lecturer on the dental hygienist program at Jönköping University, I am also an oral healthcare patient. I have been a regular visitor almost all my life, except for some years in my early 20s, using both public and private oral healthcare.

During the work on this thesis, I went for my almost bi-annual dental check-up. I have requested to be examined every year but my dentist refuses; he considers my oral health too good. But on a rainy day in November, I finally parked my car, rode up in the elevator, and greeted the dental nurse in the reception. She smiled and, as she knew my name, she welcomed me by using my first name and informed me that it would be my turn in a couple of minutes. I sat down in the waiting room, in the couch beneath the framed picture of all the oral healthcare personnel working at the office. I recognized all of them, as I have been a regular visitor there for years. Five minutes later, I was seated in the dental chair and after a brief initial informal conversation with my dental hygienist, it was time for my radiographic examination. The dental hygienist told me to breathe through my nose and relax as she knew that I feel very uncomfortable during this part of the examination. Then my dentist entered the room. He smiled and while getting ready to perform the scheduled examination, he asked if I had finished my studies. The entire clinical examination took about 10 minutes after the initial check of my medical record. My dental needs might be minor and the clinical examination quick, but then my dentist initiated a brief conversation regarding my studies, children, and other areas of my life. For about 5-10 minutes, my dentist and I had a pleasant conversation, and he obtained all the complementary information he needed:

1. *Finding:* A loud, clicking sound, sore muscles in the temporo mandibular area, and loss of enamel. *Explanation:* probably due to excessively grinding and clenching my teeth (according to my dentist it is obviously stress-related due to my studies and children, and it is

likely that it will improve after the defense of my thesis, and I should use my dental splint until then),

2. *Finding*: Excellent oral hygiene. *Explanation*: probably due to my professional pride (“of course its excellent, what did you expect?”, he asks me), and
3. *Finding*: Retained third molars (28, 38, and 48). *Treatment choices*: continued expectation or extraction. *Treatment plan*: leave and expect. *Explanation*: Too old to be scheduled for an extraction (which he justifies by referring to a dissertation regarding extraction of third molars on persons above the age of 25).

From the information he got from the clinical examination, radiographs, and the information I willingly provided, he:

1. identified my temporo mandibular disorder, gave reasonable reasons for why I grind/clench my teeth, and a manageable treatment option
2. gave me positive feedback on my oral hygiene by a simple statement (rhetorical question)
3. underlined his decision regarding extraction of my third molars with research, as he knows that research-based reasoning might be appealing to me.

By applying the FDI’s framework, my dentist identified and reflected upon: *the core elements of oral health* (no active dental caries or periodontal disease, retained third molars, intact restorations, and temporomandibular disorder perceived to affect the chewing ability and social interactions), *driving determinants* (e.g., stress, education, oral hygiene habits, social environment), *moderating factors* (e.g., age, expectations, ability to adapt), and *overall health and well-being* (allergies, no medications). During the discussion about my oral health, we talked about my temporomandibular-problems and, the retained third molars, and we inspected the radiographs together. We agreed to do nothing more as I already have a dental splint and there was no further loss of alveolar bone due to the retained third molars, and I reluctantly accepted a re-call in two years. I went out to the reception, exchanged a few words with the dental nurse in the reception, paid for my visit (due to the National Dental Insurance, I paid about 300 SEK), took the elevator down to my car, left the parking garage, and noticed that the rain had stopped.

2. Introduction

I would like to start this thesis with a simple citation from Peres et al.¹, a short sentence that captures the essence of this thesis as it positions oral health both in society and at a personal level.

Oral health matters.

Oral health has been described as a key indicator of our overall health, well-being, and quality of life [QOL]², and the statement above can be illustrated by both the prevalence of oral diseases or conditions and the economic impact oral health-related problems can have on societies and for people around the world^{1,3}. A person's health is changeable and reflects the current life situation, including for example both biomedical and psychosocial aspects, as a part of a person's everyday life⁴. As sleeping is an important part of our overall health and well-being, being diagnosed with a chronic disorder such as obstructive sleep apnea [OSA] and starting an often lifelong treatment with continuous positive airway pressure [CPAP] could also affect a person's oral health. OSA is primarily treated with CPAP if symptomatic, but other treatments are available⁵. Treatment with oral appliances [OA] and surgery have a direct effect on the oral health and to the best of my knowledge previous research about the potential associations between OSA and oral health has mainly been focused on periodontal diseases and OA. However, persons with CPAP-treated OSA report direct side effects from the CPAP treatment including xerostomia^{6,7} and shifting bites^{7,8}. As many research studies regarding the side effects of CPAP treatment have been performed from a professional healthcare perspective⁹, the persons' views on CPAP treatment from an oral health perspective have remained somewhat unclear.

During the last 30 years, attempts to create a theoretical framework to conceptualize oral health have been made in different settings. Most of them are focused on *ill*-health, describing oral health from for example a biomedical or professional point of view^{10,11}, and failing to take the persons' perceptions, experiences, values, and expectations into account. However, the World Dental Federation [FDI] proposed a new definition of oral health accompanied by a theoretical framework¹², intended to move dentistry toward oral health

promotion and prevention of oral diseases. Instead of solely focusing on risk factors for oral *ill*-health, the FDI's definition and framework is stated to include a nest of changing interactions that can serve both as barriers or support for a person as regards achieving or maintaining oral health ¹³. A lifetime of oral health can be described as a nest of integrated, continuous, and dynamic sets of exposures or experiences that can have a cumulative impact on the oral health at the personal level ¹⁴.

By using the FDI's definition and framework for oral health as a basis for exploration in this thesis, there is a possibility to illustrate oral health from different perspectives relevant for the person, oral health professionals, and other healthcare professionals such as CPAP practitioners. Exploring oral health in a general population can be seen as a starting point to gain further understanding of the potential relationships between different components of oral health. This approach in papers I and II sets the frame of reference for papers III and IV by providing an increased understanding of how the FDI's definition and framework can be understood and used. Then, to gain deeper understanding of how life-changing events such as living with CPAP-treated OSA can influence views on oral health determinants or experiences of oral health-related situations and management, a person perspective was adopted. Personal views or real-life experiences on oral health in relation to CPAP treatment can provide deeper knowledge of the importance of oral health for long-term CPAP adherence, and increased understanding of how oral health could be seen as a part of a person's general health and QOL during treatment. Finally, by combining the findings in all four sub-studies it is possible to explore differences and similarities among the findings in the included sub-studies. This can be part of exploring if and how *oral health matters* for persons with experience of CPAP-treated OSA.

3. Background

3.1. Health

The value of measuring indicators of health instead of diseases or disabilities emerged in the period 1930s-40s during WWII ¹⁵. Despite that, the biomedical perspective with a focus on finding and treating diseases has remained, even after the World Health Organization [WHO] proposed the groundbreaking definition of health in 1946. At the International Health Conference, the WHO defined health as: “*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*”¹⁶. However, this definition of health has been discussed and questioned, and regarded as an ideal rather than as possible to obtain in real life ⁴. Health is a multidimensional concept, which can be interpreted differently among people, including for example biomedical and functional aspects but also the QOL ¹⁷. Health is changeable, and it reflects a person’s present situation, and could therefore be regarded as an integrated part of a person’s everyday life ⁴. Even though the WHO’s definition of health has not been amended since its introduction, a definition of health promotion was proposed in 1986 at the first International Conference on Health Promotion in Ottawa. Then, health was described as a resource in everyday life and not the objective of living: “*(...) the process of enabling people to increase control over, and to improve, their health*” ¹⁸.

According to the WHO, oral health is a key indicator of overall health and well-being, and QOL ². Besides the association with overall health and well-being, oral diseases such as periodontal disease and dental caries, share modifiable risk factors with several major non-communicable diseases or conditions, and contribute to economic burdens of persons and societies ¹.

In this thesis, the concept of health (overall as well as oral) is understood as a wider concept than just the absence of diseases and conditions. It is viewed as a multidimensional concept, including biomedical, physical, and psychosocial functions influenced by a person’s ever-changing everyday life.

3.2. Oral health

The connection between overall health and oral health was highlighted in the Liverpool Declaration from the 8th World Congress on Preventive Dentistry in 2005 where it was stated that “*oral health is an integral part of general health and well-being and a basic human right*”¹⁹, as well as in the WHO’s frequently cited definition of oral health from 2012²⁰:

“Oral health is essential to general health and quality of life. It is a state of being free from 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.”

Even though oral health has been recognized and accepted as an important part of overall health and well-being, the concept has been interpreted differently in different contexts¹³. Traditionally, definitions and theoretical frameworks or models of oral health have been developed through biomedical approaches with a focus on diseases, conditions, and disabilities¹⁰. But as Lee et al.²¹ describe it: there has not been a universal consensus regarding the definition of oral health, and this can be illustrated by two citations by Gift¹⁵: “*there is no accepted definition of oral health*” (pg. 26), and Locker²²: “*The discourse of oral health is also often confused*” (pg. 21). Over the years, several definitions of oral health have been proposed, with a focus on the connection to overall health and well-being, physical and social functions, a life course perspective, and promotion of oral health. The connection between overall and oral health in a life course perspective was clearly expressed in the Tokyo Declaration from the World Congress 2015 - Dental care and oral health for healthy longevity in all aging society, where it was stated “*Life-long oral health is a fundamental human right*”²³. It also called for an understanding in health policies of the common risk factors for overall and oral health to prevent oral diseases, as well as to restore or maintain oral functions²³.

3.2.1. Conceptual frameworks of oral health

Through the years of dental research, numerous indices to measure biomedical aspects of oral health, focused on pathophysiological aspects of oral health, have been suggested and used. To acknowledge all complex interactions

among overall health and well-being, everyday life, and oral health, several conceptual frameworks of oral health have been proposed. In a systematic scoping review, Sekulic et al.¹¹ identified 13 different generic oral health models published between 1988 and 2015. The development of theoretical and conceptual frameworks/models followed the development of definitions of oral health, and one of them is Locker's conceptual framework of oral health²⁴.

Locker²⁴ stated that the dental community was too focused on clinical measures and had too narrow a view on oral health, equating health with absence of disease. The contemporary definitions of oral health at the time did not take person-reported factors, such as functioning, pain, or discomfort, into account. Locker then adapted the WHO's conceptual model of health²⁵ to dentistry, and argued that the model was a simple scheme and did not reflect the complexity of the relationships between the components. Locker's adaptation illustrated various relationships through a dynamic model, taking a broader perspective on the concept of oral health by also including social and psychological effects of oral diseases²⁴. This framework was seminal in its approach and has been used as a theoretical basis for several instruments aiming to measure the impact of oral health on overall health, well-being, and everyday life for the person.

3.2.2. *The World Dental Federations [FDI] definition and theoretical framework of oral health*

As there has been no global consensus on the definition oral health over the years and as the biomedical approach has traditionally been strong and persistent within dentistry, the FDI proposed a new definition of oral health. This new definition was developed as an attempt to move oral health from the traditional focus on oral diseases and treatments, and toward promotion of oral health. It was published in several scientific journals to be disseminated and used in clinical oral healthcare, educational settings, and research^{12,13,21,26}.

“Oral health is multifaceted 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 include that it is a fundamental component of health and physical and mental well-being. It exists along a continuum influenced by the values and attitudes of individuals and communities; [it] reflects the physiologic, social, and psychological attributes that are essential to quality of life; [it] is influenced by the individual's changing experiences, perceptions, expectations, and ability to adapt to circumstances.”

(pg. 126, Lee et al. ²¹)

The FDI's definition is described as a development of the widely cited and used definition by the WHO from 2012 ¹³, and to include aspects from the Ottawa Charter ¹⁸, Liverpool Declaration ¹⁹, and Tokyo Declaration ²³ regarding health promotion, connection to overall health, and a life course perspective, among other aspects. By acknowledging several aspects of oral health including the person perspective (e.g., values, attitudes, experiences, perceptions, ability to adapt to circumstances), the FDI is aiming for the definition to be universally acceptable and applicable. It also aims to clarify that oral health is a changeable part of our overall health and well-being, and could be used as the foundation for future development of standardized assessment tools and measures of oral health according to the FDI ²⁶.

By building on previous frameworks and models of oral health, the FDI also presented a theoretical framework of oral health accompanying their definition to further illustrate the complexity of oral health ¹². Instead of solely focusing on risk factors for oral *ill*-health, this theoretical framework is stated by the FDI to include a nest of interactions that can serve both as barriers or give support to achieve or maintain oral health ¹³. Besides being built on previous frameworks of oral health, the FDI's definition and framework is also stated to be built upon the WHO's Commission on Social Determinants of Health report ^{13,27}.

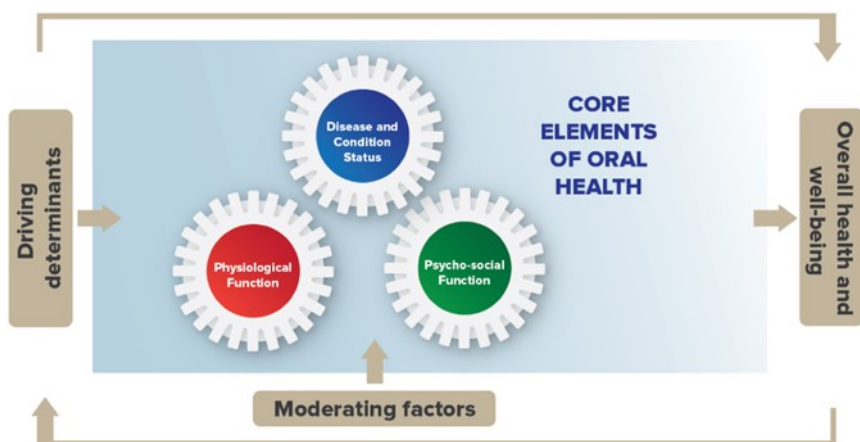


Figure 1. The FDI's theoretical framework of oral health (adapted with permission from © FDI World Dental Federation. All rights reserved.)

The FDI's framework include four main components (i.e., *the core elements of oral health*, *driving determinants*, *moderating factors*, and *overall health and well-being*), thereby aiming to incorporate several aspects of oral health. In the FDI framework, arrows indicate the relationship among the components in the framework (figure 1).

In the center, the three central parts or dimensions referred to as *the core elements of oral health* (i.e., disease and condition status, psychosocial function, and physiological function), refer to the presence of oral diseases and conditions as well as progression and severity, pain and discomfort, and physiological and psychosocial functions including the capacity or ability to perform a range of actions related to oral health. In the FDI framework, *the core elements of oral health* are illustrated to affect *overall health and well-being*, and *the core elements of oral health* are affected by *driving determinants* and *moderating factors*.

Driving determinants refers to a range of determinants that can affect a person's oral health according to the FDI. This component is illustrated to affect *the core elements of oral health*, but also to have a bidirectional relationship with *overall health and well-being*. The *driving determinants* are divided into five dimensions (i.e., genetic, and biological factors, social

environment, physical environment, health behavior, and access to care). Furthermore, *driving determinants* are stated by the FDI to interact and nest within systems and can include both barriers and facilitators for oral health and the management of oral diseases and conditions.

Moderating factors are described by the FDI as factors that affect or determine how a person value, score, or rate their oral health, and include factors such as age, expectations, experiences, culture, and adaptability. However, the FDI also state that *moderating factors* are not limited to these factors but could include other factors as well. In the FDI's framework, the component *moderating factors* is illustrated to affect *the core elements of oral health*.

The framework also includes the component *overall health and well-being*, which together with the component *driving determinants*, show the interaction between oral health and overall health and well-being. Altogether, the FDI framework aims to create a comprehensive picture regarding the complex nature of the concept of oral health ²⁶.

The FDI's definition and theoretical framework in this thesis

The FDI's definition of oral health is stated by the FDI to be *an evolution* of previously suggested definitions currently used by national dental associations and other organizations. Furthermore, the accompanying theoretical framework is stated by the FDI to further allow elucidation of the elements that represent, form, and affect oral health. According to the FDI, the definition and framework propose *a solid base for further exploration* ^{12, italics on p. 4}. Furthermore, the FDI's framework, shows how *the core elements of oral health* and factors in our everyday life could interact or nest together. The FDI framework can be used to describe oral health as well as exemplify how changes in our everyday life can affect our oral health, including experiences, perceptions, and expectations, from different perspectives and in various populations. The FDI's framework can also be used to describe barriers and facilitators for gaining or maintaining oral health, and how they can affect oral health or the ability to adapt to circumstances throughout a lifetime ^{12,13,21,26}.

In this thesis, the FDI's definition and framework was used as a basis for exploration in all four sub-studies. By that, oral health is defined, explored, and understood in relation to the FDI's definition and framework.

3.3. Social determinants of oral health

Oral health does not occur in isolation ²⁶. Several studies or reports have shown that oral health is an integrated part of our overall health and well-being, as both are affected by the way we live, work and age ^{1,27-29}. Oral health inequalities have been described as a major problem in middle- and high-income countries ³⁰. Social inequalities exist between groups in a society, and between countries ³¹. Even if the connections between overall and oral health are strong, and the factors causing inequalities are similar, oral health is often separated from general health ^{20,32,33}, for example by legislation in Sweden ^{34,35}. In a series of articles, Peres et al. ¹ and Watt et al. ²⁸ outline the importance of oral health by describing how oral disease and conditions are highly prevalent globally, and thus affect the everyday life of persons but also have economic effects on persons and societies. Furthermore, they highlight not only how oral health is connected to our overall health and well-being but also to the context a person lives in (e.g., political, and economic context) and the influence of social determinants ^{1,28}.

Oral diseases such as dental caries and periodontal diseases are, despite being largely preventable, among the most common diseases worldwide (affecting over 3.5 billion people) and should be considered global public health priorities. Oral diseases can cause discomfort, pain and even death, but also increased direct and indirect economic burdens for the society and person. The intangible costs, such as problems with eating and social interactions, also affect the total economic burden, making oral diseases the third most costly health issue in the European Union [EU] in 2015 ¹. Watt et al. ²⁸ propose that dentistry has been too focused on technical development and treatment of oral diseases based on a biomedical philosophical approach. However, technological advances, such as tele dentistry and mobile applications, have contributed to improved oral healthcare with the potential to make oral healthcare more accessible in remote areas and reducing the cost for the person, clinician, and society ³⁶. Nevertheless, the persistent socioeconomic inequalities regarding the prevalence of dental caries and periodontal disease among and within populations have been described as classic examples of social gradients of health. Even if life course oral health development studies are uncommon within dentistry ¹⁴, there are findings suggesting that

socioeconomic factors in childhood can affect oral health throughout a lifetime ¹.

3.3.1. *Strategies to promote oral health*

Within oral healthcare, prevention of oral diseases has been the main target rather than oral health promotion even if strategies to promote oral health at a population level by focusing on common determinants were suggested over 20 years ago ³⁷ by the introduction of the Common Risk Factor Approach. This approach underlined the possibility of targeting common risk factors (e.g., diet and tobacco use) and working with strategies for health promotion addressing overall and oral health issues simultaneously ³⁸. Even though the common risk factor approach was widely accepted and influential in strategies for health promotion, the interpretation was too narrow within dentistry, focusing on behavioral factors and not on the wider social determinants. To enhance the understanding of the importance of a wider perspective of the social determinants of oral health the common risk factor approach was updated, and the conceptual model for oral health inequalities was presented ³⁹. This conceptual model describes the relationship between structural determinants (described as political and economic drivers) and intermediary determinants (described as circumstances and risk for oral diseases) to show how socioeconomic- and political context affect socioeconomic position which then affects a person's daily life by creating social gradients and oral health inequalities ³⁹.

Common oral health determinants

In relation to the FDI framework, the components surrounding *the core elements of oral health* could be seen as illustrating different aspects of our everyday life that affects our oral health. *Driving determinants* include different oral health determinants where social determinants are included but also biomedical determinants, see figure 1. For this thesis, a structured literature search was performed to summarize the most reported oral health determinants during the last two decades (Appendix 1, table 1-3, figure 1), summarized below.

The range of potential oral health determinants could be described as wide, and research on oral health determinants has increased during the last ~20

years. But as Crall and Forrest ¹⁴ pointed out, there is a lack of longitudinal studies exploring oral health and determinants from a life-course perspective. Most research has been performed in a European context using cross-sectional designs. Furthermore, most research relies on the professional perspective and there seems to be a lack of research based on the personal or patient perspective. One exception is Brondani et al's. ⁴⁰ study which focused on the elderly's assessments of the existential model of oral health. By using focus groups, the elderly persons were asked for their views on the models' structure, content, and the relationships among components after receiving a vignette describing how two persons' oral health had been influenced (Appendix 1, table 2).

The most commonly reported oral health determinants in relation to each of the FDI's domains of *driving determinants* include age/year of birth and ethnicity/color of skin/self-reported race (*genetic and biological factors*), education/parental education and socioeconomic status in childhood/of household (*social environment*), neighborhood characteristics/place of living/socioeconomic level in community and living conditions (*physical environment*), dental cleaning and dental visits (*health behavior*), and healthcare system/dental care system/insurance and satisfaction with dental care (*access to care*). Other, less frequently reported oral health determinants include systemic diseases/conditions, heritability/epigenetics, social class/position, community values/beliefs or social norms, tobacco use, diet, dentist/oral healthcare in the area, marital status, and media/advertising, see appendix 1, table 3.

Oral diseases and conditions such as dental caries, periodontal diseases, and xerostomia/hyposalivation, may occur in the mouth ²⁰, but are also associated with general diseases and conditions. Moreover, oral and general diseases and conditions share risk factors which increases the risk of developing a disease/condition ^{20,32}. To show how social determinants and lifestyle factors can impact oral health, three oral diseases or conditions are described below.

Dental caries

Dental caries is defined as a localized loss of calcified hard tissue such as enamel or dentine ⁴¹. It is one of the most prevalent chronic non-

communicable diseases worldwide and people are susceptible to dental caries throughout their lifetime ⁴¹.

The dental caries process involves several factors (e.g., behavioral, social, and biomedical) as it develops over time through complex interactions between acid-productive bacteria, fermentable carbohydrates and a host response including factors as saliva, oral hygiene, and fluoride use ⁴¹.

The dental caries process is affected by several determinants such as personal factors (e.g., income, education, and oral health behavior), oral environmental factors, (e.g., salivary flow and composition) and direct factors such as bacteria in the oral biofilm and diet (intake frequency and composition) as well as immunological components, and genetic factors ⁴². General diseases or conditions, radiation therapy, and medication use could increase the risk of initiation and progression of dental caries, but the evidence level has been considered low ⁴³.

Dental caries prevention includes management of the disease throughout a lifetime. Fluoride use and oral health self-care (e.g., regular tooth brushing and interdental cleaning), is considered the golden standard for prevention of dental caries. Additional intervention on a personal level includes different preventive or treatment methods to increase salivary production or replace saliva in persons with hyposalivation ⁴².

Xerostomia and hyposalivation

Xerostomia is the person-reported feeling of oral dryness (as it is mostly referred to within sleep medicine), while hyposalivation is due to a salivary gland hypofunction such as decreased or absent saliva production ^{44,45}. The salivary flow decreases during the night as the salivary glands are in a resting state and increases when stimulated. As the resting state exist most of the time, it has the highest impact on the sensation of xerostomia ⁴⁶. A decrease in salivary flow rates can change the composition of saliva including a decrease in buffer capacity and pH values, mucosal and gingival infections and inflammation as well as an increased risk for dental caries ⁴⁷. The consequences of hyposalivation and xerostomia include impaired masticatory function and ability to speak, dysphagia, and halitosis ⁴⁸ but can also affect the person's sleep pattern during the night time ⁴⁶.

Both conditions have several causes related to overall health and well-being as well as biological and genetic factors. The salivary flow rate can be affected

by many factors such as the circadian rhythm and previous stimulation. Defining the cause of the condition is often complex as both systemic diseases and increasing age can be associated with hyposalivation and xerostomia. However, the aging process might not be the primary cause ⁴⁷. Both hyposalivation and xerostomia could be caused partly by medication use ^{47,49} and over 400 medications have reported hyposalivation as a side effect ⁴⁷. Moreover, polypharmacy has also been suggested to be part of the cause, particularly in older persons ⁴⁸.

Periodontal health and diseases

The new classification of periodontal diseases includes classifications of periodontal health, gingival diseases and conditions, periodontitis, and other conditions affecting the periodontium ⁵⁰.

Gingivitis is divided into two subgroups: plaque-induced gingivitis ⁵¹ and non-plaque-induced gingivitis which is often a manifestation of a systemic disease or condition ⁵². Plaque induced gingivitis is defined as an inflammatory process in the gingival tissue as a result of bacterial plaque accumulation above and within the gingival margin, without attachment loss. Reducing the levels of gingival inflammation is the primary preventive method for periodontitis ⁵¹. Periodontitis is clinically defined as a *microbially associated, host-mediated inflammatory process that results in loss of periodontal attachment* ^{53, p. 151}. As periodontal diseases are no longer viewed as strictly bacterial infections, determinants of periodontal health indicate that the development of periodontal diseases is complex and multifactorial involving interactions between the subgingival microbiota, the host response and environmental modifying factors ⁵⁴.

Adequate and regular oral hygiene habits are still the primary preventive measure to maintain periodontal health, together with regular professional supra- and subgingival dental care, even if these factors only account for approximately 20% of the risk of development of periodontal disease. The remaining 80% of the risk may be due to other direct and indirect risks and environmental determinants such as tobacco use (smoking), medications, and stress. Systemic modifying risk factors are defined as determinants that can alter the host inflammatory response to subgingival plaque accumulation such as host immune function, the person's general health and genetic factors ⁵⁴.

Several systemic disorders, both genetic and acquired (e.g., osteoporosis and obesity), can impact on the loss of periodontal tissue. The association with cardiovascular diseases has been established through several studies ⁵⁵⁻⁵⁷, but the association between hypertension and periodontitis is still inconclusive ⁵⁸.

3.3.2. *Oral health and quality of life*

Multiple exposures to risk factors may contribute to the development of disease or increase the susceptibility for disease ⁴³. Besides socioeconomic determinants of oral health, studies have reported associations between oral and chronic general diseases or systemic disorders, as well as their treatment ⁵⁹. However, the biomedical approach to overall and oral health is interconnected with our well-being, as health can be viewed as a resource in everyday life and not the objective of living ¹⁸. Within healthcare, clinical signs and symptoms have previously been the main focus, and in clinical oral healthcare, a person's clinical oral health status is often measured by using indices reflecting the presence/progress of disease. But those indices often fail to consider feelings of pain or discomfort, and the impact on everyday life. As there can be differences between the person and the professional regarding the assessment of one's oral health, a person-based or patient-reported measure is essential when evaluating or planning oral healthcare ^{60,61}.

Locker ²² described both health and QOL as concepts that are elusive and abstract, as we know what they mean but find them difficult to define. He elucidated his statement further, and described both as multidimensional and complex, constantly changing and predominantly subjective as they are affected by the contextual factors (e.g., social, cultural, and political) with which they are measured (pg. 12). The broad concept QOL can include aspects such as health, human rights, financial and social context, and thus may have different meanings depending on the person and context. In general, quality refers to a level of goodness, where QOL incorporates multiple dimensions or aspects of a person's life, and the health-related quality of life [HRQOL] are those aspects of life that are affected by our health ⁶⁰. The WHO conceptualized and defined QOL as a multidimensional concept on a person's view of their own position in life in their own context (including aspects such as culture and values) in relation to their own aims, expectations, concerns, and standards/norms. As also described by Locker ²² the focus lies within the

person's view, on their perception of how a disease, condition, or intervention from healthcare impacts their everyday life. In short, QOL incorporates a person's physical, psychological and social health, level of independence, and personal beliefs in the context they live in ⁶². Locker ²² continues to describe HRQOL as a way to narrow down QOL when applied within the healthcare context, but still the concept of QOL indicates something more than just health while acknowledging the person and their ability to provide information about what is important to them. In relation to this, oral health-related quality of life [OHRQOL] could be considered as the aspect of QOL or HRQOL that is affected by our oral health, and theoretical models/frameworks of oral health often include OHRQOL ¹⁰.

Oral health-related quality of life

Generic measures of QOL and HRQOL could be used to assess OHRQOL but are less likely to capture the factors relating to the person's oral health. Furthermore, as measures of HRQOL and OHRQOL are mediated by contextual and personal factors, specific instruments to capture characteristics central to certain diseases/conditions, ages, or treatments should also be considered to better assess their impact on the person's life when used as an outcome measure ⁶³. Previously, oral diseases or conditions have been investigated regarding their impact on OHRQOL in adults, showing negative associations regarding dental caries and tooth loss and inconclusive results regarding periodontal disease ⁶⁴. Both dental caries and periodontal disease are complex, and can, if left untreated, lead to tooth loss. This can affect our physical functions (e.g., masticatory function, nutritional status) and psychosocial function (e.g., smiling, talking). Even if the terms "oral health" and "OHRQOL" are often used interchangeably, Brondani et al. stated that they are not synonymous ¹⁰. Among others, the FDI has highlighted the connections among oral health, well-being and, QOL in their definition of oral health.

*"(...) Further attributes include that it is a fundamental component of health and physical and mental well-being. It exists along a continuum influenced by the values and attitudes of individuals and communities; [it] reflects the physiologic, social, and psychological attributes that **are essential to quality of life** (...);"*

(pg. 126, Lee et al. ²¹)

Sischo and Broder ⁶³, write that OHRQL theoretically is a “*function of various symptoms and experiences and represents the person’s subjective perspective*” (p. 1265). According to the FDI’s policy statement on OHRQL, it is defined as a multidimensional construct reflecting several factors that are important for everyday life. OHRQL includes factors such as comfort when eating and sleeping, interaction with others, self-esteem, and satisfaction with oral health ⁶⁵, or in respect to one’s oral health ⁶³. Commonly included dimensions in OHRQL models refer to oral health status, function, treatment/expectations, environment, and social and emotional well-being, including both positive and negative dimensions throughout a life course. Bringing in the person’s perspective and own evaluation of their oral health can shift the traditional biomedical focus on oral health and oral healthcare toward a more person-centered focus, thereby changing the dynamics in the clinical setting as this can affect the process of decision-making. Sischo and Broder stated that using person-orientated measures can enhance the understanding of the relationship between oral and overall health and well-being since measures of OHRQOL can provide information about how oral health outcomes or treatments affect the person’s everyday life ⁶³.

OHRQL has been recognized since the beginning of the 1980s. The research field has developed rapidly since the 1990s ⁶⁶ and several instruments to capture and measure the OHRQL have been developed such as Oral Impacts on Daily Performance [OIDP] ⁶⁷ and the Oral Health Impact Profile [OHIP] ⁶⁸.

Measuring oral health-related quality of life

In a recent study, forty-two original instruments to measure OHRQL in adults were identified and among them there were 74 different versions of the instruments, divided into generic and specific instruments. However, few of them have been thoroughly tested regarding validity and reliability ⁶⁹. Locker’s ²⁴ conceptual framework for oral health has been reported as the most widely used theoretical basis for constructing instruments/measures for operationalizing OHRQL, including both generic (e.g., OHIP, OIDP, Geriatric oral assessment index [GOHAI]) and specific (e.g., OHIP-edentulism, and OHIP-periodontitis) measures/instruments ⁶⁹.

The first version of OHIP included 49 items, developed with the aim of proposing a comprehensive measure of person-reported problems related to negative or adverse oral health (e.g., dysfunctions, disabilities and discomforts) focusing on aspects related to social, psychological and physical function ⁷⁰. OHIP includes seven dimensions/subscales of impact on oral health (functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap) derived from interviews with 64 oral healthcare patients in Australia ⁷⁰. In 1997, Slade presented the abbreviated version of the original OHIP, including 14 items representing the seven dimensions/subscales (i.e., OHIP-14) ⁷¹. Both versions have previously been translated into several languages and are commonly used by presenting either an additive score or by each subscale ⁶¹. In this thesis, the abbreviated version of the OHIP containing 14 statements was used.

John ⁷² and John et al. ⁷³ explored OHIP (German version of OHIP-49) in two studies. In the first study, they hypothesized that OHRQOL is a multifactorial concept and found that a summarized score can be informative about OHRQOL, and that their results corresponded to previous research. But they also recognized some overlap among the dimensions ⁷³. Then, based on Locker's ²⁴ conceptual model, they investigated the dimensions of OHRQL in the OHIP from a professional perspective and concluded that it is a multidimensional concept, as all seven dimensions in Locker's ²⁴ model were found. However, the need for further understanding of the multidimensional concept of oral health was identified by Baker et al. ⁷⁴ after they investigated the construct validity of OHIP-49. Although they confirmed the usefulness of the model, as it proposes how oral diseases can affect a person's everyday life, they also questioned the construct validity, and suggested that the complex personal perspective should be further explored ⁷⁴. The personal perspective or lack thereof was also discussed by Locker and Allen ⁷⁵. They questioned whether the instruments (e.g., GOHAI, OHIP, OIDP) claiming to measure OHRQOL really do, as they can only partially claim to be person-centered and incorporate everyday aspects of importance for the person. Even if OHIP is based on interviews with oral healthcare patients, the initial 535 statements derived from the interviews were reduced by experts in oral health according to the conceptual framework used as a basis for exploration. Even if the use of OHIP or another OHRQL instrument can provide important information on

functional and psychosocial aspects of oral health, Locker and Allen ⁷⁵ questioned whether the instruments capture the broader concept OHRQOL.

In summary, OHRQL is a multidimensional concept that could be difficult to measure due to several factors such as contextual factors and the changeable perceptions of the person. There are several instruments claiming to measure OHRQL, but they have also been questioned regarding validity, reliability, and person-centeredness. However, instruments like the OHIP-14 used in this thesis can provide information on functional and psychosocial quantifiable aspects of oral health, which can affect the process of decision-making and reflect how oral health can affect essential functions in our everyday life such as interaction with others, self-esteem, and sleep.

3.4. Sleep and sleep disorders

Sleeping is a physiological process, a complex interaction between the central nervous system, respiratory muscles, and respiratory related motor neurons ⁷⁶, and can be divided into different stages such as Rapid Eye Movement [REM] sleep and non-REM sleep ⁷⁷. The circadian rhythm helps the person to alternate between wakefulness and sleeping in a 24-hour cycle ⁷⁸. Sleep impacts the person's respiratory muscles which affect breathing. During non-REM sleep, the breathing is regular, and the respiratory rate and tidal volume are decreased compared to REM sleep where breathing, respiratory rate and tidal volume are more irregular, caused by inhibition of muscle tone in the intercostal muscles and hypotonic muscles in the upper pharynx ⁷⁷. Sleeping is proposed to serve several important physical functions such as recuperation from infectious diseases ⁷⁹ as well as consolidation of memories ⁷⁷, which makes it essential for our everyday life and well-being.

Healthy adults are recommended to sleep 7-9 hours/night on a regular basis as both sleep deprivation and excess sleep can be associated with adverse health outcomes ^{80,81}. It has been estimated that about 20 % of an adult population is sleep-deprived ⁸². Adverse effects of sleep deprivation are well documented and include cognitive and behavioral dysfunctions ⁷⁹ as well as physical effects such as increased risk for cardiovascular diseases ⁸². Sleeping problems are connected to increased co-morbidity, and sleep disorders are considered a major risk factor for cardiovascular diseases and a risk factor for diabetes and

reduced QOL ⁸¹. Self-reported poor sleep quality has also been reported to be higher in persons with oral health-related problems with eating and emotional stability measured by OIDP ⁸³. The International Classification of Sleep Disorders defines eight major categories of sleep-related disorders of which OSA is classified as a sleep-related breathing disorder ⁸⁴.

3.5. Obstructive sleep apnea

OSA is characterized by complete (apnea), or partial (hypopnea) repetitive physical blockings of the airways caused by pharyngeal collapses during sleep ^{5,85}. Despite respiratory effort, the breathing process is disturbed. The respiratory muscles in the upper airway work together during inspiration to maintain an open airway including preventing a posterior collapse of the tongue and elevating the soft palate. Due to factors such as fat depositions in the pharyngeal walls, craniofacial structure (e.g., narrow upper airway and small maxillary-mandibular volume), and decreased muscular tone in the respiratory muscles, the airway can collapse, causing an apnea/hypopnea ⁵. A complete apnea is defined as a reduced airflow (< 10%), whereas a hypopnea is defined as a reduced airflow (< 30 %), lasting more than 10 seconds when a respiratory event is present ⁸⁶.

The repeated respiratory events cause arousals from sleep and intermittent hypoxemia. Due to the arousals (noticed/unnoticed) the person's sleep is fragmented, which causes daytime sleepiness, and the intermittent hypoxemia contributes to hypertension. Repeated patterns of heavy snoring and then silence (witnessed apnea) are primary symptoms of OSA ⁵ and undiagnosed OSA has been directly associated with this pattern ⁸⁷. Other symptoms of OSA include an unrefreshed feeling after sleep, tiredness, reduced energy levels, morning headaches, choking sensations during sleep ⁵, and xerostomia upon awakening ⁸⁸. Symptomatic OSA is often referred to or defined as obstructive sleep apnea syndrome [OSAS] ⁸⁹.

An OSA diagnosis is based on anamnestic data, physical examinations, and an overnight polygraphic test at home or a polysomnography in a sleep laboratory where a person's sleep and respiration can be monitored (e.g., nasal airflow, respiratory effort, oxygen saturation, and snoring) ⁹⁰. A common way to quantify the number of respiratory events per hour of sleep and to assess

the severity of OSA is to use the Apnea Hypopnea Index [AHI], with cut-off points: AHI < 5 (normal), AHI 5-14.9 (mild), AHI 15-29.9 (moderate), or ≥ 30 (severe) ⁵. However, it is also important to consider the clinical symptoms when deciding treatment.

3.5.1. *Prevalence*

The prevalence of OSA in the general population has recently been estimated in two reviews. Both only included studies with clinical measures of OSA such as polysomnography or polygraphy, but the diagnostic criteria for OSA varied among the included articles, although the most commonly used were the American Academy of Sleep Medicine diagnostic criteria (successive from 1999, 2007, and 2012) ^{91,92}. According to Senaratna et al. (2017) the prevalence of OSA in the general population, when solely based on AHI, can be estimated at 9-38% (cut-off AHI ≥ 5), however; when using the more clinically relevant cut-off (AHI ≥ 15) the prevalence decreases to 6-17% ⁹². Benjafield et al. used an algorithm and estimated that over 900 million persons aged 30-69 years globally have OSA, based on the American Academy of Sleep Medicine's (2012) diagnostic criteria ⁹¹. The estimated prevalence of OSA in Sweden was 17.0% (cut-off AHI ≥ 5), and 12.7% (cut-off AHI ≥ 15) ⁹¹.

OSA is more common in persons with overweight/obesity, resistant hypertension, and type II diabetes ⁵. Franklin et al. ⁹³ describe a complex relationship between age and snoring, where snoring increases with age until 50-60 years, then decreases, but the prevalence of OSA continues to increase. OSA is also associated with several other factors that can increase the risk for developing OSA, often mediated by increased snoring, especially in persons younger than 70 years. Regarding sex, OSA has been reported to be more common in men than in females, but Franklin et al. ⁹³ showed in a study that 50% of the females (age 20-70 years) in their study had an AHI ≥ 5 .

3.5.2. *Treatment*

If left untreated, OSA can increase the morbidity (e.g., systemic hypertension ⁸¹, stroke ^{94,95}, coronary heart disease, and type II diabetes ⁹⁶). Untreated OSA has also been associated with increased mortality ^{81,94}, linked to increased

cardiovascular mortality but also to increased all-cause mortality⁸¹. However Franklin and Lindberg⁹⁵ reported inconclusive results regarding increased mortality except for males under the age of 70 years. Nevertheless, for persons with OSAS, treatment is essential.

The primary treatment for symptomatic OSA is positive airway pressure [PAP], but treatment options include OA, weight loss, sleep position restrictions, and for select persons, surgery in the soft palate region/upper airway⁵. The mechanism of the PAP is an increased intraluminal pressure that exceeds the surrounding pressure, and by that stabilizes the upper airway by acting like splint during inspiration. The pressure can be delivered in different ways such as though bilevel or continuous pressure⁵, and CPAP is one example of PAP treatment. Correct use can reduce or eliminate periods of apnea/hypopnea during sleep⁹⁷. The CPAP equipment includes a mask that covers the face (total face mask), mouth and nose (oronasal mask), mouth (oral mask), nose (nasal mask), or nasal pillows⁹⁸. CPAP treatment is not curative, but a long-term treatment (often lifelong)⁵. The mask is intended to be used at least seven hours/night, but studies have estimated the average time for use to be approximately 4-5 hours/night^{97,99}. CPAP adherence is an important issue. Studies have shown that CPAP can reduce respiratory events and normalize the AHI in up to 90% of users. There is also an association between use and symptom improvement (i.e., more hours of usage increase the improvement of symptoms). Furthermore, treatment with CPAP can reduce blood pressure in persons with hypertension, reduce sleepiness significantly, increase the ability to maintain wakefulness, and increase the sleep related QOL. Even if the effect of CPAP treatment on the risk for cardiovascular events and increased all-cause mortality is inconclusive due to limited evidence, it cannot be ruled out¹⁰⁰. Thus, adequate adherence over a long period of time is essential for the treatment of OSA.

Adherence to CPAP treatment

According to Gottlieb and Punjabi⁵, the arbitrary cut-off for adequate adherence is commonly set to at least four hours/night five nights/week. About 30 % of all CPAP users choose to abandon the treatment due to difficulties in getting used to the treatment and/or side effects from the CPAP^{6,97}. In the last

20 years there has been no sign of improvement of adherence to CPAP treatment ⁹⁷, and 65-80% of all users are still active after four years ⁵.

Several factors can act as barriers or facilitators for CPAP adherence. Barriers include preconceived attitudes and expectations, initial practical difficulties, physical discomfort, and fear of social and health-related issues. Among facilitators, several factors can motivate a person's adherence such as decrease of social and health-related issues/difficulties, decreased risk of affecting relationships or social contacts, and risk of losing the driver's license ⁹. Other factors that can affect adherence are the use of a humidification device (increased adherence if used) ¹⁰¹, and supportive (e.g., by telemonitoring, web, or telephone, peer support, or extended follow-up visits) and behavioral interventions such as motivational interventions to change attitudes toward treatment ¹⁰². As the biomedical perspective in dentistry has been persistent, most research regarding oral health and OSA has been focused on its association with periodontal disease and OA. However, some research has been made to investigate possible associations between oral health and CPAP treatment or side effects of CPAP treatment, often in relation to adherence.

3.6. Oral health and OSA

Considering the prevalence of oral diseases/conditions and OSA alone, both can be described as public health issues. There are also indications that oral health and OSA have common risk factors and could be associated both directly and indirectly. Both oral diseases and conditions as well as OSA can affect a person's QOL and can be assumed to increase the economic burden of persons and societies worldwide.

3.6.1. *Biomedical perspective on the association between oral health and OSA*

The American Academy of Dental Sleep Medicine defines dental sleep medicine as follows “*focuses on the management of sleep-related breathing disorders (SBD), which includes snoring and obstructive sleep apnea (OSA), with oral appliance therapy (OAT) and upper airway surgery.*” In 2018, a new definition was proposed: “*the discipline concerned with the study of the oral and maxillofacial causes and consequences of sleep-related problems*” ¹⁰³, p. ¹⁰⁹, as dental sleep

medicine was considered to cover orofacial pain, oral moistening disorders, and mandibular movement disorders, besides sleep disorders ¹⁰³. Even so, most research within dental sleep medicine concerns biomedical aspects of the association between oral health and OSA, specifically periodontal disease.

OSA and periodontal disease have been suggested to be associated by having common risk factors and confounders such as systemic inflammation, cardiovascular diseases, and obesity ^{5,58,104,105}, but the association has not been established and more research is needed ^{106,107}. Research regarding OSA and dental caries is limited, even if xerostomia is a common person-reported side effect of CPAP treatment ^{6,7,108,109}. Besides a relationship between duration of snoring complaints and Decayed, Missed, Filled, Teeth [DMFT], no association between OSA, CPAP treatment and dental caries has been reported ¹¹⁰. The number of teeth or a reduced number of teeth have been reported to impact the risk of having poor sleep quality ⁸³ and to increase the risk for OSA ¹¹¹. Also, edentulous persons have been reported to have increased risk of poor sleep quality compared to persons with 20 or more teeth, a pathway presumed to be mediated by chewing ability ⁸³.

Wu et al. ¹¹² concluded that persons with suspected or confirmed sleep apnea after a polysomnographic examination had a higher incidence of persistent pain in the temporomandibular joint and/or muscles, than persons without sleep apnea. However, in this study they were not able to distinguish between obstructive and central sleep apnea ¹¹². Furthermore, tooth wear has previously been reported to be associated with OSAS, and Durán-Cantolla et al. ¹¹³ showed that persons with an AHI ≥ 30 had more severe tooth wear. Wetselaar et al. ¹¹⁴ performed a narrative review of sleep disorders and tooth wear and found that OSAS could be linked to tooth wear through indirect pathways such as gastro esophageal reflux, sleep bruxism, and xerostomia.

Other research concerns craniofacial shape, intra/extra oral features, and composition of the head and neck, that could be associated with OSA. As described by Gottlieb and Punjabi ⁵, respiratory muscles movement in the breathing process involve structures in the oral cavity such as the tongue and soft palate. Other specific features in the cranio-facial structure such as having a retrognathic mandibula ^{5,115}, inferior placement of the hyoid bone ⁵, or loss of posterior teeth ¹¹¹ have also been associated with an increased risk for

developing OSA. Intra-oral features can also be associated with OSA through decreased nasal space (e.g., high, and narrow hard palate) that affects the airflow in the nasal cavity. This feature also decreases the intermaxillary space, which can affect the position of the tongue ⁵. Together, the craniofacial shape, and extra and intra-oral features can affect the airflow in the nasal-, oropharyngeal, and pharyngeal area and thereby increase the risk of OSA.

Biomedical effects or side effects of CPAP treatment

In some persons, skeletal and dental side effects of clinical relevance can occur due to long-term treatment with OA or mandibular advancement device ¹¹⁶. Craniofacial or occlusal changes have also been related to CPAP treatment ^{7,117,118}. The changes have been reported by clinical measures e.g., cephalometric radiographs showing retrusions of the anterior maxilla or a decrease in maxillary-mandibular discrepancy and convexity ¹¹⁸. Regarding other clinical measures in relation to CPAP treatment, Carra et al. ¹¹⁹ compared persons with CPAP/BiPAP treatment with a control group to investigate clinical measures (plaque accumulation, gingivitis, masticatory function, presence of calculus, and number of missing teeth) as proxy measures for periodontal disease. The results showed no differences among groups and concluded that persons with CPAP/BiPAP treatment did not have an increased risk for developing periodontal diseases ¹¹⁹.

Person-reported side effects of CPAP treatment

Oral health-related side effects are often reported in studies regarding side effects to CPAP treatment even if oral health was not the main area of interest. However, the content of questionnaires and interviews has mainly been derived from expert knowledge and not from the persons' perspective. Even if open-ended questions and semi-structured interviews have been used, the interviews have been constrained within a specific topic often regarding problems with CPAP adherence. Usually, the wording used refers to CPAP usage as problematic, and there is a need for research that focuses on the personal perspective from lived experience, and how specific issues have been managed in everyday life ⁹. One exception to this is the Side-effects to CPAP treatment Inventory [SECI] derived from in-depth interviews with persons using CPAP, a literature review and consensus from an multiprofessional expert group ⁹⁹. When using the SECI in research, results have shown that

some side effects are more correlated with non-adherence and treatment abandonment than others. According to Ulander et al. ⁸, CPAP-related side effects are subject to change during treatment as some side effects can be more pronounced at the beginning of the treatment and then decrease in impact, and vice versa. Side effects of CPAP treatment are common and mostly related to CPAP mask problems causing discomfort ^{9,120}, and have been reported to contribute to non-adherence ¹²⁰. Apart from a few studies from an oral healthcare perspective ^{7,109}, most research has been performed from a healthcare perspective.

Tsuda et al. ¹⁰⁹ reported that almost 40 % of persons using CPAP report an oral health-related symptom or side effect to their CPAP treatment. Xerostomia is the most frequently reported oral health-related side effect ^{6-8,108,109}, and has been related to increased non-adherence and treatment abandonment during the first year of treatment ⁸. But other side effects are reported such as uncomfortable pressure from the mask ¹⁰⁸, excessive salivation, shifting bites ⁷, gingival bleeding, halitosis, tooth hypersensitivity, uncomfortable occlusion, abnormal tooth mobility, and jaw pain ¹⁰⁹.

4. Rationale

Oral diseases and conditions affect billions of people all around the world. Periodontal disease and dental caries are among the most prevalent non-communicable diseases, and can cause pain and discomfort, but also contribute to economic burdens of persons and societies. Even though oral health has been recognized as a part of our overall health and well-being for quite some time, there is no commonly accepted definition within or outside the dental community. Furthermore, even if the traditional focus on advances in technology and treatments within dentistry have been beneficial for persons, oral healthcare professionals, and societies, the recognition of functional, social, and psychological aspects of oral health as well as the awareness of social determinants and global inequalities, have increased. As the FDI proposed a new definition and an accompanying theoretical framework of oral health that incorporate biomedical, functional, and psychosocial aspects of oral health, as well as the personal experiences, expectations, perceptions, and ability to adapt to circumstances, their definition and framework was set as the basis for exploration in this thesis. However, the FDI's definition and framework have not yet been explored with empirical data. There is still a lack of knowledge regarding to what extent the framework can be applied to describe oral health and how it can be used in research and clinical dentistry.

Oral diseases and OSA are prevalent among populations worldwide, making both public health issues. Besides being associated with the same systematic or metabolic diseases or conditions (e.g., cardiovascular diseases and obesity), they share risk factors and can affect our everyday life. But even though there has been an increase in research within dental sleep medicine on OSA, most of the research has focused on OA and periodontal disease. Although xerostomia has been reported as one of the most common side effects to CPAP treatment, research from an oral health perspective focusing on personal experiences is scarce. CPAP treatment could affect the oral health, and it is therefore important to explore how CPAP treatment is viewed or experienced as influencing one's oral health.

By using the FDI's contemporary definition and framework of oral health, exploring oral health from different perspectives and populations could reveal different and holistic aspects of oral health. The first part of the FDI's definition and the component *the core elements of oral health* focuses on diseases and conditions, as well as physical and psychosocial functions. Investigating oral health measures in a general population can provide increased understanding of how oral health can be described, used, and interconnected with determinants and overall health and well-being from a professional perspective by including both clinician and person-reported measures. This could be seen as a starting point or basis for further exploration of how oral health is viewed and experienced from the perspective of a specific population. To explore how different oral health determinants can affect everyday life or how persons are able to adapt to circumstances, lived experiences should be acknowledged. Oral health determinants differ among persons and there are also differences in the impacts they have. Targeting a population with experience of CPAP treatment can provide increased understanding of the persons' changing experiences, views, and ability to adapt to new circumstances in their lives. The combination of using both a general adult and a specific population could increase the understanding of oral health, how oral health determinants might differ among populations and settings, and specifically how CPAP treatment can influence oral health through the lens of persons with lived experiences. By this approach it is possible to explore *if or how oral health matters* for persons with experience of CPAP-treated OSA.

5. Overall aim

The overall aim of this thesis was to gain a deeper understanding of how the FDI's theoretical framework of oral health can be applied in a general population and how oral health is experienced in a specific population of persons with increased risk for adverse oral health.

To achieve the overall aim, four sub-aims were included in this thesis which corresponds to the empirical studies in this dissertation, the specific aims were as follows.

1. To explore oral health measures relevant for a general adult population to be included in the core elements of oral health in the FDI's theoretical framework of oral health.
2. To investigate structural relations of the components in the FDI's theoretical framework of oral health based on measures from a general adult population.
3. To explore what persons with experience of CPAP-treated OSA view as determinants for their oral health.
4. To explore how persons with experience of CPAP-treated OSA experience situations associated with their oral health and which actions they take to manage these.

A description of how the four sub-studies included in this thesis relate to the FDI's framework of oral health, population, and the overall aim is illustrated in figure 2.

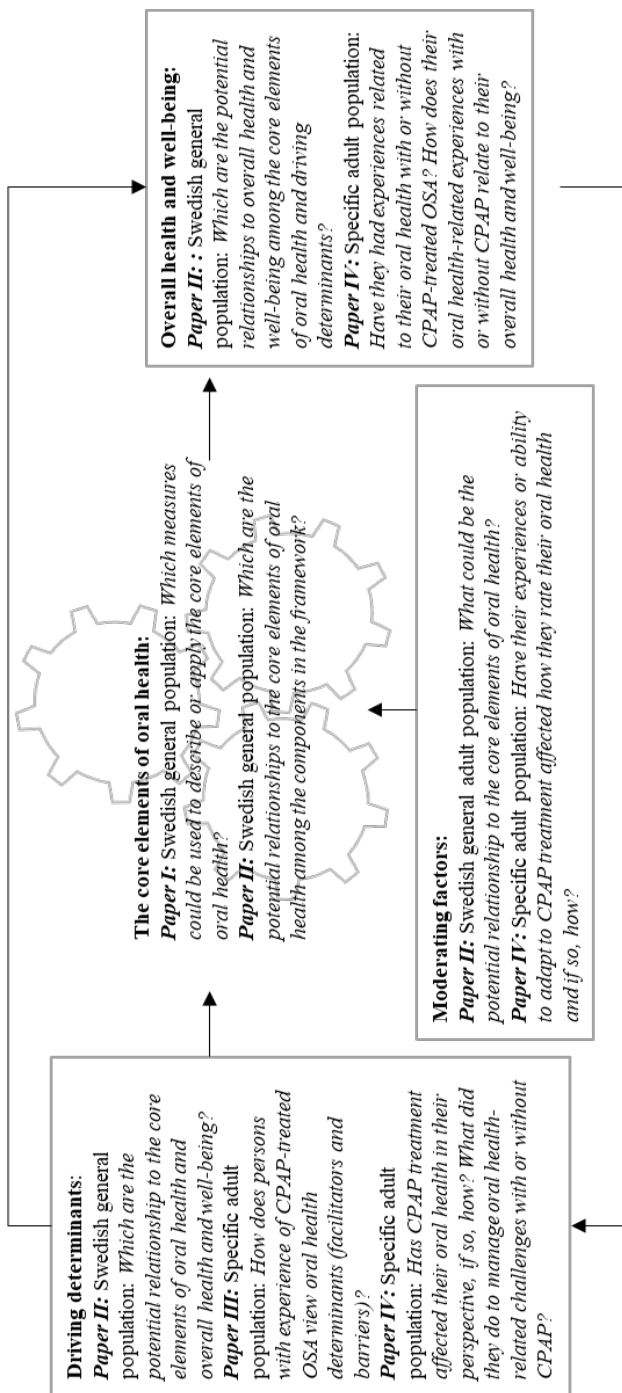


Figure 2. Description of the included papers related to the FDI's theoretical framework and population

6. Methods and material

This thesis is based on two populations (table 1). The research reported in papers I and II was performed by using a quantitative approach and the data was retrieved from the Jönköping studies, an epidemiological research project based on clinical examinations and questionnaires on oral health collected by repeated cross-sectional studies every 10 years since 1973. For this thesis, material from the data collection in 2013 was used. The research reported in papers III and IV was performed using qualitative approaches, and the material was based on a purposeful selection of participants with CPAP-treated OSA derived from the *Hypersleep study*. All participants (Papers I-IV) currently live or lived in the same region in southern Sweden during data collection.

Using both qualitative and quantitative methods has been described to facilitate a deeper understanding of a complex phenomenon in a project ¹²¹. In this thesis, both quantitative and qualitative data has been collected and analyzed with the aim of including different perspectives, such as professional and personal, thereby adopting a more holistic approach to oral health. First, oral health was investigated from a professional perspective (including clinical, radiographic, and questionnaire data) in a general population to frame the area of interest (Papers I and II). Secondly, to explore which (Paper III) and how (Paper IV) oral health determinants can affect the oral health in persons with experience of CPAP treatment, personal views and real-life experiences were explored.

Table 1. Description of included sub-studies

<i>Paper</i>	<i>Design</i>	<i>Selection</i>	<i>Sample (N)</i>	<i>Aim</i>	<i>Data collection</i>	<i>Data analysis</i>
I	Quantitative	Random	N= 630. Persons from the	To explore oral health measures relevant for	Clinical and	PCA
	Cross-sectional	selection	Jönköping study 2013, age groups 20, 30, 40, 50, 60, 70 & 80 years.	a general adult population to be included in the core elements of oral health in the FDI's theoretical framework of oral health.	radiographic examination. Questionnaire.	
II	Quantitative	Random	N= 621. Persons from the	To investigate structural relations of the	Clinical and	SEM
	Cross-sectional	selection	Jönköping study 2013, age groups 20, 30, 40, 50, 60, 70 & 80 years.	components in the FDI's theoretical framework of oral health based on measures from a general adult population.	radiographic examination. Questionnaire.	
III	Qualitative	Purposeful	N= 18. Persons from	To explore what persons with experience of	Individual semi-	DCA
	Deductive approach	selection	Hypersleep study with CPAP-treated OSA.	CPAP-treatment view as determinants for their oral health	structured interviews.	
IV	Qualitative	Purposeful	N= 18. Persons from	To explore how persons with CPAP-treated	Individual semi-	CIT
	Inductive approach.	selection	Hypersleep study with CPAP-treated OSA.	OSA experience situations associated with their oral health and which actions they take to manage these.	structured interviews.	

Key: CIT, critical incident technique; DCA, directed content analysis; FDI, World Dental Federation; OSA, obstructive sleep apnea; PCA, principal component analysis; SEM, structural equation modeling.

6.1. Participants

6.1.1. *Papers I and II*

Participants in papers I and II were randomly selected from a medium sized community in southern Sweden (Jönköping County) with approximately 131,000 inhabitants in 2013. Jönköping county is an administrative, educational, transportation, and commercial center in the region. Previously, it was reported that the population of Jönköping county was younger than the Swedish population as a whole, and approximately 14% of the persons in the county were born in another country than Sweden during the time of data collection ¹²². According to a report from the National board of health and welfare published in 2013, the access to oral healthcare was adequate and was provided by both public and private oral healthcare clinics the years before the data collection (2010-2012, most data from 2011 except questionnaire data which were collected in 2012). In the Jönköping region, 73% of the population visited an oral healthcare clinic over a period of two years (2010-2011) which was the highest visitation frequency in Sweden among adults ¹²³.

The selection procedure was repeated every 10 years in the same four parishes including both the urban and rural parts of the county, from 1973. In each age group (3, 5, 10, 15, 20, 30, 40, 50, 60, 70 and 80 years old) 130 persons were invited to participate. The sample was retrieved from the county administrative board and potential participants were contacted using a personal information letter, and when possible, also contacted by telephone. The information letter contained information regarding the aim of the project, the examination process, and the questionnaire. In the age groups 3, 5, 10, 15, 30, 40 and 50 years old an additional sample was made due to high non-respondent rates in those age groups (28-44%). In the age groups 30, 40, and 50 years old, a random additional sample were invited to participate, (n= 40, 40, and 50 persons respectively) ¹²². Only the adult participants (20-80 years old age groups) were included in papers I and II ^{122,124}. In the 2013 data collection wave, the total sample consisted of 630 adults.

6.1.2. *Papers III and IV*

In 2007, the project *Hypersleep* was initiated with the aim of studying early interventions in persons with hypertension and OSA within primary care ¹²⁵. Participants were consecutively selected at primary healthcare clinics in a region in southern Sweden. In total, 2500 potential hypertensive participants (>140mmHg/90mmHg), 18-65 years of age were invited. Participants assessed as having an elevated risk for OSA (n=918) were then invited to undergo further examinations including respiratory recordings with monitoring of nasal airflow, pulse oximetry, respiratory movements, and body position. In total, 394 participants followed through all examinations and 59% were diagnosed with OSA ⁸⁷.

To investigate the oral health in this population, 366 participants (n=28, lost e.g., deceased, emigrated) were contacted again in 2018. The potential participants were informed about the aim of the project and asked to participate in clinical and radiographic examinations, to respond to a questionnaire and, to give permission to review their dental records from 2007-2017. In addition, they were informed of the planned interviews with persons with experience of CPAP-treated OSA. In total, 171 participants granted permission to review dental records and 121 agreed to participate in clinical and radiographic examinations and to respond to the questionnaire. One person agreed to only respond to the questionnaire, and questionnaire data from 122 persons was obtained (figure 3).

In papers III and IV, participants were selected through a purposeful selection method. In conjunction with the clinical examination in 2018/19 (not included in this thesis), persons who were identified as active or as previous CPAP users through the medical records were personally invited to the interviews. In total, 27 participants with experience of CPAP-treated OSA agreed to participate. Due to the Covid-19 pandemic, the planned face-to-face interviews were replaced with telephone interviews and the data collection was postponed. Thus, the participants were contacted by mail in September 2020 to obtain written informed consent. Not all potential participants responded to the information/invitation letter, and thereby declined participation.

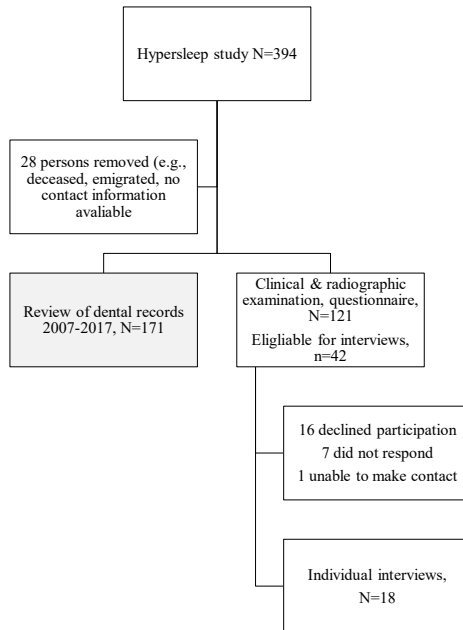


Figure 3. Description of sampling process papers III and IV

6.2. Description of data and data collection

6.2.1. Papers I and II

The Jönköping studies were performed in the period 1973 to 2013, collecting data on oral health. The aim was to describe and compare oral health changes and trends over time in a general population in Sweden, but also to evaluate implemented systematic preventive oral healthcare measures ¹²⁶. Data for papers I and II was collected between autumn 2013 and autumn 2014. At one visit, each person was asked to participate in a full dental examination (including clinical and radiographic examinations) and asked to respond to a questionnaire. The data collection was performed using the same standardized study protocol developed for the project, with minor changes in the procedure since the start ^{122,124}. The dental examination was performed by eight experienced dentists (five from the Departments of Periodontology and Endodontics, Prosthodontics, Pediatric dentistry, Stomatognathic physiology, and Oral medicine, and three from general dentistry). Before the

examinations, all dentists were calibrated regarding diagnostic criteria and procedure by three senior specialized dentists (Orofacial medicine, Periodontology and Stomatognathic Physiology).

Information regarding the radiographic and clinical examinations, and the questionnaire has been thoroughly reported elsewhere ^{122,124,127,128}. The protocols relevant for this thesis are provided in Appendix 2, table 1, and the variables are further described below.

Clinical dental examination

All examinations were performed in an oral healthcare clinic with optimal settings regarding light, and with modern dental equipment.

Number of teeth, dental caries, and restorative treatment

The number of teeth was recorded as the number of fully erupted molars, premolars, canines, and incisors. Third molars were recorded separately regarding their presence, prevalence, and position. The presence of dental caries was recorded on all surfaces possible to examine clinically (occlusal, buccal, lingual, and palatine) ¹²⁹. Initial dental caries was recorded if mineral loss (i.e., chalky appearance of enamel) without clinical cavitation was present. Manifest caries was recorded if a *new* clinical cavitation (that is, not in proximity to a restoration) could be verified by probing a fissure, in which the probe got stuck even with light pressure. Secondary caries was recorded according to the same criteria as manifest caries, but on a surface with a present restoration. Presence of caries on root surfaces was recorded if present. Restorations, crowns, bridges, and implants were registered regarding position (surface level for teeth and position regarding implants) and material (e.g., composite, amalgam, glass ionomer cement, porcelain, metal, and gold). If a surface had more than one restorative material, the most extensively used was recorded. If present, removable dentures were recorded regarding position (maxilla/mandibula), and whether complete or partial.

Periodontal status including oral hygiene variables

The presence of visible plaque was recorded on four surfaces for each tooth after the tooth surface had been air dried ¹³⁰. For participants with removable dentures, records of denture hygiene were recorded regarding the presence of

plaque and calculus. Gingival status was examined by light probing corresponding to the Gingival index and recorded as present or not on four surfaces ¹³¹. Pocket probing depth was also recorded on four surfaces on each tooth, if $\geq 4\text{mm}$.

Radiographic examination

For the age groups 20-50 years old, the radiographic examinations were carried out by an orthopantomogram and six bitewings. For the age groups 60-80 years old, the radiographic examination included an orthopantomogram, and a full-mouth intra-oral radiographic examination including both periapical radiographs and bitewings. If needed, additional radiographs were taken. In edentulous participants, the radiographic examination was carried out with an orthopantomogram ¹²⁴. If the participant had recently had a radiographic examination done, radiographs were obtained from their regular oral healthcare clinic, and only additional radiographs (e.g., orthopantomogram) were carried out. All radiographs were reviewed by specialist dentists at the Department of Dentomaxillofacial Radiology.

Radiographic diagnostic criteria

Radiographs were used to diagnose several dental diseases and conditions. Initial proximal dental caries was diagnosed as verifiable lesions not deeper than $2/3$ of the enamel, or deeper than $2/3$ of the enamel but with no involvement of dentine. Manifest proximal dental caries was diagnosed as a verifiable manifest lesion if extended into the dentine. Periodontitis was classified according to Hugoson and Jordan's criteria of Classification according to the severity of periodontal disease experience ¹³². Group 1, Healthy or almost healthy gingiva with normal alveolar bone height, bleeding on probing not exceeding twelve locations in the premolar/molar region. Group 2, Gingivitis with bleeding on probing on more than 12 locations in the premolar/molar region and normal alveolar bone height. Group 3, Alveolar bone loss ($< 1/3$ of root lengths) around most teeth. Group 4, Alveolar bone loss (between $1/3$ - $2/3$ of root lengths) around most teeth. Group 5, Alveolar bone loss ($> 2/3$ of root lengths) around most teeth and presence of angular bony defects and/or furcation involvement. *Almost around all teeth* was defined as including 80-100% of examined teeth. Subgingival calculus was recorded as present, if visible on radiographs on a proximal surface on at least

one tooth in a sextant. The sextants were delimited by the canines in both the maxilla and mandibula.

Questionnaire

After the dental examination, the participants were asked to respond to a web-based questionnaire. For the 2013 wave of data collection some modifications have been made to keep the questionnaire up to date regarding terms and theoretical backgrounds. In total over 100 questions were included in the questionnaire, although not all participants responded to all questions. Some questions were linked to follow-up questions that were revealed only if the participant responded in a certain way ¹²². The questions from the extensive questionnaire used in this thesis can be found in Appendix 2, table 1 and are further described below.

Aesthetic satisfaction was included as a single variable based on ten questions regarding how the participant experienced the appearance of their face, mouth, teeth, and prosthetic tooth replacements was included (dental prosthesis, crowns, bridges, or implants). On a scale from 0 to 10 the respondents chose the most appropriate response according to their perceptions of their appearance, and the responses were then summarized. The Swedish version of the abbreviated version of the Oral Health Impact Profile-14 [OHIP-14] was used. In paper I, the 14 questions were merged pairwise into the seven dimensions as described by Slade ⁷¹, and in paper II the additive score of OHIP-14 was used. The Swedish version of OHIP has previously been shown to have sufficient validity and reliability ^{133,134}. The free text response to the question *Which disease or condition do you have?* was categorized into no reported chronic condition, cardiovascular disease, diabetes mellitus (type I/II), respiratory disease, cancer, other, two chronic conditions, and >2 chronic conditions. Regular interdental cleaning was categorized into seven categories depending on whether the person regularly performed such cleaning and which interdental aid (one or more) they used. The seven categories were regular user of interdental brushes, toothpicks, and dental floss; toothpicks and dental floss; interdental brushes and dental floss; interdental brushes and toothpicks; interdental brushes; toothpicks; dental floss; or not a regular user.

6.2.2. *Papers III and IV*

Data collection for papers III and IV was conducted between November 2020 and January 2021. The study participants were interviewed on one occasion by using an interview guide designed to capture two different perspectives on oral health. A two-step procedure was used to pretest the interview guide before the data collection (i.e., test interviews and pilot interviews). To practice the interviewing technique and the use of technical equipment, three test interviews were performed with persons within the same age range as the study participants (one female, two males), one in the initial phase of CPAP treatment. Then, two pilot interviews were performed with persons in their initial phase of CPAP treatment (< 1 year). After the pilot interviews, the persons provided feedback on the interview guide. Minor changes were made such as to the wording of questions: changing oral health to health of the mouth and teeth, in Swedish: “*munhälsa*” ändrades till “*din mun och dina tänders hälsa*”, increasing the detail level of follow-up questions, and changing the order in which the questions were asked.

After written consent was confirmed, all study participants were contacted by telephone to schedule a telephone interview. At the first contact, information was provided regarding the estimated time and content of the interview (based on the pilot interviews ≈ 60 minutes), technical prerequisites (e.g., if possible, to use a headset and have a fully charged cell phone), the optimal setting (e.g., the possibility to participate without being disturbed), and the study participants were given the opportunity to ask questions. They were also reminded that the interviews would be recorded. At the time of the interviews this information was repeated. The interviews were recorded with a Dictaphone (Olympus VN- 8500PC) to enable verbatim transcripts. Before the data analyses, verbatim transcriptions were performed by the interviewer HA and a research assistant. During the transcription, all interviews were labeled, to enable identification of who the transcript, and later the meaning units, belonged to without disclosing their identity.

Interview guide

A semi-structured interview guide was developed in collaboration between HA and supervisors with expertise in oral health, methodology, and sleep medicine. The first part included general questions (i.e., age, person/self-

reported health, current diseases or conditions, current medical treatment, medication use, last visit to a dental office, current employment, previous employments, and education within oral or general healthcare). The interview guide included three main areas: sleep, OSA and CPAP treatment, the participants general views on oral health, and views on their own oral health. Some of the questions in the first main area were mainly used to introduce the persons to the area of interest. The areas were introduced through a short description by HA and intended to guide the participant toward the focus of the interview. The questions in each area were open-ended and based on the response, follow-up or probing questions were asked. The interview guide also comprised seven main questions with one to five subset questions and questions guided by the Critical Incident Technique [CIT]. Throughout, the study participant's descriptions and response set the pace, direction, and content of the interview, however, to keep the focus on the area of interest, the study participants were guided by HA's questions. In the information letter, the study participants were asked to recall specific events that they had experienced in relation to their CPAP treatment. As a guide, they were given an example of how CIT can be applied in an interview setting, and thereby were given the opportunity to reflect on their experiences before the interview. During the interviews, they were asked or spontaneously described situations they had experienced and how they were managed, and then specific follow-up questions were asked to gain a detailed description of the event (Appendix 3).

The development of the interview guide was based on the following descriptions of the two approaches used for analysis.

In paper III, a Directed Content Analysis ¹³⁵ approach was used. This approach can be described as a suitable choice of method when the aim of the analysis is to evaluate, elucidate, or extend a theoretical framework or theory. The existing theory or theoretical framework can help the researcher to direct the questions toward the area of interest and thereby focus the questions and interviews on specific topics. Questions are often open-ended with subsets of questions relevant to the intended concepts of analysis.

In paper IV, the CIT approach was used as it relies on descriptions of retrospective events that have generated an action for a specific purpose. CIT

was originally developed within another context (i.e., a US Air Force aviation program to evaluate and reduce critical situations for pilots) ¹³⁶. Since then, CIT been modified and used within several contexts such as dentistry and healthcare, and additional aspects have been added ¹³⁷⁻¹⁴⁰, and one of the first studies using CIT was conducted within dentistry ¹³⁸. Crucial for the technique is to obtain study participants that can recall critical incidents (both positive and negative) and how they were managed ¹³⁶.

6.3. Data analysis

Papers I and II were based on cross-sectional data from repeated cross-sectional studies, where the data from the 2013 data collection wave was used.

6.3.1. Paper I

Paper I focused on the component *the core elements of oral health*, which consists of three elements or dimensions that represent disease and condition status, physiological function, and psychosocial function in the FDI's framework. Exploring which measures could be used to operationalize *the core elements of oral health* was regarded to be a first step to further explore the remaining components in the FDI's framework ¹³. Considering the large number of potential measures, a reduction in this number was needed, and a selection of measures had to be made. The description of the components in the FDI's framework was set as the basis for the selection procedure ¹³.

Discussions were performed in different settings (within the research group and with expert and lay persons representatives) and in different stages and these were followed by Principal Component analysis [PCA]. Throughout all the discussions, field notes were written. The data reduction procedure was initiated within the research group consisting of dental hygienists, dentists (specialist and general practitioners), nurses, and epidemiologist. Measures that were regarded as more fitting in other components than *the core elements of oral health* were excluded from further examination. The aim with all discussions was to ensure concordance with the FDI's framework, to include both experts' and lay persons' perceptions, and to enhance face and content validity.

The initial reduction resulted in 55 remaining measures to be further examined. To ensure content validity, the selection was discussed with the expert group comprising of dental hygienists and dentists within the fields of general dentistry, public dental health, periodontology, cariology, oral prosthetics, orthodontists, pediatrics, oral pathology, and Stomatognathic Physiology (including Temporomandibular disorders and orofacial medicine). The discussion was initiated with questions such as *Is the initial selection of measures relevant based on the FDI's theoretical framework of oral health?* and *Which measures could be included in the core elements of oral health, and which are more fitting in for example driving determinants?* This step reduced the number of measures to 31.

After performing a first PCA, the result was again discussed within the research group, resulting in a reduction of measures to 16 based on the statistical results. Once again, the measures were discussed within the research group, and another PCA was performed, reducing the measures to 11. Another discussion with the expert representatives followed to ensure content validity. The expert group were asked to suggest relevant changes or additions to reflect their knowledge and experience within their area of expertise. This step increased the number of measures to 15, which were statistically tested by a third PCA.

To confirm face validity and to include a person perspective, a group of lay person representatives were involved in this stage of the selection process. They were recruited by a purposeful convenience sampling from the same region as the study population, the aim being to include adults (n=4) with oral health-related experiences and with variation in age, sex, and education (including persons with and without university/college degrees). Representatives with professional experience within oral healthcare were excluded. The lay person representatives were introduced to the project and the FDI's framework was visualized by a projected image throughout the discussion. First, the group was asked: *What do you think is important to include in the core elements of oral health?* Second, the preliminary model derived from the last PCA was presented and the group were asked to compare their perceptions and experiences to the suggested model. This step revealed some minor differences between the expert group and the lay person representatives' group, which were adjusted before the final selection was

confirmed. The lay person representatives suggested keeping all the measures, merging some of them to enhance the readability and understanding. The suggested adjustments were implemented in the preliminary model before performing a final PCA, which constitutes the final model in the paper.

6.3.2. Paper II

For this paper, the minimum adult oral health standard set [AOHSS] was used as the basis for the selection of variables to include in the model ¹⁴¹.

The AHOSS was developed through a collaboration between the FDI and The International Consortium for Health Outcomes Measurement [ICHOM] who established an international working group to create a minimum standard set of oral health outcomes and case-mix concepts. The ICHOM aims to support value-based healthcare and facilitate measurement and comparisons of different health outcomes. All of their standard sets are stated to be person-centered, and include both clinician and person-reported outcomes and case-mix concepts (i.e., *factors that will affect the patient-centered outcomes that are not influenced by the management of the condition and are used to allow the construction of risk-adjustment models* ^{141, pg. 2}), validated instruments, and time-points. The working group consisted of oral healthcare professionals from several countries (e.g., Australia, Nigeria, the Netherlands, and Brazil), lay persons and corporate/industry representatives, and ICHOM representatives, who performed the variable selection in several steps focusing on dental caries and periodontal disease. The steps included a structured literature search where two researchers assessed the abstracts to identify relevant outcomes and case-mix concepts (independent reviews until satisfactory inter-rater reliability, Cohen's Kappa >.7), but also including focus group interviews with lay person representatives. The final steps included using a consensus driven modified Delphi technique with working group members from different countries and a global open review by online surveys delivered to different groups including oral health professionals, and industry representatives, but also one survey directed to patient/ lay person representatives ¹⁴¹.

The final version of the AOHSS contains 31 outcome and case-mix concepts which have been mapped into the FDI's framework of oral health.

After identification of the 31 measures of the minimum AOHSS in the cross-sectional data set utilized in this paper, correlations between the components in the FDI's framework were analyzed. Criteria for further analysis were *i)* correlation > 0.20 , *ii)* theoretical relevance. This analysis yielded 16 measures relevant for further analyses, which were investigated regarding differences in the wording of questions and the number of response options. Some differences were found between the minimum AOHSS and the measures in the data set, see comparison in table 2 and 3.

Table 2 Description of similarities and differences among variables, clinician reported

<i>AOHSS</i>	<i>Original question</i>	<i>Original response options</i>	<i>Question in data set</i>	<i>Response options in data set</i>
Caries staging	Caries status of every tooth	N/A, missing, sound, restored, enamel/dentine/ pulp involvement	Decayed, filled surfaces, number of missing teeth	Continuous, n
Periodontal disease staging	Basic periodontal examination/ sextant	Healthy, pocketing $<5\text{mm}$, $5-7\text{mm}$, $>7\text{mm}$	Classification according to the severity of Periodontal disease	Score, 1-5 ^a
Visible plaque	Is plaque visible on clinical examination?	Yes, no	Visible plaque index	Continuous, %

Key: NA/, not available. ^a According to Hugoson & Jordan (1982); Visible plaque on air dried surfaces according to Silness & Loe.

Table 3. Description of similarities and differences among variables, patient/person-reported

AOHSS	Original question		Original response options		Question in data set		Response options in data set	
Date of birth	Date of birth		MM/DD/YY		Age group		20, 30, 40, 50, 60, 70, 80 years	
Level of education	What is the highest level of school you have completed?		Record via per the ISCED		Which education level applies to you?		Academic degree, upper secondary school (3-4 years), upper secondary school (2 years) folk high school, elementary grade school, elementary/grade school (<6 years)	
Oral hygiene	How often do you clean your teeth?		Two or more times/day, once a day, a few times/week, never		Do you regularly (every day) use interdental brushes (IDB)?		Yes, no	
	In the last 6 months, how often have you had sugary foods/drinks?		Never, a few times/month, a few times/week, once/week, once/day, 2-3 times/day, 4 or more times/day		Do you regularly (every day) use toothpicks (TP)? Do you regularly (every day) use dental floss (DF)? How many times/day do you eat/drink something between meals? Do you drink sugar containing beverages (soft drink, energy drink or lemonade/juice) between meals?		0-9, more than 10 Every day, often (several times/week), sometimes, never	
Dry mouth experience	In the last 6 months, how often has your mouth felt dry?		Never, hardly ever, sometimes, fairly often, very often		Do you feel dry in your mouth?		Never, occasionally, often, always	
	Food alteration		Never, hardly ever, sometimes, fairly often, very often		Swedish version of OHIP-14: How often in the last year have you experienced the following situations because of problems with your teeth, mouth, or dentures?		Very often, fairly often, sometimes, hardly ever, never	
	Ability to speak		Never, hardly ever, sometimes, fairly often, very often					
	Ability to sleep		Never, hardly ever, sometimes, fairly often, very often					
Productivity								
Self-confidence								
Smiling								
Social participation								
Oral pain								
Ability to eat								
Aesthetic satisfaction	In the last 6 months, how often have you been happy with the way your teeth, gums, or dentures look?		Never, hardly ever, sometimes, fairly often, very often		Appearance of your face Appearance of your profile Appearance of your mouth Appearance of your teeth Shape of your teeth Color of your teeth Appearance of your gums Your whole appearance of your face, mouth, & teeth		Score on each question, 0-10	
	Does the patient have any of the following conditions? (CVD, DM, respiratory disease, cancer, other		Yes, no		Do you think your state of health prevents you from doing things you want to do? How do you assess your overall state of health? How do you perceive your health compared to others in your age? Which disease or condition?		Not at all, partly, largely Good, average, bad Better, similar, worse Free text	

Key: CVD, cardiovascular disease; DM, diabetes mellitus.

Caries staging and missing teeth were included as continuous measures, compared to one measure for each tooth in the AOHSS. Periodontal disease staging was classified according to Hugoson and Jordan¹³² and is an overall classification (patient level), compared to the basic examination in the AOHSS which included probing pocket depth (one recording for each sextant) and presence of bleeding on probing. Plaque index (%) was included as a continuous variable reflecting visible plaque after all tooth surfaces had been dried with air¹⁴², compared to the dichotomized measure that was included in the minimum AOHSS (i.e., visible presence of plaque or not).

Age was represented by age group in the data set that was used in the paper, and in the AOHSS the full date of birth was included to represent age. Level of education was based on the highest level of completed school with seven response options, comparable to International Standardized Classification of Educations [ISCED 2011] education programs. Three questions were merged into interdental cleaning, based on regular interdental cleaning (every day). Sugar consumption was measured by two questions regarding snacking frequency and drinking sweet drinks between meals. Dry mouth experience was represented by one question in both the minimum AOHSS and the data set, but with differences in the number of response options and time. In the AOHSS, the question concerned the last six months whereas in the original data set no specified time was given.

OHIP -14 which in previous studies has demonstrated good validity and reliability^{133,134} represented the patient-reported outcome measure [PROM]. Some differences were found, for example OHIP-14 does not concern the person's ability to sleep. The additive score for OHIP-14 was obtained by summarizing the response for each item, and the question in the original data set concerned the last year, compared to six months in the AOHSS. Regarding aesthetic satisfaction, in the AOHSS this concept is represented by a single question in the AOHSS and concerns the last six months. In the original data set the question *How do you today perceive the appearance of your face, mouth, teeth, and tooth replacements (dentures, crowns, bridges, implants)?* includes ten aspects and concerns the person's current perception of their appearance.

The variable *chronic medical condition* contains a single question in the AOHSS and has five response options. Four questions were selected from the

original data set, where three additional measures were included to fit the model and reflect current self-assessed health status. To reflect the question and response options included in the minimum AOHSS (*Does the patient have any of the following chronic conditions?*), the free text response from the question *Which disease/condition?* included in the data set was divided into the proposed medical conditions in the AOHSS, and two response options were added to reflect persons with two or multiple chronic conditions.

6.3.3. *Papers III and IV*

The material for papers III and IV consisted of verbatim transcripts of recorded interviews. For both studies, the focus was on the manifest content of the material to ensure that the meaning units remained close to the views or lived experiences described by the study participants. In total the material consisted of 270 pages, Times new roman, pt. 11, space 1.15. The transcripts constituted the base for the unit of analysis in the studies.

Paper III, was analyzed using directed content analysis ¹³⁵ as this way of categorizing data can reflect the concordance between the FDI's framework and CPAP-treated study participants' views on oral health determinants. Before analysis, a code book based on the FDI's description of *driving determinants* in their framework was developed (Appendix 4). The code book contained five predetermined categories: *i)* biological and genetic factors, *ii)* social environment, *iii)* physical environment, *iv)* health behavior, and *v)* access to care, directly derived from the FDI's framework ^{13,26}.

First, using an inductive approach, all meaning units relevant to the aim of the paper were highlighted in the transcripts. Next, the meaning units were extracted into an Excel file and carefully condensed to retain the essence of the quotation. Secondly, a deductive approach was used. By using the code book, all condensed meaning units were carefully sorted into the predetermined categories, coded, and critically reevaluated to ensure they were categorized into the appropriate category. Finally, the codes were iteratively compared and clustered into subcategories. After critical evaluation and reflection within the multiprofessional research group, a final coding scheme was confirmed by all authors.

In paper IV, the material was analyzed using CIT^{136,140}. An inductive approach was used. The analytic process has been described as a modified thematic content analysis as the researcher clusters situations iteratively based on the content of the described situations and actions guided by the aim of the paper¹⁴³. Thus, all oral health-related situations experienced by the study participants and the actions they took accordingly were highlighted in the transcripts guided by the aim of the paper. To show the variety of the descriptions in the categorization matrix, while presented in a summarized and structured manner^{136,143}, the meaning units were extracted and divided into two data sets: one containing all experienced situations, and one with the actions they (i.e., the study participant) took accordingly. During this open coding process, notes were written, and the entire description was extracted into the data sets to make sure the detailed descriptions were retained. Then the meaning units were condensed and coded. Within each data set, condensed meaning units describing a similar experience or action were clustered into subcategories and categories.

6.4. Statistical analysis

All statistical analyses were performed in IBM Statistical Package for the Social Sciences [SPSS] version 25 and 27¹⁴⁴, and in IBM SPSS AMOS version 27¹⁴⁵.

6.4.1. Paper I

PCA was used both to reduce the number of possible measures and to create subsets of measures based on intercorrelations to create components. As no prior assumptions regarding the final construction were made except for general specifications derived from the FDI's framework, PCA was regarded as a suitable method¹⁴⁶. The data was examined regarding suitability for PCA by inspection of the correlation matrix (coefficients ≥ 0.3). Factorability of the correlation matrix was inspected by performing Bartlett's test for sphericity regarding redundancy between measures (statistical significance $p < 0.001$) and the Kaiser Meier Olkin [KMO] test of sampling adequacy regarding the proportion of variance in the sample (value above 0.6)^{147,148}.

To cluster the measures, PCA was performed by using Varimax rotation with Kaiser Normalization, and the extraction method was set to a fixed number of components representing disease and condition status, psychosocial function, and physiological function. Kaiser's criteria¹⁴⁹ and Cattell's scree plot¹⁵⁰ were used to control eigenvalues >1 ¹⁵¹. The Kaiser criteria were regarded as suitable as the number of cases was large and the number of included measures <40 . The number of components was fixed ($n=3$) and therefore lay within the calculated range 2.6-4.3¹⁵². To ensure that the measures fit within the components, communalities were inspected for low values <0.3 ^{146,151,153}. The reliability of the three-component solution, measured as internal consistency, was estimated by Cronbach's Alpha. The estimation was performed for all three components to estimate the average degree of correlation between the included measures¹⁵².

A computer-generated split-file, cross-validation analysis (50% of all cases) was performed to test the stability of the three-component solution. After the data file was split in half, the statistical analyses were repeated. The results from the split-file analyses were then compared with the results from the analyses where all cases were included.

6.4.2. Paper II

First, the measures were analyzed for correlations between components¹⁵⁴. The following correlations were investigated: *Driving determinants on the core elements of oral health; moderating factors on the core elements of oral health; the core elements of oral health on overall health and well-being*. Correlations were analyzed by Pearson product-moment correlation coefficient (r) and Spearman Rank Order Correlation (ρ). Statistically significant ($p < 0.05$) measures with correlation ($r/\rho > 0.20$) with one or more of *the core elements of oral health* or regarded as theoretically relevant were selected for further statistical processing using Structural Equation Modeling [SEM]¹⁵⁵.

Using SEM have several benefits as regards reducing the complexity of data by analyzing complex relationships between multiple measures simultaneously (e.g., direct, and indirect relationships or effects between multiple measures). The direct effect of *the core elements of oral health*,

driving determinants and *moderating factors*, on *overall health and well-being*, and *driving determinants* and *moderating factors* on the *core elements of oral health* were estimated. In addition, possible mediating effects of *driving determinants* and *moderating factors* on the *overall health and well-being* through the *core elements of oral health* was also investigated (figure 4).

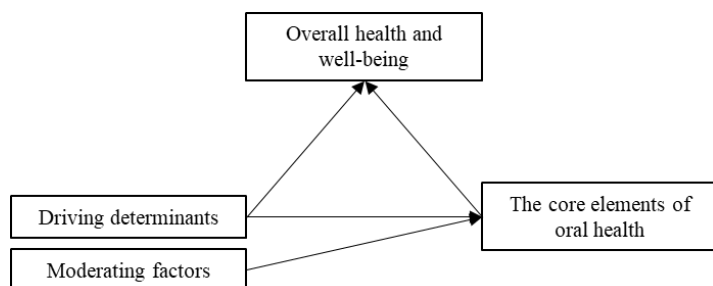


Figure 4. Description of suggested relationships between the FDI's components investigated in paper II.

The proposed model comprised two latent variables and six observed variables (aesthetic satisfaction, DFS, xerostomia, missing teeth, periodontal classification, and OHIP-14). The first latent variable was *overall health and well-being* with the following indicators: chronic conditions, perceived state of health, perceived health status compared to others of the same age, and state of health prevents you from doing things you want. The second the latent variable was *driving determinants* and *moderating factors* with indicators: age, education, regular interdental cleaning, plaque index, drinking sweet drinks between meals, and eating or drinking between meals (figure 5). Sample size was estimated by using Westland's sample size for SEM based on anticipated effect size (0.3), number of latent variables and indicators (power 0.9, $\alpha=0.05$). All cases were considered for inclusion except participants who had not responded to questions regarding sex and/or age. Little's MCAR test was used to control data for missing values and showed that data was not missing completely at random [MCAR], ($\chi^2= 35.0$, $df= 14$, $p< 0.01$). Data missing at random [MAR] was assumed as it could be presumed that missing data could be related to other observed variables, and not due to factors such as unwillingness to respond¹⁵⁶. The missing data was imputed by the Full Information Maximum likelihood [FIML] method in AMOS. According to Collier¹⁵⁷, compared to listwise/pairwise deletion of

cases, imputation or using FIML can be described as the preferred option between them as it is possible to obtain accurate estimates while maintaining the number of participants.

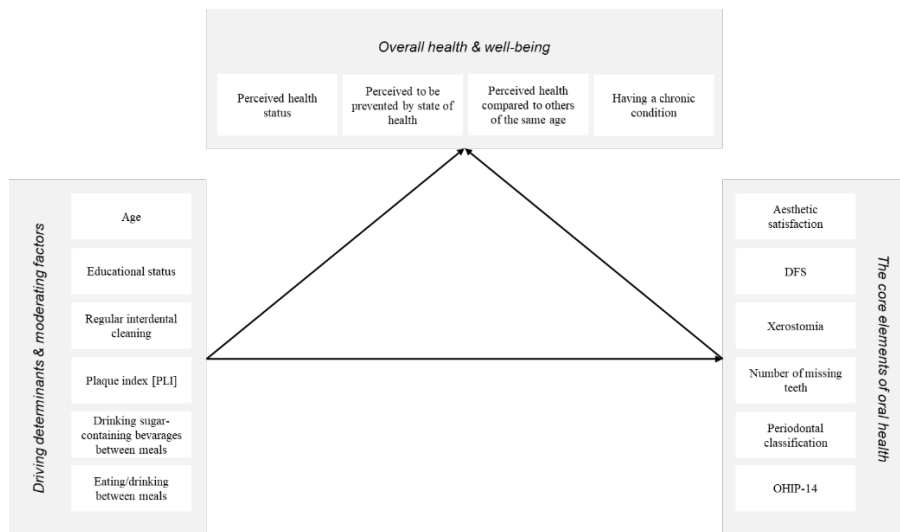


Figure 5. Proposed model for analysis in AMOS

As the multivariate assessment of normality showed non-normal distribution and to enable investigation of mediation a bootstrap analysis was performed before estimating the model using the FIML method. Bootstrap analysis was performed by using 5000 bootstrap samples, with 95 % confidence intervals¹⁵⁷. The variables included in the model were estimated using maximum likelihood which is the default method in AMOS and described as a method that provides estimates that are accurate and stable¹⁵⁸.

According to Hair et al.¹⁵⁸ multiple fit indices should always be used to evaluate model fit. Sample size, the complexity of the model, and degrees of error should also be considered when evaluating model fit. For example in smaller samples with less complexity, or with fewer indicators for latent variables the fit indices could be held to stricter values to be considered sufficient for determining acceptable or good model fit^{157,158}. To evaluate model fit, several indices were used. As the absolute fit index χ^2 - test tends to be over-sensitive in larger samples ($N > 200$), and therefore presumed to be significant, the relative χ^2 - test was also estimated (satisfactory if < 3)^{157,159}. The goodness/badness of fit indices root mean square error of approximation

[RMSEA] and standardized root mean square residual [SRMR] were estimated and considered satisfactory if $RMSEA < 0.08$ (confidence interval 0.05-0.08) and $SRMR < 0.09$. The incremental fit indices comparative fit index [CFI] and Tucker-Lewis's index [TLI] were considered satisfactory if $> .90$ ^{157,159}. Statistical significance level was $p < .05$.

7. Ethical considerations

In papers I and II, data was collected in 2013-2014. Prior to the data collection, the ethical rules described in the Declaration of Helsinki ¹⁶⁰ were thoroughly discussed and then applied, and used as guidelines for the entire process of data collection, and the processing and presentation of results. Before the data collection was initiated, the project was approved by the Regional Ethical Board in Linköping (ref. no. 2012/191-31). The ethical considerations concerning papers I and II were discussed together with the main investigator of the Jönköping studies and the research team before using the material for analysis. No further ethical approval was considered necessary but ethical aspects related to this thesis are discussed below. Regarding papers III and IV, the data collection was preceded by a research ethics evaluation and discussion based on the Declaration of Helsinki ¹⁶⁰ and CIOMS guidelines ¹⁶¹. Besides the initial ethical approval from the Regional Ethical Board in Linköping (ref. no. 2018/36-31), four additional applications regarding changes in the original research plan were approved (ref. no. 2017/451-32, 2018/261-32, 2018/348-32, 2019-05662) for the entire project. Additional applications were sent to the Regional Ethical Board in Linköping even though only minor adjustments to the initial research plan were made, such as the replacement or addition of an item in a questionnaire. This decision was based on the importance of following regulation and legislation in Sweden ¹⁶², and minimizing the risk of violating the basic ethical principles stated by Beauchamp and Childress ¹⁶³: *respect for persons, beneficence/non-maleficence and justice*.

7.1. Respect for persons

The basic ethical principle of respect for persons regards *respect for a person's* autonomy. Individually informed consent can be considered to have been obtained in all four sub-studies. Potential participants were first contacted using an information letter stating the aim of the project and papers, and providing details regarding the examination procedures, potential risks and benefits, management and storage of sensitive data and contact information. The information letter also included information regarding the participants

possibility to withdrawal from the study without negative consequences for them. The information given in all four studies, both written and verbal, was intended to fulfill the principle of *respect for persons*. The information was written to be easily understandable and the possibility to ask questions was given. All data have been handled with confidentiality and stored where unauthorized persons cannot access it. All results have also been reported in such a manner that identification of the persons involved is not possible.

7.2. Beneficence/non-maleficence

The concepts of *beneficence* and *non-maleficence* comprise not inflicting harm as well as preventing and removing harm and promoting good ¹⁶³. All four sub-studies (I-IV) sought to do good by increasing the knowledge and understanding of oral health and oral health in persons with CPAP-treated OSA. However, as stated in the Declaration of Helsinki ¹⁶⁰, the goal of generating new or increased knowledge must never take precedence over the human rights of persons involved in a research project.

Regarding papers I and II, data was collected in optimal oral healthcare settings and all examinations were carried out by experienced dentists to minimize the risk of doing harm. Participants were invited to participate free of charge and if they were not physically able to go to the dental clinic by themselves, suitable arrangements were made to enable their participation. Only necessary radiographs were carried out, and the participant's regular dental clinics were able to request the radiographs. All pathological findings were communicated to the participant and their regular dental clinic if necessary to increase the beneficial outcomes for the participant. In papers III and IV, a risk/benefit assessment was carried out during the planning of the studies. However, due to the Covid-19 pandemic restrictions, the initial plan of face-to-face interviews was revised as many participants were presumed to be at risk for a more severe infection (if infected). Firstly, the interviews were postponed for about six months based on a faint hope of improved infection rates and reduced risk for infection. During the summer/early autumn the decision to perform the interviews by telephone was made as the infection rates of Covid-19 were still too high and the risk for the participants of being infected increased.

There is always a risk involved when interviews regarding medical issues are performed and personal information discussed. To minimize the risk of feelings of discomfort or fear, the participants were able to withdraw their consent at any time, without further questions asked. The participants were also given the opportunity to choose the place of the interview, and most chose to have it in the comfort of their own home. However, there is a risk involved regarding the interview situation as the interviewer have no insight in the participants environment during the interview. There was a potential risk that the participant was not feeling comfortable in their home or in the setting of their choice, which could have affected their possibility to speak freely while feeling safe. Considering the length of the interviews and the positive conversations before and after the recording, no sign of a harmful or uncomfortable environment could be identified by the interviewer. On the contrary, many of the participants seemed to appreciate the possibility to talk about their experiences of CPAP treatment and oral health. As the interviews were conducted during a period where most had minimized their social interactions due to Covid-19 restrictions, the interviews could have contributed positively as well.

7.3. Justice

The principle of *justice* includes aspects of who receives the benefits from research and who pays the price? ¹⁶³. *Justice* can be described in terms of who is given the possibility to participate in research (e.g., regarding the invitation and physical possibility to participate) and who will benefit from the results ¹⁶⁴.

In papers I and II, the participants were randomly selected by a registrar at the County Council. The selection was based on birth month (born March through May) and was designed to include different parts of a medium sized county, with the possibility to include participants from all potential groups of assumed socioeconomic status. The benefits from participating in the original research project were received both by the participants and the surrounding community. However, the benefits for the participants in papers I and II, however, cannot be said to directly benefit the participants in the original research project. In a wider context, investigating oral health could reflect a

wider perspective on oral health that will benefit this population. Regarding papers III and IV, all eligible participants were given the opportunity to participate and to choose the place, date, and time for the interviews, which could be considered a facilitator for participation. However, when the original study was performed in 2007/9 one of the inclusion criteria was to be able to speak and understand Swedish. This may have contributed to bias in the interviews, as persons that were not eligible to participate could have had other perspectives on oral health, which might not have been described by the participants. However, the results from papers III and IV can benefit all persons with CPAP-treated OSA in the long run as the findings could increase the understanding of how CPAP treatment can affect oral health. For the participants, the immediate benefits from participating in the entire project included both a radiographic and clinical examination free of charge, and a possibility to talk about their CPAP treatment and oral health which could be perceived as positive by the participants.

8. Findings

This section will start by presenting the findings in each of the papers (I-IV). Then this is followed by a comprehensive understanding of the main findings in relation to the FDI's framework of oral health to increase the understanding of how the four papers in this thesis relate to each other and provide deeper knowledge of oral health and how it can be viewed or experienced from different perspectives.

8.1. Papers I and II

By using PCA in paper I, 13 clinical and self-reported/person-reported measures were included in the three fixed components representing: *disease and condition status*, *physiological function*, and *psychosocial function*. Four measures were included in the component *disease and condition status* (DFS, experience of periodontal disease, missing teeth, number of dental implants, crowns, and bridges), four in *physiological function* (ability to chew tough foods, perceived ability to chew, physical pain, and functional limitation), and five in *psychosocial function* (social, physical, and psychosocial disability, handicap, and psychosocial discomfort). When inspecting the pattern matrix, cross-loadings were found between the components *psychosocial function* and *physiological function* regarding the measures physical pain and functional limitation (0.47 and 0.41, respectively but with higher loadings in the latter, 0.48 and 0.45, respectively). The final three-component solution explained 60.85% of the variance in total (table 4). The cross-validation (computer-generated split-half) analyses showed no major differences.

In conclusion, for an adult general Swedish population, 13 clinician and self/person-reported measures could be considered relevant for inclusion in *the core elements of oral health* in the FDI's framework.

Table 4. Description of the PCA statistics

Bartlett's test for sphericity	$\chi^2=2871.15$, $P<0.001$	
KMO test of sampling adequacy	0.78	
Communalities	0.37-0.76	
Component loadings	0.45-0.87	
Component	Variance explained	Cronbach's Alpha
Psychosocial function	31.61%	0.87
Disease & condition status	18.57%	0.68
Physiological function	10.67%	0.61

Key: KMO, Kaiser Meier Olkin

In paper II, one model was constructed based on the FDI's framework using SEM. As predicted, the χ^2 -test was significant (239.302, df 81 < 0.001), but the relative χ^2 -value was considered acceptable (2.954), table 5. Together, the predictors explained 24.1% of the variance of *overall health and well-being* (latent variable). Statistically significant direct effects were found, but no indirect effects (mediation).

Table 5. Description of model fit statistics

<i>Model fit statistics</i>	<i>Value</i>
CFI	0.933
TLI	0.900
RMSEA (CI 90%)	0.056 (0.048-0.064)
SRMR	0.0597

Key: CFI, comparative fit index; TLI, Tucker-Lewis's index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual.

In the model, the following statistically significant effects were found. *Driving determinants and moderating factors* had statistically significant direct effects on *the core elements of oral health* (xerostomia, periodontal classification, missing teeth, OHIP-14, and DFS). *The core elements of oral health* (xerostomia, OHIP-14, and aesthetic satisfaction) had statistically significant direct effects on *overall health and well-being* (Table 6).

Table 6. Statistically significant direct effects in the proposed model

<i>Effect</i>	<i>B</i>	<i>Bootstrap SE</i>	<i>Bias-corrected CI (95%)</i>	<i>p-value</i>
On overall health and well-being				
Xerostomia	0.209	0.050	0.106-0.304	<.001
OHIP-14	-0.321	0.052	-0.420--0.216	<.001
Aesthetic satisfaction	-0.112	.0047	-0.201--0.017	.023
Driving determinants & moderating factors on the core elements of oral health				
Xerostomia	0.120	0.040	0.043-0.198	.004
Periodontal classification	0.516	0.030	0.455-0.572	.001
Missing teeth	0.485	0.026	0.431-0.533	.001
OHIP-14	0.176	0.036	0.103-0.245	<.001
DFS	0.761	0.023	0.712-0.802	.001

Key: β , bootstrapped standardized estimate; SE, standard error; OHIP-14, Oral Health Impact Profile

Statistically non-significant effects (direct and indirect effects, $p > 0.05$) were also found. *The core elements of oral health*: periodontal classification, missing teeth, and DFS, had no statistically significant direct effect on *overall health and well-being*. The latent variable *driving determinants and moderating factors* had no direct or indirect effect (mediated by *the core elements of oral health*) on *overall health and well-being* ($p=0.380$), or on *the core element of oral health* aesthetic satisfaction (Table 7).

Table 7 Non-statistically significant effects in proposed model

<i>Effect</i>	<i>B</i>	<i>Bootstrap SE</i>	<i>Bias-corrected CI (95%)</i>	<i>p-value</i>
On overall health and well-being				
Periodontal classification	0.046	0.053	-0.058-0.147	0.383
Missing teeth	0.087	0.056	-0.020-0.199	0.113
DFS	0.053	0.078	-0.100-0.202	0.486
Driving determinants and moderating factors	0.033	0.097	-0.159-0.230	0.762
Driving determinants & moderating factors on the core elements of oral health				
Aesthetic satisfaction	0.023	0.042	-0.064-0.104	0.616

Key: β , bootstrapped standardized estimate; SE, standard error; OHIP-14, Oral Health Impact Profile

In conclusion, the overall model fit was considered acceptable but not excellent. Not all the hypothesized relationships were statistically significant. In this general population, *driving determinants and moderating factors* had direct effects on *the core elements of oral health* except aesthetic satisfaction, three of *the core elements of oral health* had a direct effect on *overall health and well-being*, but *driving determinants and moderating factors* had no direct effect on *overall health and well-being*. No indirect effects were found. The FDI's framework could be used to describe different aspects or components of oral health and the relationship among them in this population and setting, and thereby support further research using the FDI's framework as a basis for exploration.

8.2. Papers III and IV

In paper III, five predetermined categories based on the FDI's description of the dimensions of oral health determinants was used. In the first category, *Biological and genetic factors*, meaning units were divided into three subcategories: consequences of life stages, one's genetic predisposition is a part of oral health, and the influence of saliva (Table 8). In this category, the study participants described their views on how differences in the stages of life could influence them immediately and later in life. They also described how their genetic differences, described as heritage, could play a part in the development of oral diseases. Based on heritage or luck, some people were more susceptible to oral disease, and for them it was harder to balance risk factors and protective factors. The saliva was also viewed as an important biological factor. During CPAP treatment, xerostomia was common even if they also considered other factors such as increasing age to affect the saliva flow.

Table 8. Description of the meaning units and subcategories in the category Biological and genetic factors

Meaning unit	Sub-category	Category
<i>"(...) I don't think it is just the CPAP [that increase the oral dryness], I try to think that it is, (...) both the CPAP and becoming older (...)."</i>	Consequences of differences in life stages	Biological& genetic factors
<i>"When I was in my mom's belly. My mom ate well, so she affected me when the teeth developed (...)"</i>		
<i>"(...) there are those around me (...), who are extremely careful with their teeth and brush and keep going on, (...) who have much worse teeth than I've ever had. So, it's not just how you take care [of your teeth] but a little bit of luck and what you have inherited as well".</i>	One's genetic predisposition is a part of oral health	
<i>"(...) That's why I say that that I think I have a good heritage (...)"</i>		
<i>"(...) That you get more oral dryness, and it is not the same...maybe it releases a bit more...as everything dissolves. (...) and then I wonder if they [the restorations] release more if they are drier or if they calm down and release more if they are wet? (...)"</i>	The influence of saliva	
<i>"It is probably the saliva, it's a lot and then (...)"</i>		

The category *Social environment* included descriptions of how the study participants viewed the influence their social surroundings had on their oral health. Two subcategories (influence from one's family members and influences from oral health campaigns and advertisements) included meaning units describing their views on how the social environment formed their oral health habits in childhood and altered in adulthood. The immediate family, peers, and the social context were viewed to have influenced their oral health habits including dietary and oral hygiene habits. In the category *Physical environment* (influences from one's local environment and changes in one's environmental circumstances), the study participants described their view on their local environment in childhood and during CPAP treatment. Specific factors such as naturally high levels of fluoride in drinking water during childhood and air humidity due to seasonal changes or change of location were described as influential on their oral health (table 9).

Table 9. Description of the meaning units and subcategories in the categories social and physical environment

Meaning unit	Sub-category	Category
<p><i>"(...) you don't have to go further than to your own children or grandchildren and compare their oral health to mine. It's a big difference. (...) But it [oral hygiene habits] can vary between families, I don't know, I only know how it is with us (...) "</i></p> <p><i>"No, no, it wasn't. Not at all. Not at all when I was little, I almost said... It wasn't good. (...). If it had been done in another way and a bit more, then I might have looked different today, it's possible."</i></p>	<p>Influence from one's family members</p>	Social environment
<p><i>"(...) It's not that easy today because we are overwhelmed by commercials for a lot of stuff that is not healthy. Unfortunately. "</i></p> <p><i>"Sometimes it's the one [toothpaste] that the dentist recommends, that they advertise (...) "</i></p>	<p>Influences from oral health campaigns and advertisements</p>	
<p><i>"(...) where I grew up, where I live now as well, there it has always been a lot of fluoride (...). It could have been good; it could strengthen the teeth. But then it has been a couple of years in between (...). That it [dental caries] have developed...I have gotten dental caries (...) "</i></p> <p><i>"It could have been different in different places, but I was born on the countryside and maybe the teeth weren't so important out there. I don't know".</i></p>	<p>Influences from one's local environment</p>	Physical environment
<p><i>"Yes, but more or less [xerostomia]. But it can be worse some days, some mornings it can be worse (...) for example, if you don't have the window open, one night, it can be the fresh air, that's not bad either, it comes in [the bedroom] in one way or another (...) "</i></p> <p><i>"(...) but if you are abroad in a different location where you can't have the same hygienic situation as you do at home then it becomes a bit sloppy sometimes (...) "</i></p>	<p>Changes in one's environmental circumstances</p>	

The category *Health behavior* (the oral health habits one forms, support from oral health professionals, one's motivation to maintain oral hygiene, and willingness to change one's behavior) included descriptions of the study participants' views on their oral health habits. The oral health behavior (hygiene habits, dietary habits such as snacking, and utilization of oral healthcare) was viewed to have been formed during childhood but could change during life due to previous experiences or education. Having healthy habits such as regular tooth brushing and interdental cleaning and not eating a lot of sugar-containing products were viewed as important and could be influenced by the support from oral healthcare personnel, participants' motivation, and willingness to change when needed (table 10).

Table 10. Description of the meaning units and subcategories in the category health behavior

Meaning unit	Sub-category	Category
<p><i>"(...) But I think I heard it from someone that you either have one or the other [dental caries or calculus]. However, sometimes I have noticed that you have both, you [I] had both cavities and calculus (...)"</i></p> <p><i>" Yes, it's important to have good oral hygiene, not snack between meals, not that much sugar. And go to the dentist or dental hygienist regularly and take care of it."</i></p>	The oral health habits one forms	Health behaviors
<p><i>"(...) if you [I] had received it [the information] during my 20s you know, it had probably affected [my oral health] in a different way... (...) (pause) Yes, it had affected it [oral health], that I am convinced of, but then if you are receptive for it [the information] it's like that. Maybe I wasn't. It's possible that someone tried, one [I] was not receptive for it [the information]"</i></p> <p><i>"(...) the latest 10–15 years I have had quite frequent visits with the dental hygienist and gotten a few advise by that. She has improved my dental hygiene so to speak."</i></p>	Support from dental professionals	
<p><i>"(...) Brushing your teeth is, as you say, in the bone marrow, I have always done it (...)"</i></p> <p><i>" Yes, if you don't brush your teeth, it doesn't feel as smooth and fresh in your mouth".</i></p>	One's motivation to maintain oral hygiene	
<p><i>"Yes, I have, it is probably that I have understood that there are some risks that when you, with the CPAP the oral hygiene could deteriorate (...)"</i></p> <p><i>" I don't eat that much candy. I can maybe eat some candy, but that can't be that bad."</i></p>	Willingness to change one's oral health habits when needed	

In the category *Access to care*, three subcategories were described (having and taking opportunities for oral healthcare, financial aspects of oral healthcare, and trust in oral healthcare personnel), as well as views regarding determinants affecting oral healthcare visits throughout life. For some, parental education or profession had a positive effect on availability during childhood, but descriptions of lack of availability of oral healthcare clinics or oral healthcare was also present. The views from the study participants showed that other factors than having an oral healthcare clinic available or nearby affected their view on having access to oral healthcare. Aspects regarding having control, organization of oral healthcare, the financial separation between general and oral healthcare, and having trust in oral healthcare personnel were viewed as influential (table 11).

Table 11. Description of the meaning units and subcategories in the category access to care

Meaning unit	Sub-category	Category
<p><i>"Otherwise, it is better to go to the dentist a bit more often, then you have more control, you know. (...) It is important."</i></p> <p><i>" (...) but it was something [an oral health problem] we were supposed to go to that dentist and check it up. Was always available (...)."</i></p>	Having and taking opportunities for oral health care	Access to care
<p><i>"(...) But I can also understand why some people don't go, it's too expensive. That's what I mean it should be included in the regular health insurance system because it is equally important as the rest of the body (...)."</i></p> <p><i>" It's a lack of dental hygienists too or if it's a lack of money, I don't know which it is."</i></p>	Financial aspects of oral health care	
<p><i>"A treatment like that as it was back then. It was forced treatment, because they tied one [me] to the dental chair to make me sit still. And then it wasand the drills ...the water they kept going until there was smoke, now it is water cooling so now it doesn't feel either. The old drills were driven by big straps in the ceiling, it was a terrible appliance. Just to see the equipment made you, [I felt I] almost died."</i></p>	Trust in oral health care personnel	
<p><i>"Yes, it sure is (...). It's very important what dentist you have, really. I would say that you need someone you both can trust and talk to and get advice on different alternatives of what you can do."</i></p>		

In conclusion, from the perspective of persons with experience of CPAP treatment, a range of different oral health determinants related to all five dimensions in the FDI’s *driving determinants* can affect a person’s oral health during life. CPAP treatment can be considered an oral health determinant which also interacts with other oral health determinants, showing that CPAP treatment is an important aspect to consider when assessing a person’s oral health.

In paper IV, the study participants described oral health-related situations they had experienced with or without their CPAP, and the actions they took accordingly. Two main areas (CPAP treatment affects oral health and adapting to everyday life with CPAP) described situations and actions, respectively (figure 6, 7).

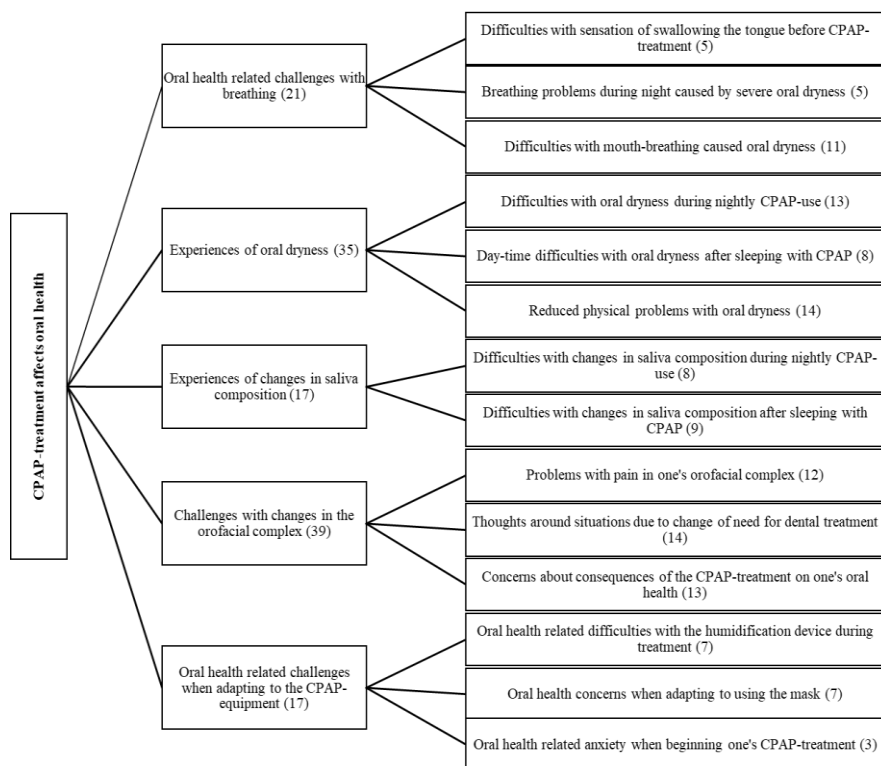


Figure 6. Situations experienced by persons with experience of long-term CPAP treatment (in parenthesis: number of quotations)

The study participants described situations of experienced challenges with breathing due to mouth-breathing, a choking sensation (swallowing the tongue), and breathing problems due to xerostomia (referred to as oral dryness in paper IV). The experiences of xerostomia could vary in degree of severity and could occur during CPAP use at night and after CPAP use during day. Xerostomia upon awakening was commonly described, often decreasing or vanishing soon after awakening but could also remain during the day. The study participants also described situations where they experienced alterations in their saliva composition where the saliva was described as more viscous. But they also described how their oral health had changed, suddenly or unexpectedly. The changes in oral health could lead to negative thoughts or concerns about how their CPAP treatment affected their oral health. This could make them question their treatment. Even so, there were also

descriptions of how the study participants received praise for their oral health or oral hygiene.

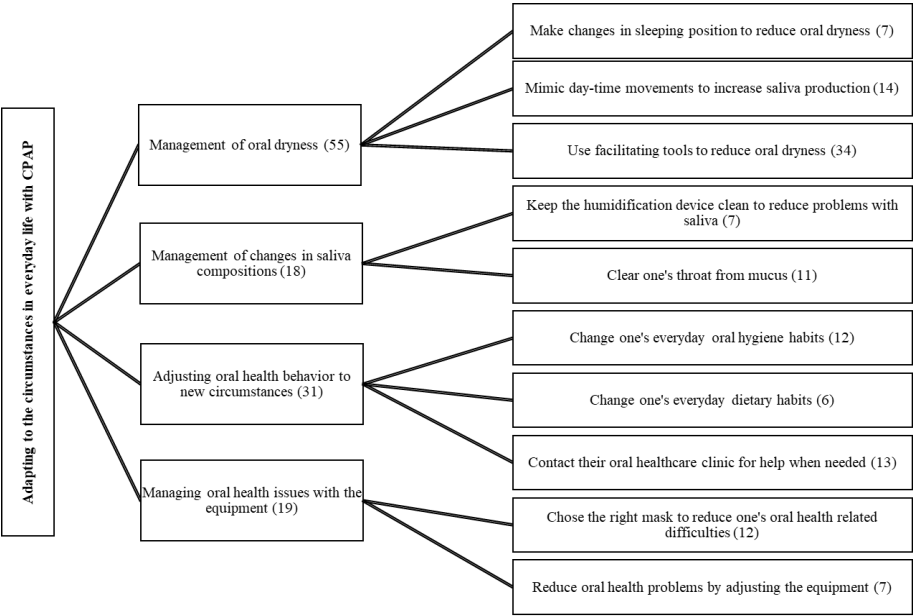


Figure 7. Actions to manage oral health-related challenges with or without CPAP treatment (in parenthesis: number of quotations)

When they experienced challenges or problems with xerostomia, the study participants drank tap water, rinsed their mouth, or used a chinstrap and/or humidification. They also increased the movement of the tongue, lips, or mouth, but also sat up, changed sleeping position, or got out of bed. In contrast, there were also descriptions of how CPAP treatment had reduced their xerostomia, due to eliminating mouth-breathing and use of humidification. If they experienced alterations of their saliva, they managed this by cleaning the humidification device or by coughing. If the study participants experienced problems with their oral health (e.g., pain, discomfort, or fractures) they changed their everyday oral health habits (e.g., dietary, oral hygiene) or contacted their oral healthcare clinic. If negative feelings related to their oral health emerged, the study participants described how choosing the right mask and adjusting the mask could be other ways to get used to their treatment and to adhere to their treatment.

In conclusion, persons with experience of CPAP treatment experienced a range of oral health-related situations related to CPAP-treated OSA. The oral health-related situations were both positive and negative, with the latter often being successfully managed, which may contribute to long-term CPAP adherence.

8.3. Comprehensive understanding of the findings in relation to the FDI's theoretical framework

First, an illustration summarizes the findings from all four sub-studies combined by adapting the FDI's framework according to the findings (figure 8). In the FDI's definition and framework, oral health is described to be multifaceted, and influenced by a range of factors in our everyday life and the complex interactions among them. In this summary, the interactions among the components in the FDI's framework are described in relation to each other, based on the findings in papers I-IV.

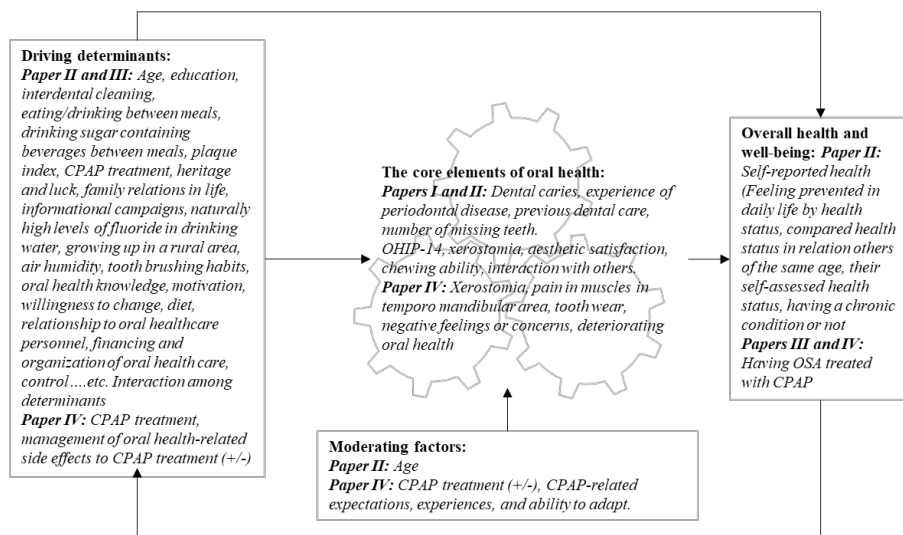


Figure 8. Summary of findings in papers I-IV incorporated in the FDI's framework of oral health (+/- indicates positive and negative effects/experiences)

8.3.1. *The core elements of oral health*

In papers I and II, all three dimensions *of the core elements of oral health* as described by the FDI could be described by clinician and person-reported measures: disease and condition status, physiological function, and psychosocial function. Clinician-reported measures of the presence of dental caries, classification of periodontal disease, number of missing teeth, and previous dental care (restorations, dental implants, crowns, and bridges), as well as patient/person-reported measures of aesthetic satisfaction, presence of xerostomia, OHRQOL, and chewing ability, were included. Together, they represent more than one dimension of oral health and show that oral health is a multifaceted concept in this general adult Swedish population.

Situations experienced by persons with experience of CPAP treatment in paper IV, related to the level of xerostomia, which was described as a *core element of oral health* in paper II. The study participants described xerostomia as a part of their oral health. Their experiences ranged from mild to severe xerostomia, and these affected their functional abilities (ability to sleep, talk, swallow, and breathe). They also described how changes in the saliva composition could affect their social interactions as they changed their habits by avoiding coughing when with other people or by explaining why they coughed. The study participants also described experiences of pain in the muscles in the tempo mandibular region and excessive tooth wear causing sores on the tongue (related to *physiological function* and *disease and condition status*). Another *psychosocial function* they experienced was the negative feelings caused by problems in their mouth (fractured restorations or crowns, sudden changes of oral health status).

The study participants' descriptions also show the relationship between *the core elements of oral health* and *overall health and well-being*, as described in the FDI's framework (figure 8). Negative experiences of xerostomia and deteriorating oral health (*the core elements of oral health*) influenced their well-being and could also make them question their CPAP treatment. In contrast, a reduced level of xerostomia (included as a *core element of oral health* in paper II) improved their *overall health and well-being*, as it improved their sleep and led to a better perceived general QOL. In paper II, this relationship was also shown by the direct effect that OHIP-14, xerostomia,

and aesthetic satisfaction had on the latent variable *overall health and well-being*.

8.3.2. *Driving determinants*

In papers II and III, the findings show that several determinants can affect or influence or are viewed as affecting the oral health, as described in the FDI's framework. The common determinants from the general population in paper II and the views from the specific population of persons with experience of CPAP treatment in paper III concerned oral healthcare habits (e.g., interdental cleaning), dietary habits (e.g., eating or drinking sugar-containing products), and education or parental education. Age was included in the component *driving determinants and moderating factors* in paper II and was also described in paper III as something that could affect the study participants' oral health (increasing age or challenges in different life stages). In paper II, plaque index was also included and could be associated with the oral hygiene habits described in paper III (the importance of tooth brushing and interdental cleaning).

In paper III, the oral health determinants described by the study participants were divided into the five dimensions in the FDI's framework. The persons with experience of CPAP-treated OSA described in an elaborated manner which determinants they viewed to affect their oral health, previously or currently. Xerostomia was regarded as a *core element of oral health* in papers II and IV, but the influence of saliva and xerostomia during CPAP treatment was described in paper III as an oral health determinant. In paper III, decreased salivary flow was viewed to affect their teeth, increase the risk for adverse oral health outcomes, but also to make them more careful with their oral hygiene habits to prevent adverse oral health outcomes when treated with CPAP.

Views in paper III also concerned balancing or compensating for a disadvantaged heritage or negative experiences from childhood throughout life, which was viewed as important since early life experiences were considered to affect them later in life. The social and physical environment was described to affect their oral health differently during childhood and adulthood. Naturally high levels of fluoride in drinking water during childhood was viewed as having strengthened their teeth, and changes in air

humidity could affect their experienced level of xerostomia during CPAP treatment when changing location or due to seasonal changes in adulthood. Also, their oral health habits were described as having been formed during childhood, but also altered in adulthood, including both tooth brushing with fluoride toothpaste and interdental cleaning. But this was affected by the support they received from oral healthcare personnel, their own motivation, and willingness to change when needed. CPAP treatment could increase their awareness of their oral health and make them more motivated to change their oral health behavior. The willingness to change varied and was affected by their view on their possibility to change. This related to the views on trust in oral healthcare personnel, where a trustful relationship could facilitate involvement in treatment planning. When experiencing a lack of trust, the study participants considered changing their oral healthcare provider.

The findings in paper III also concerned the complex relationships among *the core elements of oral health*, *driving determinants*, and *overall health and well-being* as described in the FDI's framework. The study participants recognized that as their OSA (*overall health and well-being*) was treated with CPAP (*driving determinant*), this could affect their oral health in a positive or negative direction (*the core elements of oral health*), which in turn could affect their well-being (*overall health and well-being*). In relation to this, the study participants in paper IV described oral health-related situations that they experienced with and without CPAP treatment and the actions they took accordingly. The persons described how they could affect their oral health by management of xerostomia (described as oral dryness), changes in saliva composition and changes in the orofacial complex. By successful management of their oral health-related challenges, they could stay adherent to their CPAP treatment and thereby experienced a positive effect on their *overall health and well-being*. In paper II, the relationship between *driving determinants* and *moderating factors* and *the core elements of oral health*, as *driving determinants and moderating factors* had direct effects on all of *the core elements of oral health* except aesthetic satisfaction. However, no indirect effect could be found (i.e., *driving determinants and moderating factors*) on *overall health and well-being* mediated by *the core elements of oral health*), in contrast to paper IV where this relationship could be noticed in the descriptions provided by the study participants.

8.3.3. *Moderating factors*

In paper II, *moderating factors*, which is described as factors that affect how a person values, score or rate their oral health in the FDI's framework, were represented by age. Together with *driving determinants*, *moderating factors* had a significant direct effect on all *the core elements of oral health* in the model, except for aesthetic satisfaction. The study participants in paper IV described how CPAP treatment made them concerned or had caused negative thoughts about their oral health. This indicates how they value their oral health by showing a change in their rating of their own oral health with or without CPAP treatment. The persons seemed to rate their oral health as worse during CPAP treatment as they experienced concerns in relation to changes in their orofacial complex, exemplified with the view of deteriorating oral health in general, or sudden changes creating a need for more invasive dental treatments. Increasing age was described as an alternative reason for their experiences of worsened oral health due to experiences of xerostomia. In contrast, the descriptions of reduced xerostomia when using the CPAP device seemed to make them rate their oral health higher, as the humidification or other facilitating tools eliminated or reduced their oral health-related problems or challenges. This also relates to the descriptions of expectations, experiences, and adaptability in paper IV, which in the FDI's framework can affect how a person value/score their oral health. Descriptions of how they adapted to their CPAP treatment contributed to how they rate their oral health, as they would still consider themselves to have good oral health despite experiencing oral health-related difficulties such as xerostomia or negative thoughts. In paper IV, they described how their experiences made them question their CPAP treatment which also related to their expectations. If they had known that their oral health would deteriorate during CPAP treatment, they might have considered not starting use of CPAP at all, which could be interpreted as a decrease in their rating of their oral health, but also indicating how they value their oral health in relation to their CPAP treatment.

8.3.4. *Overall health and well-being*

In paper II, *overall health and well-being* was represented with four patient-reported questions concerning how the study participants assessed their state of health, whether their state of health prevented them from doing things they

wanted to do, how they rated their state of health compared to others of their age, and whether they had any chronic conditions. In paper II, three *core elements of oral health* (OHIP-14, xerostomia, and aesthetic satisfaction) showed direct effects on *overall health and well-being*. *Driving determinants* and *moderating factors* did not show any significant direct or indirect effects (mediated by core elements of oral health) on *overall health and well-being*. Relating to *overall-health and well-being*, were the views on the financial and organizational separation between general healthcare and oral healthcare in Sweden described in paper III. This separation was questioned as the study participants viewed oral health as part of their overall health and well-being. The organizational aspects were further exemplified in paper IV, where the organizational challenges seemed to contribute to lack of treatment for OSA. In paper III, the study participants described how their overall health and well-being could be affected by oral health determinants, but also that their overall health could contribute to their possibility and ability to make changes in their oral health habits (e.g., medication use or physical challenges). The complex relationship among *overall health and well-being*, *driving determinants*, and *the core elements of oral health* described above was also described by the study participants in paper IV. The oral health-related situations they had experienced with or without CPAP treatment were all related to their CPAP-treated OSA, that is: how their overall health affected their oral health. With or without CPAP, they described how their oral health was affected in a positive or negative direction (e.g., reduced, or increased xerostomia, changes in saliva composition and changed need for oral healthcare).

9. Discussion

In this thesis, the overall aim was to gain a deeper understanding of oral health by exploring how the FDI's theoretical framework can be applied in a general population and how oral health is experienced in a specific population of persons with an increased risk for adverse oral health. The wider approach in papers I and II was used to set the frame of reference to the oral health context while papers III and IV further elaborated on how oral health can change during a lifetime and illustrated a person's ability to adapt to circumstances after experiencing a specific (sometimes) life-changing event. Previously, research on oral health in persons with CPAP-treated OSA has been predominantly focused on the presence or progression of diseases (e.g., periodontal disease) or treatments relevant to oral healthcare (i.e., OA). Research focusing on *oral health* or views from the persons receiving CPAP treatment has been scarce. Obtaining a comprehensive picture of the oral health of persons with CPAP treatment can therefore be difficult, and knowledge of barriers or facilitators for maintaining oral health during CPAP treatment have been lacking as well. By exploring views on oral health determinants in a broader perspective with open-ended interview questions it was possible to explore if (paper III) and how (paper IV) CPAP treatment could affect oral health and thereby, if CPAP treatment could be viewed as an oral health determinant. However, the possible associations between CPAP-treated OSA and oral health need to be further investigated, and the findings in this thesis can be used as a starting point.

By using empirical data, it was possible to show that oral health is a multifaceted and changeable concept that can be affected by several determinants throughout a lifetime. In short, *the core elements of oral health* can be described by using both clinician and person-reported measures, *driving determinants* can be described in a population by factors from all five domains suggested by the FDI, *moderating factors* can include age, experiences, expectations, and ability to adapt, and *overall health and well-being* can be described by person-reported health. The findings also showed that from a person perspective, CPAP-treated OSA can be viewed as an oral health determinant as it can affect a person's oral health both positively and

negatively, where the latter can be successfully managed, often with easily accessible facilitating tools. Combined, the findings illustrate oral health from different perspectives and populations including the professional perspective of clinician and person-reported oral health measures and specific views and experiences as described by persons with an increased risk for adverse oral health.

9.1. The FDI's definition and theoretical framework

The FDI's framework describes oral health and how complex interactions among the components in the FDI's framework affect each other and is stated to build on previously suggested definitions and frameworks of oral health. For example, the circular way of illustrating oral health was used by MacEntee¹⁶⁵ and further developed by Brondani et al.⁴⁰, showing that factors that affect oral health change and interact with each other in a non-hierarchical way. Other definitions and frameworks have been identified by Lee et al.²¹ to have influenced the FDI's definition and framework, such as Fischer-Owen's conceptual model for influences of children's oral health¹⁶⁶ and Watt and Sheiham's³⁹ integration of the common risk factor approach in a social determinants framework. Thus, the FDI's definition and framework incorporates previous models for oral health which previously have been influential on research in several areas regarding for example oral health in different life stages and differences in contextual factors affecting oral health.

By proposing a new definition and accompanying framework, the FDI also intended to move dentistry toward oral health promotion and support¹³. However, the FDI's definition and framework were mainly developed by dentists and are directed toward all oral health professionals, and the relevance for dental hygienists and for this thesis is worth considering. In the professional profile and competence description for European dental hygienists¹⁶⁷, the dental hygienist is described as the key provider of preventive and promotive oral healthcare for persons, groups, and societies. In that sense, working toward oral health promotion lies within the scope of the dental hygienist profession, which also was highlighted by Watson¹⁶⁸ in an editorial on how the FDI's definition and framework relates to the dental hygienist profession. Moreover, both in the common European curriculum for

dental hygiene ^{169,170} and in Watson's editorial ¹⁶⁸, the person-centered approach, as well as behavioral, biomedical and social aspects of oral health are highlighted, but also the importance of taking the person's perspective and lived experience in consideration when planning oral healthcare. Watson ¹⁶⁸ also described the association between oral and overall health and well-being and the increasing interest among dental hygienists in learning more about OSA. From a dental hygienist perspective, those aspects could be considered included in the FDI's definition and framework. Considering the FDI's intentions and the promotive and preventive foundation of the dental hygienist profession, exploration from our perspective can contribute to an increased understanding of oral health. However, it should be mentioned, that choosing FDI's definition and framework as the basis for exploration was sometimes a challenge. As the definition and framework were proposed quite recently ²⁶, previous studies based on the definition and framework are lacking and the descriptions of the different components are somewhat vague and not clearly described. For example, *driving determinants* are divided into five dimensions but the description of this component does not clearly state what makes an oral health determinant *driving* nor the distinction with or relationship to *moderating factors* ²⁶. There are also other pathways or relationships among the components in the FDI's framework that should be further investigated based on the findings in papers III and IV.

9.1.1. *The core elements of oral health*

In this thesis, *the core elements of oral health* were represented by both clinician and patient/person-reported measures (papers I and II), and in paper IV the study participants described their oral health in relation to situations they had experienced with and without CPAP treatment. The clinician-reported measures from papers I and II showed similarities with Listl's seven tentative key elements for assessing oral health outcomes (i.e., tooth loss, dental caries, and periodontitis), and the patient/person-reported (i.e., oral function, orofacial pain, orofacial appearance, and psychosocial impact). Even though Listl ¹⁷¹ referred to value-based oral healthcare, and the key elements were used for illustration, the importance of also including the person perspective was highlighted. Furthermore, gathering both clinician and person-reported data has been suggested to be relevant when comparing oral

health among countries ¹⁷². The importance of also involving the person and a focus on preventive oral healthcare instead of just focus on clinical measures of oral diseases or conditions was underlined. This is also described in the FDI's framework as *the core elements of oral health* do not only refer to clinical measures, but also physical and psychosocial functions. Measuring the presence and progression of oral diseases is important, but as tooth loss, pain, and discomfort due to oral diseases/conditions can affect physiological and psychosocial functions, several aspects of oral health should be considered. In this thesis, the progression of oral diseases was not possible to analyze in papers I and II as cross-sectional data was used. However, including factors such as the presence of oral diseases, missing teeth, and restorative treatments could in some way show different stages of oral diseases. The bidirectional or circular representation of the relationships among the components was also described in paper IV where the persons described how experiences during CPAP treatment influenced them in a negative direction and how it affected their physiological and psychosocial functions. Acknowledging the person perspective on oral health is essential in both person-centered oral healthcare ^{173,174} and shared decision-making ¹⁷⁵. Within healthcare settings, several models of shared decision-making exist ¹⁷⁵, commonly describing how factors such as personal preferences, tailoring information, and learning about the person are important components. In oral healthcare settings, studies regarding shared decision-making are limited ¹⁷⁶. In Sweden, the caregiver is obligated to inform their patients about diagnosis and prognosis, as well as treatment needs or alternatives ¹⁷⁷. To obtain informed consent, it is important that the patient understands the given information. But in shared decision-making, other factors than informed consent are important to consider. To gain an understanding of the person encountered, awareness of the contextual factors is essential as there are differences in everyday life among persons. Thus, the findings in papers III and IV can be useful in describing oral health determinants, real-life experiences, and management of oral health-related situations in this patient group.

Xerostomia was described as a *core element of oral health* and as a part of the study participants' oral health (papers II and IV). Referred to as oral dryness, xerostomia was experienced to interact with several important functions such as speaking, breathing, and sleeping. Moreover, changes in their oral health

status caused negative thoughts or concerns regarding their CPAP treatment. Altogether, the descriptions pointed out how their psychosocial functions were affected. Therefore, it is important for oral healthcare professionals and CPAP practitioners to be aware of the associations among OSA, CPAP treatment and oral health as such awareness enables identification of oral health-related difficulties during CPAP treatment and makes it possible to provide adequate treatment. Previously, dentists' knowledge about OSA has been described to be increasing due to increased scientific publications within sleep medicine and interest in OA-treatment ¹⁷⁸. Berggren et al. ¹⁷⁹ described how oral healthcare professionals in Sweden identified persons with OSA by formal and informal conversations, and by anatomic markers such as the form of the palate and tongue, but also said that the knowledge and experience varied. Despite this, increased interprofessional collaborations among persons encountering this group of persons was encouraged ¹⁷⁹. The FDI's definition and framework is stated to be written in terminology common within healthcare ¹³, and could therefore be used to further illustrate the association among oral health and CPAP-treated OSA, and thereby be a way to enable increased interdisciplinary collaboration. Development of innovative workforce teams including professionals from both the oral and general healthcare sectors has been considered an effective model, but increases the demand on the professionals' skills (e.g., interprofessional collaboration and communication) ¹⁸⁰ which is also highlighted in the common European curriculum for dental hygienists ¹⁶⁹. At present, there is no general structured care program or a defined educational plan for caregivers regarding OSA, but recently, a national care program for treatment of adults with OSA was published, with the main purpose of building a foundation for equal care for this group in Sweden ⁹⁰. This is essential as equal care for the entire population is a (human) right regulated by legislation in Sweden ³⁵. When the care plan and more structured educational activities have been implemented, this can contribute to improvement in equality and structure in the care of persons treated with CPAP. Even if oral healthcare professionals are mainly involved in treatment with OA, identifying and adequately treating patients experiencing oral health-related difficulties or challenges during CPAP treatment could contribute to increased CPAP adherence. Hopefully the findings provided here can be useful in clinical settings for both oral healthcare professionals and CPAP practitioners. By highlighting the person

perspective on oral health, this thesis could contribute to increased understanding of the association among OSA, CPAP treatment and oral health, which later could contribute to enabling increased interdisciplinary collaboration.

9.1.2. *Driving determinants*

In the FDI's framework, *driving determinants* have both direct and indirect effects on other components in the theoretical framework¹³. Even though no indirect effects could be found in paper II, descriptions of how *the core elements of oral health, driving determinants, and overall health and well-being* could affect each other were expressed by study participants in papers III and IV. The subcategories in paper III entail numerous descriptions of several of the *driving determinants* included as indicators in paper II even if not visualized as sub-category names. The study participants described their views on how determinants such as education (own and parental), interdental cleaning, and dietary habits had affected their oral health during life and during CPAP treatment. The findings in paper III provided a deeper insight into how the persons reasoned regarding their habits or how the social and physical environment influenced their oral health. This information is valuable as the measures or indicators included in paper II only provide information regarding *the what*, and not *the why or how* from the persons' point of view.

However, the model presented in paper II somewhat fails to acknowledge the structural level of oral health determinants as the model mainly included intermediate determinants. But the component *driving determinants and moderating factors* incorporate determinants from different levels which had impacted the study participants in all four sub-studies in this thesis. From a structural determinant level perspective, the participants in all four papers (I-IV) had probably in some way been affected by the same political, economic, and welfare policies in Sweden³⁹. Moreover, the general organization of oral and general healthcare in Sweden is controlled by national legislation^{34,35,181}, even if regional differences exist. Even if the data collection for papers III and IV, was performed after the data collection in papers I and II, both were performed after the latest major oral healthcare reform in Sweden in 2008^{181,182}. The study population in paper III described oral health determinants

which could be considered fairly common among persons of their age in Sweden such as frightening experiences in childhood, genetic predisposition, and how they formed their oral health behavior from childhood to adulthood. But the study participants in papers III and IV shared a risk factor for adverse oral health outcomes (CPAP-treated OSA) which probably influenced what they considered oral health determinants and what they had experienced during CPAP treatment, specific for this population of persons with experience of CPAP treatment.

Interestingly, there are differences regarding the influence of the community in the illustration of the FDI's framework, among the numerous publications made when the FDI introduced and disseminated the definition and framework^{12,13,21,26,183}. When included, this influence can be interpreted in two ways: *i)* as a separate component, influencing the relationship of *driving determinants* to *overall health and well-being*, or *ii)* as a surrounding contextual factor influencing all the components in the framework. When using the latter, the contextual factors (i.e., structural determinants) could be regarded as incorporated in all four sub-studies as described above. This interpretation could be regarded as reasonable, as the FDI's definition and framework is stated to be built on the WHO's Commission on Social Determinants of Health conceptual framework^{13,27}. The study participants in paper III highlighted this by describing the influential aspects of the social and physical environment during life. By describing the wider society's impact on the oral health, the study participants in some way acknowledged the importance of public oral health strategies such as the influence of informational campaigns/commercials. However, determinants on the intermediate level were described to a higher extent in paper III. Commonly, the study participants' views corresponded to Watt and Sheiham's description of how the living circumstances and the risk for oral diseases differ among persons³⁹, as the findings showed that several determinants on different levels can affect a person's oral health.

Up-stream and community-based strategies (targeting structural determinants) have been promoted previously^{1,184}, advocating public oral health strategies to improve oral health for all and to reduce oral health inequalities. This way of targeting oral health issues was also discussed in a draft on global strategies for oral health published by the WHO¹⁸⁵ where a public health and life course

approach, people-centered oral healthcare, and optimized digital technologies for oral health were among their suggested guiding principles. Due to the high degree of digitalization in the world, digital technology could target both structural and intermediate oral health determinants, and research regarding for example teledentistry seems to have increased globally. The technical advances in society provide numerous possibilities. For example, technical advances have provided the possibility of the use mobile applications to improve oral hygiene habits and to perform remote oral healthcare consultations. This could be one way to increase oral health promotion and has also made possible the implementation of larger scale public oral health strategies. Therefore, the WHO published an implementation guide for mobile technologies, focusing on oral health literacy, education, and epidemiology where technical solutions could be used on different levels ¹⁸⁶, and today there are several mobile applications and cell phone text messages (i.e., SMS) designed for this purpose ¹⁸⁷. Increased digital technology solutions have also been developed within OSA and CPAP research, where telemonitoring and education have been applied and several mobile or web-based systems exist, focusing mainly on increased adherence ¹⁸⁸. According to Hwang et al. ¹⁸⁹ telemonitoring with automated feedback can increase the CPAP adherence during the first 90 days of treatment. However, for oral health and CPAP related mobile applications, concerns about both the quality and validity have been raised ^{188,190}. In relation to the results in papers III and IV, CPAP treatment could be considered an oral health determinant and finding a way to increase the knowledge, understanding and collaboration among the person, oral healthcare professionals, and CPAP practitioners is important. Using technological advances to facilitate increased collaboration among them could be one way forward.

9.1.3. *Moderating factors*

In paper II, age was included as a *moderating factor* and together with *driving determinants* showed direct effects on all *the core elements of oral health* included in the model except aesthetic satisfaction. How a person values their oral health could be reflected in how they rate their oral health after experiencing a change. If the oral health is considered important for the person, a negative change could contribute to a decreased rating of their oral

health. Besides age, changes in oral health since starting their CPAP treatment were described by the study participants in paper IV, reflecting a shift in their oral health rating and indicating that experiences and expectations of CPAP treatment could be considered *moderating factors*. This is in line with the description of *moderating factors* in the FDI's framework and definition as it reflects changes in oral health and a person's ability to adapt to circumstances²⁶. However, the description of *moderating factors* in the FDI's framework is somewhat vague and could include factors that also could be considered *driving determinants* (e.g., age, education, culture, and income)^{29,191}. This could be considered a weakness of the FDI's framework as it is sometimes hard to differentiate between *moderating factors* and *driving determinants*. It is plausible that factors that affect the oral health also affect how a person values or rate it. For example, financial, educational, and occupational factors have previously been reported to contribute to persistent social gradients of self-perceived oral health^{33,192-194}. After the latest major revision of the oral healthcare system in Sweden in 2008, Molarius et al.¹⁹⁴ showed that even though 75% of the respondents reported their oral health as good, there were differences in self-rated oral health and oral healthcare attendance between groups based on for example education, country of birth, employment status, and financial security. Between 2004 and 2016 the percentage rating their oral health as fairly good or good increased from 72 to 78% in Sweden¹⁹⁵. Despite the increase, factors such as increased age, low socioeconomic status, and lifestyle factors (e.g., tobacco use, and BMI > 30) made the participants rate their oral health worse¹⁹⁵. The influence of community and personal values is also described in the FDI's definition²¹ and could affect how we rate our oral health in relation others in society. Thus, several factors could have an impact on how a person rates their oral health where one of them could be how the oral health is valued by the society or the person. Locker et al.¹⁹⁶ explored the underlying frame of reference people use to rate their oral health. In the study, they found that a range of reasons underpinned the perception or rating of oral health and that people rely on different sources with internal variability and used complex reasoning. While some only considered their current oral health status, problems or treatment needs and oral hygiene habits, others also referred to past experiences. But they also considered the opinions of oral healthcare professionals, and made comparisons with others in their social surroundings¹⁹⁶. Even if *moderating factors* were not specifically investigated

in paper IV, the findings indicated a shift in their oral health ratings based on similar reasoning to that described by Locker et al.¹⁹⁶. Both negative and positive experiences and expectations seemed to influence their perception of their oral health. In relation to this, it is possible that *moderating factors* and *driving determinants* should be illustrated to affect each other as well in FDI's framework if it was to be revised. For now, *moderating factors* is illustrated in the FDI's framework to influence a person's oral health (i.e., an arrow from *moderating factors* into *the core elements of oral health*), but the component *moderating factors* has no arrows pointing into it. Some of the findings in paper III regarding oral health determinants (e.g., relationship with their oral healthcare professional and being a regular oral healthcare visitor) correspond to the findings in Locker's et al. study¹⁹⁶. Thus, those underpinning reasons relate to the dimensions in *driving determinants* and could at the same time also be reflecting experiences, expectations, or ability to adapt, i.e., *moderating factors*. However, these are only tentative relationships and have not been further investigated in this thesis. Moving back to the findings in paper IV, where the study participants used their experiences and expectations to value/rate their oral health. What expectations did those who described experiences regarding negative feelings related to changes in their oral health (e.g., deteriorating oral health in general or increased xerostomia) have before starting their CPAP treatment? For example, xerostomia is commonly described as a side effect of CPAP treatment. It has been reported as one of the side effects that can cause major problems and can also contribute to treatment abandonment during the first phase or period of CPAP treatment^{8,108}, and was also included as a common side effect in the national guidelines for treatment of OSA for adults⁹⁰. It is therefore reasonable to assume that the persons were aware of xerostomia as a common side effect that could occur during treatment, and many of the persons also used a humidification device and/or chin straps. But the study participants in paper IV received their CPAP treatment in conjunction with another research project and might have received more or other information than persons receiving regular care. Other difficulties or negative experiences described by the study participants in paper IV might not have been included in the patient information at the time of treatment initiation as the knowledge of how the persons' oral health could be affected or viewed to be affected had not been explored to a great extent. Information of potential effects (negative or positive) on the oral health could

be of importance for persons' who is about initiate their CPAP treatment, depending on how they value their oral health. This further underlines the importance of more research on the association between CPAP-treated OSA and oral health but also the importance of a more structured or defined educational plan ⁹⁰ for professionals working with this group.

9.1.4. Overall health and well-being

The findings in papers II-IV, contribute to the body of knowledge regarding oral health as an integrated part of *overall health and well-being* by the direct effects of three *core elements of oral health* and the explained variance (24.1%) of the predictors on the latent variable *overall health and well-being* (paper II), but also through the views and experiences described by the persons in papers III and IV. This reflects several parts of the relationship between oral and overall health and well-being regarding biomedical aspects as well as functional (physiological and psychosocial) aspects of oral health. The physiological and psychosocial aspects described in papers III and IV included both negative and positive experiences, but also the differences among the experiences. While medications or health problems were described as barriers for oral hygiene in paper III, the opposite was described in paper IV, where the CPAP treatment facilitated improved oral health habits. When feeling less tired skipping tooth brushing before going to bed, and the need for energy drinks decreased. Furthermore, CPAP treatment could reduce both xerostomia and mouth-breathing, showing how a treatment for an overall health condition can affect the oral health in a positive direction (paper IV). In that way, treatment of the sleep-related breathing disorder could contribute to improved oral health over time.

The FDI's definition refers to oral health as an important component of health, mental and physical well-being ²⁶. However, there is no description of the component *overall health and well-being* in relation to the framework, and the dimensions in *driving determinants* could theoretically also refer to different aspects of a person's overall health and well-being. In paper IV, the study participants described a relationship that could be interpreted as missing in the FDI's framework. In the FDI's framework, the relationship between the components' *overall health and well-being*, *driving determinants*, and *the core elements of oral health* is illustrated by arrows displayed in a

circular/bidirectional manner (Figure 1) In paper IV, the study participants described experiences of their overall health and well-being having a direct influence on their oral health. One way to interpret the description is that OSA refers to *overall health and well-being*, while the CPAP treatment becomes a *driving determinant*. But it could also be interpreted as a difference between the lay persons' and oral healthcare professionals' perspectives and should be taken into consideration. Moreover, the study participants described experiences of how a common cold (overall health) could negatively affect their possibility to use the CPAP, thereby affecting both their well-being and oral health due to increased xerostomia. Some experienced increased levels of general well-being due to improved sleep, but at the same time decreased well-being due to increased xerostomia during CPAP treatment (paper IV). Thus, the study participants described a complex picture, referring to both biomedical and psychosocial aspects of health and well-being. Interestingly, despite the relation between the FDI's definition and framework and the AOHSS, only one health-related measure was included in the AOHSS (Chronic medical conditions, clinician-reported case-mix concept) ¹⁴¹. Considering the FDI's definition includes the relationship between oral and overall health *and* well-being, we included other measures to capture a wider perspective of the person's health and well-being in paper II. Even if the included PROMs in the AOHSS could be considered to also reflect HRQOL, the questions refer to OHRQL. The three additional questions included in the latent variable *overall health and well-being* reflect the persons' perception of their health regarding aspects such as status, participation, and functions. By using the single-item measures included in the data set in addition to the presence of chronic medical conditions, it was possible to obtain a broader measure of their health. However, it would have been optimal to use a validated health status questionnaire such as the RAND SF-36 (i.e., a widely used and validated health status questionnaire) to increase the reliability and validity ⁶⁰, but this was not included in the data set nor suggested in the AOHSS. Due to the lack of a description of *overall health and well-being* in the FDI's framework, it is difficult to obtain a clear picture on which and how relationships, measures, or questions, should be further investigated or explored. A framework aiming to be applicable in all contexts globally cannot be too specific as it could compromise the applicability in different contexts, but a validated and generic measure of health could be considered for

inclusion in the AOHSS. The findings in papers III and IV showed that by using qualitative methods it is possible to obtain a deeper understanding on how persons' can experience or view their own oral and overall health and well-being. Thus, using different methods, perspectives, and populations can provide increased knowledge of the relationship between oral and overall health and well-being.

According to the FDI's definition of oral health, our oral health contributes to essential everyday functions (e.g., eating, touching, swallowing, and conveying feelings without discomfort or embarrassment). But upon being asked in an online lecture, Williams ¹⁹⁷ explained that breathing was not considered part of oral health due to the position of the airways and the involvement of the nose in the breathing process. However, the findings in paper IV somewhat contradict this perception. The study participants described how experiences of severe xerostomia affected their ability to breathe but also that mouth-breathing could contribute to xerostomia as well. In a healthcare context, oral health could certainly be considered a relevant and integral part of the respiratory system, as oral health status and oral hygiene can affect the occurrence of ventilator-associated pneumonia in an intensive care unit setting ¹⁹⁸. Based on the findings in this thesis, it can be argued that breathing could be considered an essential everyday function that could affect or be affected by our oral health. Some examples of this were found in papers III and IV, where mouth-breathing, and breathing affected due to xerostomia, as well as the positive impact that CPAP treatment could have on oral health habits, were described by the study participants. In that way, CPAP-treated OSA relates to oral health and is an important aspect to address further in research within sleep medicine.

9.2. Methodological considerations

As in most research projects or papers, this thesis has strengths and limitations that should be considered when interpreting the results.

9.2.1. *Reliability and validity*

Papers I and II

In papers I and II, material from the Jönköping studies was utilized. The Jönköping studies could be considered well known within dentistry in Sweden, and many papers have been published in scientific journals, thereby providing a rich body of material to consider regarding aspects of reliability and validity. In addition, the principal investigator of the most recent Jönköping studies was involved as a co-author in papers I and II. But the data was collected in 2013-2014, and it is therefore possible that oral health in Jönköping County today (i.e., in 2022) differs from the findings in 2013/14. Thus, it should be noted that the Jönköping studies have both methodological strengths and weaknesses, some highlighted below.

Not all variables in the data set have been tested regarding reliability and validity, and others are classified or measured differently today compared to when the Jönköping studies were initiated. In relation to this, the clinical examinations were performed by several dentists from both general and specialized oral healthcare during almost a year (i.e., autumn 2013 to autumn 2014). Before starting the clinical examinations, the examiners were calibrated regarding diagnostic criteria, and re-analyses of radiographs to examine the consistency of the examiners over time were performed. Recently, a new classification of periodontal disease has been proposed which includes changes from the 1999 classification⁵⁰. Although, it would have been optimal to use the latest classification, the included classification was based on measures relevant for clinical oral healthcare. Regarding dental caries, Ni Riordain et al.¹⁴¹ included a basic level of dental caries data to be collected, including missing teeth, but did not preclude other standard measures of dental caries experience. Even so, the number of teeth is a more common way of reporting than missing teeth, and in a study focusing exclusively on dental caries or periodontal disease, having a detailed level of disease classification is preferred. For this thesis, DFS, missing teeth, and the classification of periodontal disease could be regarded as sufficient or acceptable considering the limitations stated. Interestingly, tooth loss has been proposed as a single but complex measure of oral health¹⁹⁹. Measuring tooth loss or number of missing teeth could be seen as a reflection of both the burden of periodontal

disease and dental caries as well socioeconomic factors (e.g., willingness to extract teeth due to higher costs for other treatments such as dental implants). The level of xerostomia was included as a single question, and in paper II this was in line with the suggested measure in the AOHSS, even though the questions and response options differed. It would have been optimal to use a more comprehensive instrument such as the Xerostomia Inventory ²⁰⁰, but a Swedish version was not available at the time of data collection. OHIP-14 has previously been validated and used in a Swedish context ^{127,134}, but has been questioned regarding the ability to capture the intended dimensions of Locker's conceptual model ^{74,201}. In paper I, the OHIP-14 was divided into the seven dimensions, but in paper II, the additive score was used. In retrospect, it could have strengthened the findings of paper I if the same measures had been used in a confirmatory analysis in paper II. But to fit the model, we chose to use the additive score to explore whether the overall OHRQOL had direct or indirect effects on *overall health and well-being*. To gain deeper knowledge of the relationships among components in the FDI's framework, and how oral health can impact a person's everyday life, the questions in the AHOSS or OHIP-14 could be explored separately in future studies.

Both PCA and SEM are large sample methods because sample size can affect the precision and replicability of the findings. For both factor analysis and SEM, a sample size of >200-300 has been suggested as a rule of thumb ²⁰². In factor analysis, the sampling error decreases with increased sample size, and the component solution is more stable and more true to the structure in the population ¹⁵³. However, the sample size is dependent on communalities, and well-determined components besides the number of cases included in the study. In paper I, the communalities and sample size were regarded as sufficient for the three-factor solution. Even if the communalities had been low and the components weak, the sample size would have been sufficient as under those circumstances the required sample size has been estimated to as >500 ¹⁵³. To assess the reliability, the Cronbach's Alpha coefficient was calculated for the components (0.87, 0.68, and 0.61, respectively). It should be noted that the coefficients were below the common threshold 0.7 ²⁰³, and to increase the Alpha values a reduction or addition of variables was possible, but as it did not improve the Alpha values, but could affect the content validity, this was not performed.

In paper II, sample size was estimated based on anticipated effect size, number of latent variables, and indicators²⁰⁴, and was regarded sufficient for the study. As both the χ^2 -test and χ^2/df -ratio are sensitive for sample size (i.e., in large samples, χ^2 -test tends to be significant, falsely rejecting the model), several other fit indices less sensitive for sample size (e.g., RMSEA) were reported. Furthermore, to investigate both direct and indirect effects and as the multivariate assessment of normality showed non-normal distribution, bootstrap analysis was performed (5000 bootstrap sample, 95% confidence intervals), and missing data was imputed by using the FIML method. Together, the measures taken to decrease the impact of sample size on the model could be considered sufficient. Also worth considering are the thresholds for the indices used to assess the model fit. We decided that the common thresholds for CFI >.90, TLI >.90, RMSEA <.08 (CI .05-.08), and SRMR <.08^{157,159} would be sufficient based on the complexity of the model and sample size. However, this matter has been debated over the years^{159,205,206}. CFI and TLI values >.95, SRMR <.08 and RMSEA <.06 have been recommended¹⁵⁹, but also regarded as too rigorous, with increased risk of falsely rejecting models, and presenting several indices has been suggested instead²⁰⁶. Moreover, there are numerous indices included in the output in AMOS. By using commonly reported fit indices, including absolute, incremental, and goodness/badness of fit indices, to assess and report model fit the plausibility of falsely accepting a poorly fitted model was considered decreased. Given the model fit indices used in paper II, the model was considered acceptable but did not show a perfect or excellent fit. As only one model was constructed and assessed, it is plausible that other models would have shown a better fit, or that other or additional measures could have improved the fit. Hence, the construction of additional models and using an additional sample for comparisons would have been optimal. For example, the data from the study population in papers III and IV (clinical, radiographic and questionnaire data) could have been used. However, as the sample (N=121) was considered too small for SEM analysis this was not conducted.

In paper I and II, the same data set was used, but the selection of variables differed. In paper I, discussions within and outside (expert and lay persons representatives) of the research group was performed. In paper II, the selection of variables relied on suggested variables in the AOHSS. After a structured literature search regarding oral health determinants was performed, the wide

range of determinants became even more evident. During this time the FDI and ICHOM proposed the AOHSS ^{141,197}. Due to the similarities in theoretical ground (i.e., the FDI's definition and framework), correspondence with the measures in paper I, and the findings in the structured literature search, as well as the rigorous method they used for variable selection ¹⁴¹, it was decided to base the selection on the AOHSS. However, the AOHSS was proposed after the data for papers I and II was collected, and some alterations to the variables had to be made. It would have been optimal to use the exact variables, wording, and response options as in the AOHSS even if some flexibility in data could be acceptable, as stated by Ni Riordain et al. ¹⁴¹. Moreover, using the same measures in papers I and II would also have strengthened the findings in the papers, and methodological issues such as the modification of the included measures might have been avoided.

The variable selection in papers I and II was based on the FDI's definition and theoretical framework and included both professional and lay perspectives, which can be considered to enhance the face and content validity. Nevertheless, other, or additional measures should be considered in other contexts or settings as there are differences among populations regarding for example oral health determinants. Currently, the FDI is using the mobile application Oral Health Observatory [OHO] to collect data based on the AHOSS in several countries ¹⁹⁷. The OHO contains questions regarding for example self-rated oral health, oral healthcare visit frequency, and interactions among oral health status, QOL, and oral health behavior (e.g., tooth brushing frequency and use of fluoride). Considering the connections among the FDI's definition and framework, the AOHSS, and OHO, it will be interesting to compare the findings in papers I-IV to the findings of the first studies based on the OHO data when published. But to our knowledge, the papers included in this thesis are among the first to use empirical data when exploring oral health based on the FDI's definition and framework. As validation could be seen as an ongoing process ²⁰⁷, the papers could be seen as initial steps toward validation of the FDI's framework or assessment of applicability. Thus, more research is needed in several populations, contexts, and settings, and using different study designs to ensure that all aspects of validity, reliability, and applicability are considered and assessed. If using longitudinal data, it is possible to investigate all included and possible relationships among the components in FDI's framework, but also the progress of disease or

conditions. Those are two aspects missing in paper II that should be considered for further investigation.

Regarding the generalizability of the findings, some reflections should be noted. The study population in papers I and II has been regarded as representative for the Swedish population ^{122,124,208}, but it should also be noted that the population in Jönköping was somewhat younger than in Sweden as a whole, consisting of an urban population in an administrative center of southern Sweden ¹²². The study participants were randomly selected in all repeated cohorts with clearly defined age groups including children, adolescents, and young-middle- and older aged adults even if only the adult age groups were included in this thesis. Every wave of data collection included a random selection of participants (including persons from the age of 3 to 80 years of age), providing a comprehensive picture of the oral health in the study population. But the non-response rate increased between 1973 and 2013, and in the data collection wave in 2013 the non-response rate ranged from 28 to 44% in the age groups 20-80 years, resulting in an additional random selection of participants in the age groups 30-50 years old ¹²². Reasons for non-participating varied (e.g., lack of interest, moved away, having dental anxiety, seriously ill/deceased, reported to be edentulous, or recently examined) ¹²². As the parishes included in the studies could be considered urban (even if the parishes included rural parts of Jönköping county), differences among findings between persons living in the rural and urban parts of Jönköping County were compared in the late 1990s and also discussed in relation to other regional and national studies, where no major or important differences were found ^{209,210}. Even so, the specific Swedish context should be considered when assessing the generalizability of the findings in papers I and II.

Social gradients can be found in all types of welfare states in Europe, and inequalities of oral health in adults are present in all Scandinavian countries ²¹¹. Even if other countries in the EU (e.g., France and Germany) and the United Kingdom [UK], provide universal oral healthcare for children and subsidized oral healthcare for adults as well ²¹², the Swedish context should be considered when interpreting the findings. Globally, the availability of oral healthcare, and financing systems differ from the Swedish context in which the sub-studies were performed. Since the introduction of the public dental healthcare in the 1930s and the National Dental Insurance in 1974, oral

healthcare in Sweden has been generally available and subsidized in different forms by taxation ²¹³. Furthermore, based on data from the Jönköping studies, the oral health in Sweden has been greatly improved in general since the project began ¹²⁴. The Swedish oral healthcare system has probably contributed to the general improvement, but there are still differences among persons and groups within Sweden. Besides the oral health outcomes (e.g., prevalence of dental caries and periodontal disease), different oral health determinants can facilitate or act as barriers for oral health. All participants in the included papers (I-IV), lived in the same structural context (e.g., political and welfare policies) at the time for data collection, but both the structural and intermediate determinants have probably affected the study participants differently.

9.2.2. *Trustworthiness*

As trustworthiness is an important issue in qualitative research the following measures were taken to increase credibility, dependability, transferability, and conformability ^{214,215}.

Credibility refers to the robustness/appropriateness of the collected data and analytical process in relation to the aim of the paper ²¹⁴. Regarding paper III, directed content analysis has been described as a suitable method when a theory or theoretical framework exists, and the aim is to further explore, evaluate, or extend it ¹³⁵. To the best of my knowledge, no previous studies have been published using the FDI's framework as the basis for exploration of the person perspective on oral health determinants. A limitation to the directed content analysis approach is the potential bias as the investigator has limited ways to disregard her preunderstanding of the codes, thus there is a risk that the investigator will be more likely to find support than nonsupport. To enhance the trustworthiness, an audit trail or audit process description is recommended ¹³⁵. To minimize the risk, the analysis was conducted within a multiprofessional research group of researchers with different preunderstandings of oral health. Furthermore, repeated reading of and reflection on the material were carried out to compare what the study participants said and how it related to the FDI's framework. In paper III, the consolidated criteria for reporting qualitative research [COREQ] was used as a guide ²¹⁶. Even though not explicitly expressed in paper IV, COREQ was

used to structure the paper as well. However, due to word limitations (especially in paper IV) the level of detail regarding the research process was limited.

In paper IV, CIT was regarded a suitable method as the aim was to explore which and how oral health-related situations were experienced and managed by persons with experience of CPAP treatment. By using CIT, perspectives based on real-life experiences from a person's point of view were explored, adding useful information to the FDI's framework. Also, as CPAP adherence is essential, to enlighten both positive and negative oral health-related situations and actions could facilitate increased interprofessional collaboration and thereby minimize barriers to CPAP adherence in this specific group. When using CIT, retrospective situations and actions are explored ¹³⁶, which could enable increased understanding of how CPAP treatment affects oral health from the person perspective, which previously has been overlooked from an oral health perspective. Aiming to explore situations and actions during CPAP treatment, some experiences were remembered from several years previously. To reduce the risk of including situations that were not accurate, all identified situations and actions were thoroughly reflected upon before inclusion. Hence, if the situation is recalled and described in detail, it is reasonable to assume that the description of the event is accurate. If any doubt regarding the accuracy of the description arose, the situation was excluded. Furthermore, it is not uncommon that some experiences are not followed by an action. Considering Viergever's description of the analytic process strategies ¹⁴³, the categories and subcategories are clustered in a way that is the most useful for the aim of the study (pg. 1071) and contain a minimal amount of overlapping. As an example, in paper IV some of the challenges with breathing were closely connected with severe xerostomia and were thus resolved by management of the xerostomia. The aim was to provide a comprehensive and logical structure in the categorization regarding the connection between situations and actions however, this was not always possible.

However, as the oral health perspective described by persons with experience of CPAP treatment has not been explored before, credibility regarding the selection of study participants, data collection and analysis is essential. To increase the credibility in papers III and IV, the study participants with

experience of CPAP treatment (>1 year) were selected using a purposeful selection process. The study participants were all diagnosed with OSA between 2007 and 2009 and received their CPAP at that time. The final sample consisted of a variety of persons in terms of sex, age, education, and oral health, however reflecting a somewhat elderly CPAP population. It is possible that other aspects of oral health determinants, situations, and actions would have been described, if other study participants had been invited. As an example, the inclusion criteria in the initial project included ability to understand (e.g., read and speak) Swedish ^{87,125}. If brought up in another country, it is possible that different views of oral health determinants based on experiences in childhood could have been described. In another step to increase the credibility and conformability (accuracy of the data) of the findings and categorization ²¹⁴, examples of questions, the coding process, and representative quotations were included in papers III and IV. All co-authors had access to the material, and there were repeated discussions and reflections within the multiprofessional research group (with expertise within oral health, sleep medicine, and methodology) until consensus was achieved.

To increase both credibility and dependability, two pilot interviews were performed to determine if the semi-structured interview guide was structured enough to capture the intended focuses and still maintain flexibility for emerging questions during the interviews. The study participants were willing to share their views and experiences, resulting in a rich body of material to analyze. This reflects the usefulness of the interview guide, and its ability to capture the intended focus areas. For paper III, the code book was also pre-tested to ensure that the categorization matrix was suitable for the material and aim of the paper ^{214,215}. Furthermore, before the pilot interviews, three test interviews were performed to improve my interviewing technique and test the technical equipment. Regarding dependability (changes in data over time), the interviews were performed from November 2020 to January 2021, and the risk of inconsistency due to time was limited. However, as the semi-structured interview guide allowed flexibility in data collection, the insights gained throughout the process may have influenced follow-up or probing questions. But as directed content analysis and CIT, guided the data collection this risk could be limited as the design helped to focus the questions. For papers III and IV, the initial plan was to conduct the interviews face-to-face, but due to the Covid-19 restrictions during the period of data collection, telephone

interviews were performed instead. Even if telephone interviews are commonly used and accepted as a data collection method, there is an increased risk for loss of information regarding non-verbal communication (e.g., facial expressions and hand/body movements). This could have affected how the probing or follow-up questions were put as well as the interpretation of what was said. However, during telephone interviews laughs, pauses, hesitations, and other expressions besides words/sentences contribute to the understanding of what is said. As the method for analysis in paper III and IV concerned the manifest content, telephone interviews was considered suitable ²¹⁷. To create a comfortable environment in the interview situation for the study participant, additional time was spent before and after the interviews for both questions and conversations about everyday life, and despite being performed by telephone, the interviews resulted in a rich body of material for analysis.

To increase the transferability, which is the extent to which the findings can be transferred into other contexts or populations, both papers (III and IV) include a description of the context. The Swedish context regarding oral health and oral healthcare utilization, as well as the characteristics of the study population, should be considered. This specific group had participated in research before, were mostly elderly, and had in general long-term experience of CPAP treatment. For persons with shorter experience of CPAP treatment, or in a younger population with no previous experience of research participation, the findings might not reflect their views or experiences. However, some of the findings have previously been commonly described. For example, xerostomia has been reported as one of the most common side effects of CPAP treatment ⁸, and the oral health determinants described by the study participants (paper III) are in line with the social determinants of oral health as described by Watt and Sheiham ³⁹. The inductive approach in paper IV, however, made possible in-depth descriptions of experiences and actions that have not been reported before and provided new knowledge and hopefully understanding of how oral health can be affected by CPAP treatment. It is possible that the study participants' experience of participation in other research projects enabled in-depth conversations during the interviews and had a positive effect on their willingness to share their experiences.

9.3. Implications

9.3.1. *Practical implications*

The multifaceted concept of oral health was investigated in four sub-studies in this thesis. By combining the findings in all four sub-studies, some practical implications are suggested below.

- Oral health is multifaceted, complex, and changeable. Several aspects of oral health should be considered when assessing a person's oral health, based on both clinician- and person-reported measures. In clinical oral healthcare settings, it is important to ask the person questions about their everyday life to identify potential barriers or facilitators for oral health, enable shared decision-making, and build a trustful relationship. This could be done through formal and informal conversations and with respect for the person's integrity.
- In a clinical setting, oral health professionals should consider which and how oral health determinants in a person's everyday life can affect their patient's oral health. Person-reported information regarding barriers or facilitators is of importance considering several factors such as a person's knowledge, motivation, and willingness to change when needed. From the perspective of persons with CPAP-treated OSA, communication is essential for oral healthcare professionals to obtain information but also to create a trustful environment that supports persons to gain or maintain oral health.
- Increased knowledge and understanding of how CPAP treatment can affect a person's oral health among oral health professionals and CPAP practitioners can contribute to early detection or identification of oral health-related challenges or difficulties in clinical settings. Also, positive experiences such as improved oral health habits regarding oral hygiene and diet should be identified by oral healthcare professionals to enable promotive oral healthcare.
- It is essential for oral healthcare professionals to obtain information about whether CPAP treatment has been received by asking the person. This

could be done when updating their medical history and noted in their dental record to enable follow-ups. Furthermore, it is also important to ask if the person has experienced any oral health-related difficulties or challenges. In addition, it is important to assess the person's oral health in adequate and personalized time intervals to enable early detection or identification. For some persons, follow-up visits might be performed by telephone (e.g., to discuss increased xerostomia), but for others personal visits could be preferred (e.g., for adjusting or assessing a dental splint) after initial recommendations are given or a treatment is performed.

- Experienced difficulties during CPAP treatment can often be managed by easily accessible facilitating tools (e.g., using a humidifier and/or chinstraps, drinking or rinsing the mouth with water when experiencing xerostomia). Many of the difficulties can be managed by recommendations from both oral healthcare and CPAP practitioners but must be tailored to the person's specific needs and oral health status (i.e., after obtaining a comprehensive picture of the person's oral health). It is therefore important for CPAP practitioners to know when they should refer a person to an oral healthcare clinic for further assessment and treatment if needed (e.g., when the person is experiencing pain or discomfort in the temporomandibular area, increased tooth wear, or describing deteriorating oral health).

9.3.2. *Suggestions for future research*

Based on the findings in this thesis, a wide range of studies could be performed to further test and explore the FDI's framework and to increase the knowledge and understanding of how CPAP treatment can affect a person's oral health.

Research aiming to further investigate or explore the FDI's framework in different contexts or settings, and specific and general populations could include:

- Observational studies (e.g., cross-sectional, or longitudinal studies) to explore measures to include in the components in the FDI's framework. Longitudinal studies enable investigation of all relationships among the components in the FDI's framework, including both the present relationships and the ones suggested in this thesis.

- Explorative studies using data from interviews or focus groups to examine the person perspective of all components in the FDI's framework.

Research aiming to further explore or investigate the oral health in persons with CPAP-treated OSA could include:

- Observational (e.g., cross-sectional, case-control, or cohort studies) and interventional studies. Comparative studies using clinical and/or questionnaire data to investigate the oral health of persons without OSA, persons with OSA, and persons with CPAP-treated OSA.

Research aiming to further explore or investigate interprofessional collaborations among healthcare and oral healthcare could include:

- Observational and interventional studies to investigate how interprofessional collaborations could be further developed and implemented in oral and general healthcare. These could include explorative studies using interviews or focus groups to examine how an interprofessional collaboration is perceived by oral healthcare professionals, CPAP practitioners, and persons receiving CPAP treatment.
- Observational (e.g., cross-sectional, longitudinal, or case control) and interventional studies to examine if and how a mobile application or module in an existing mobile application could be used to increase knowledge of oral health and support persons during CPAP treatment. These could also include individual interviews, group interviews, or focus groups to explore the person perspective on using a mobile application.

10. Conclusions

- The FDI's theoretical framework can be applied in a general population to describe different components of oral health and the relationship among them, including both clinician and person-reported measures. However, the components and the structural relations among them need to be further explored in different contexts, settings, and populations, to assess other or additional measures, and to explore present and additional relationships of interest.
- The component *driving determinants* in the FDI's theoretical framework was useful to describe oral health determinants in all suggested dimensions when applied to a specific population. CPAP treatment can be viewed as an oral health determinant among a range of oral health determinants that can be experienced during a lifetime.
- Oral health-related negative situations such as increased xerostomia and tooth wear, changes in saliva composition, and deteriorating oral health status as experienced by persons with experience of CPAP treatment can be successfully managed and thereby could contribute to CPAP adherence. Negative experiences can contribute to reduced self-rated oral health.
- Oral health-related positive situations such as decreased xerostomia and mouth-breathing, improved oral hygiene habits, and changed dietary habits as experienced by persons with experience of CPAP treatment can contribute to CPAP adherence and improved self-rated oral health.

11. Sammanfattning på svenska

Bakgrund

Världshälsoorganisationen har beskrivit oral hälsa som en nyckelindikator för hälsa, välbefinnande och livskvalitet. Vidare definierar World Dental Federation [FDI] den orala hälsan som en mångfacetterad och föränderlig del av vår allmänna hälsa och välbefinnande eftersom den bidrar till vardagliga funktioner såsom att äta, prata, och förmedla känslor. Orala sjukdomar som karies och parodontit tillhör de vanligaste icke smittsamma sjukdomarna i världen. De kan bidra till smärta och obehag samt påverka individen och samhället ekonomiskt. Förutom att orala och generella sjukdomar delar riskfaktorer för att utveckla ohälsa påverkas den orala hälsan av en mängd faktorer, s.k. bestämningsfaktorer. Dessa kan under en livstid ha både negativ och positiv påverkan. Obstruktiv sömnapné [OSA] som behandlas med övertrycksandning via mask kan vara en av dessa bestämningsfaktorer. Ett av flera exempel på övertrycksandning via mask är (eng.) continuous positive airway pressure [CPAP]. Personer med OSA, med eller utan CPAP-behandling, har tidigare ofta rapporterat muntorrhet. Däremot har den möjliga kopplingen mellan OSA, CPAP-behandling, och oral hälsa utifrån en bredare definition av oral hälsa inte undersökts i lika stor utsträckning. När FDI föreslog sin nya definition för oral hälsa presenterade de även ett teoretiskt ramverk. Målet med definitionen och ramverket var att de skulle kunna tillämpas empiriskt i alla populationer och kontexter globalt samt bidra till ett mer hälsofrämjande förhållningssätt i tandvården. Genom att undersöka hur FDI:s ramverk kan tillämpas i en generell population kan vi få en ökad förståelse för hur oral hälsa kan beskrivas och hur den påverkas. Detta kan skapa en referensram för hur den orala hälsan kan påverkas och erfaras i en specifik population av personer med erfarenhet av CPAP-behandling.

Syfte

Det övergripande syftet med avhandlingen var att få en fördjupad förståelse för hur FDI:s teoretiska ramverk kan användas i en generell population och hur den orala hälsan erfars i en specifik population med personer som har en ökad risk för försämrad oral hälsa. För att besvara syftet genomfördes fyra delstudier (I-IV) inom ramen för avhandlingen.

Material och metod

För att besvara det övergripande syftet undersöktes FDI:s ramverk utifrån olika perspektiv (professionellt och individ) genom att använda datamaterial från två olika urval av studiepopulationer. I de två första studierna (I och II) användes ett datamaterial från 630 vuxna personer som samlats in via en klinisk tandvårdsundersökning inklusive röntgenundersökning och en enkät. I de andra studierna (III och IV) användes ett material som samlats in via individuella intervjuer med 18 vuxna personer med erfarenhet av CPAP-behandlad OSA. I två av studierna (I och II) användes olika kvantitativa metoder för att analysera datamaterialet statistiskt (principalkomponentanalys och strukturell ekvationsmodellering). För att analysera datamaterialet i studierna III och IV användes två olika kvalitativa metoder (riktad innehållsanalys och kritisk incidentteknik).

Sammanfattning av resultat

Resultaten i de fyra delstudierna visade att FDI:s ramverk kan tillämpas för att beskriva och förklara oral hälsa i olika urval av vuxna personer. Genom resultaten i delstudierna bekräftades att den orala hälsan är mångfacetterad och är en del i vår allmänna hälsa och välbefinnande så som den är beskriven av FDI. Vidare påvisade resultaten även att den orala hälsan är föränderlig då flera faktorer kan påverka en persons orala hälsa under en livstid. Resultaten visade även att CPAP-behandlad OSA kan ses som en bestämningsfaktor för oral hälsa då den kan påverka fysiska, funktionella, och psykosociala aspekter av den orala hälsan. Genom beskrivningar från personer med erfarenhet av CPAP-behandling påvisades att CPAP-behandling kan påverka en persons orala hälsa både i positiv och negativ riktning, samt att negativa erfarenheter ofta kan hanteras framgångsrikt.

Resultaten i delstudierna I och II visade att FDI:s ramverk kan tillämpas för att beskriva oral hälsa i en generell vuxenpopulation genom både kliniska och person-rapporterade aspekter av oral hälsa. I den första delstudien (I) visade resultatet av den statistiska analysen att tretton olika aspekter relaterade till förekomst av orala sjukdomar och tillstånd, fysiologisk funktion, och psykosocial funktion kan inkluderas för att tillämpa FDI:s ramverks centrala del (eng. the core elements of oral health). I delstudie II visade den statistiska analysen att den modell som konstruerats kunde accepteras i sin helhet. Vidare

undersöktes också om olika komponenter av FDI:s ramverk hade några statistiskt signifikanta direkta effekter på varandra och i så fall hur stor effekten var. Där visade den statistiska analysen olika resultat då en del av FDI:s föreslagna relationer mellan komponenterna kunde bekräftas helt eller delvis men inte alla. Inga statistiskt signifikanta indirekta effekter (dvs. att en komponent kan påverka en annan via en tredje komponent) kunde påvisas. Sammantaget visade resultatet från de statistiska analyserna i delstudierna I och II att flera olika aspekter eller mått kan användas för att beskriva och förklara en persons orala hälsa och hur den kan påverkas. De olika aspekterna kan inkludera kliniska aspekter (som antal kariesskador och fyllningar, erfarenhet av parodontal sjukdom, plackförekomst, och antal saknade tänder), men även person-rapporterade aspekter (som upplevd muntorrhet, tillfredsställelse med tändernas/munnens utseende, utbildningsnivå, antal intag av sockerhaltiga drycker, mellanrumsrengöring, samt oralhälsorelaterad livskvalité). Hur olika bestämningsfaktorer kan påverka en persons orala hälsa utifrån ett personperspektiv undersöktes vidare i delstudierna III och IV.

Resultaten i delstudierna III och IV visade hur personer med erfarenhet av CPAP-behandling såg på bestämningsfaktorer för oral hälsa, hur deras orala hälsa har påverkats i olika riktningar samt hur de har hanterat negativa erfarenheter av sin CPAP-behandlade OSA. Samtliga bestämningsfaktorer som de deltagande personerna beskrev i studie III beskrev kunde kategoriseras in i någon av de dimensioner av bestämningsfaktorer som FDI föreslagit: biologiska och genetiska faktorer (ex. påverkan i olika stadier i livet, arv och salivens påverkan), social miljö (påverkan från familjemedlemmar och från informationskampanjer/reklam), fysisk miljö (ex. förutsättningar och förändringar i fysisk miljö), hälsorelaterat beteende (ex. hur egenvårdsrutiner formas under livet och stöd från tandvården), och tillgång till vård (ex. att få och acceptera möjligheter för tandvårdsbesök och förtroende för tandvårdspersonal). Att behandlas med CPAP beskrevs som något som kan påverka den orala hälsan men också att den kan interagera med andra bestämningsfaktorer. I studie IV beskrev deltagarna både positiva (ex. minskad muntorrhet med CPAP) och negativa erfarenheter (ex. andningssvårigheter på grund av svår muntorrhet, ökad muntorrhet och tandslitage, och negativa känslor) som de erfarit innan och under sin CPAP-behandling, samt när de under sin behandling inte använde sin CPAP. De beskrev också hur de hanterade svårigheter relaterade till den orala hälsan där

deras beskrivningar visade att de flesta negativa erfarenheter hade hanterats framgångsrikt. Detta hade personerna gjort genom att till exempel ha vatten tillgängligt nattetid, använda befuktare och/eller hakband, och ta kontakt med tandvården för att få hjälp. Det framkom också att den organisatoriska uppdelningen mellan tandvård och övrig hälso- och sjukvård kan bidra till att OSA inte behandlas.

Konklusion

FDI:s teoretiska ramverk är tillämpligt i en generell vuxenpopulation för att beskriva olika delar av oral hälsa genom att använda både kliniska och personrapporterade mått. Det är även användbart för att beskriva synen på och erfarenheter av oral hälsa i en specifik population med förhöjd risk för negativ påverkan på den orala hälsan. CPAP-behandling kan ses som en bestämningsfaktor för oral hälsa, eftersom behandlingen kan påverka en persons orala hälsa i både positiv och negativ riktning. Om en person under CPAP-behandling upplever negativa påverkan på den orala hälsan kan dessa oftast hanteras framgångsrikt med relativt enkla hjälpmedel eller metoder.

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Appendices

Appendix 1. Structured literature search

Description of structured literature review

A focus question was developed using Population, Interventions, Control Outcome [PICO], to guide the structured literature search: *In a general adult population, what are the driving determinants of oral health?* Specifically, general adult represented population (P), *driving determinants* represented intervention (I), and oral health represented outcome (O). No control (C) was selected. The electronic search was performed by the main investigator with assistance from a librarian at Jönköping University library. Electronic searches were performed in Dentistry & Oral Sciences Source [DOSS], MEDline, and CINAHL on February 26th, 2020.

Table 1. Search strings for the structured literature search

Database	Search string	Limiters
MEDLINE (EBSCOhost)	((MH "Oral Health") OR (AB (oral or dental) AND health)) OR TI (oral or dental and health)) AND (AB (determinant* or pathway* or trajectory*) OR TI (determinant* or pathway* or trajectory*))	Published Date: 20100101- 20201231; English Language
DOSS (EBSCOhost)	((TI (oral or dental health) OR AB (oral OR dental) AND health)) AND (TI (determinant* OR pathway* OR trajectory*) OR AB (determinant* OR pathway* OR trajectory*))	Publication Type: Academic Journal; Published Date: 20100101-20201231; English language
CINAHL (EBSCOhost)	((TI (MH "Oral Health") OR (oral OR dental health) OR AB ((MH "Oral Health") OR (oral OR dental) AND health)) AND (TI (determinant* OR pathway* OR trajectory*) OR AB (determinant* OR pathway* OR trajectory*))	Peer-reviewed; Published Date: 20100101-20201231; English Language
Scopus	(TITLE-ABS-KEY ("oral health") OR TITLE-ABS-KEY ("dental health") AND TITLE-ABS-KEY (determinant* OR pathway* OR trajectory*))	Document type (article OR review) AND Published year > 2009

An additional search was performed in Scopus to ensure inclusion of a broader selection of scientific articles published in other fields than oral health, nursing, and medicine. “Gray literature” was not searched, and no contact was

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made with authors to identify additional unpublished material or projects. Expert opinions, poster abstracts, articles in press and invited interviews were included in the search. Essential articles and other publications published before 2010, which were regarded as relevant to include were also included using manual searches. Duplicates were removed after all electronic searches were performed. Both free-text searches and MeSH-terms/CINAHL Subject Headings/Subject searches were performed (Table 1). Truncation was used to enable the inclusion of different variations of a search word. Limitations in all searches were set to peer-reviewed, ethical approval, language (Swedish and English), and time (2010-2020).

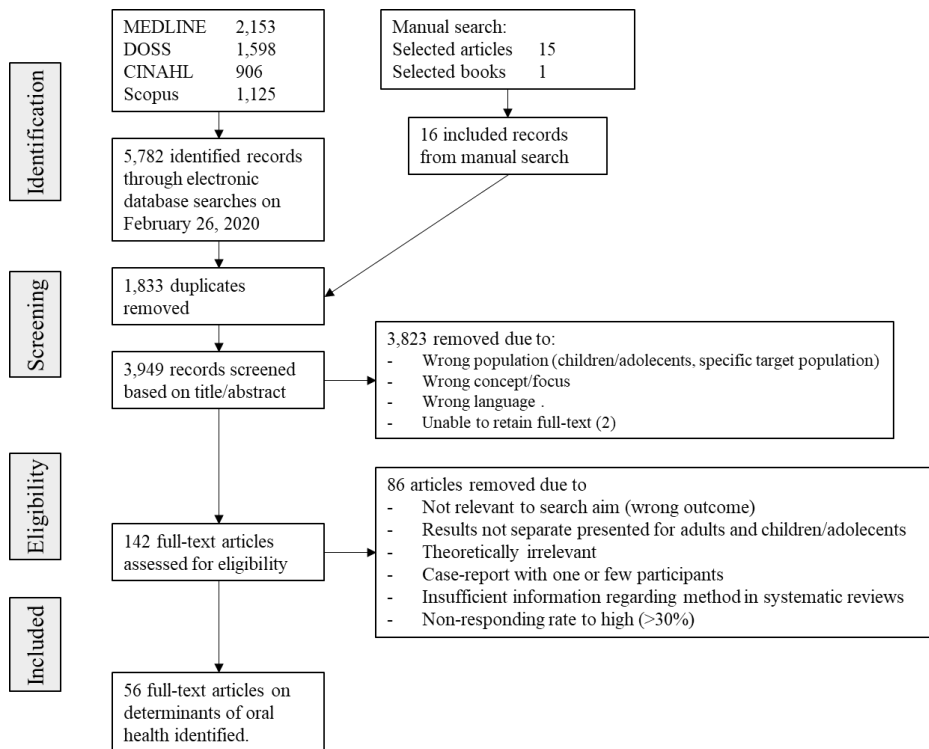


Figure 1. PRISMA flow chart of structured literature search

The article selection and quality review were performed by the main author (HA) alone, for the compilation of articles. First, the title was read to

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determine if the article could be included in the compilation. Second, the abstract was read to determine if the article was eligible. Articles that did not meet the inclusion criteria were excluded (e.g., wrong population or different focus/concept). Next, selected articles were retrieved and read in full text for individual assessment. Articles that did not include the outcome of interest, did not separate the results between children/adolescents and adults, had a non-response rate >30% (without sufficient information regarding sampling process or small non-representative sample), or were theoretically irrelevant, were excluded. A total of 56 articles were included in the structured literature search (Figure 1). After compiling all included articles, the full texts were read in depth to identify oral health determinants in the results and conclusion sections.

Table 2. Summary of articles describing common determinants of oral health

<i>Variable</i>	<i>Number of articles= 56</i>
<i>Year of publication</i>	
<i>Before 2000</i>	1
<i>2000–2010</i>	11
<i>2011–2015</i>	22
<i>2016–2019</i>	22
<i>Location (more than one possible)</i>	
<i>Africa</i>	2
<i>Asia</i>	6
<i>Europe</i>	18
<i>North America</i>	13
<i>Oceania</i>	8
<i>South America</i>	13
<i>Not stated</i>	2
<i>Method/design</i>	
<i>Cross-sectional</i>	22
<i>Review (critical, systematic, systematic & meta-analysis)</i>	13
<i>Cohort</i>	9
<i>Theoretical/conceptual framework (provide/apply)</i>	4
<i>Case-control (matched/unmatched)</i>	3
<i>Consensus report</i>	1
<i>Focus groups</i>	1
<i>Not stated</i>	3

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Table 3. The three most reported oral health determinants, divided into the five domains proposed in the FDI's framework

<i>Oral health determinant</i>	<i>Number of articles</i>
Genetic & biological factors	
<i>Age/year of birth</i>	15
<i>Sex/gender</i>	13
<i>Ethnicity/color of skin/self-reported race</i>	11
Social environment	
<i>Education (own and parental)</i>	34
<i>Household income/income/satisfaction with income</i>	26
<i>Socioeconomic status in childhood/of household</i>	9
Physical environment	
<i>Neighborhood characteristics/place of living/socioeconomic level (community)</i>	8
<i>Living conditions</i>	5
<i>Occupational hazards/safety</i>	4
<i>Leisure time/ activities</i>	4
Health behavior	
<i>Dental cleaning (e.g., tooth brushing, interdental cleaning)</i>	22
<i>Dental visits (e.g., frequency, reason, type of facility)</i>	22
<i>Oral hygiene/dental plaque</i>	19
<i>Personal characteristics (e.g., self-esteem, adapting, expectations, coping)</i>	19
Access to care	
<i>Healthcare system/dental care system/insurance</i>	9
<i>Public policies/political culture</i>	6
<i>Material wealth (community)/development</i>	5
<i>Satisfaction with dental care</i>	5

Appendix 2. Description of questionnaire, papers I and II

Table 1 Description of the questions used in papers I and II, from the Jönköping studies

Question	Response options
Self-reported sex	Male/female
Age group	20, 30, 40, 50, 60, 70, and 80 years
Level of education	Academic degree, upper secondary/vocational school 3-4 years, upper secondary/vocational school 2 years, independent adult education, primary and secondary school, primary school, and primary school < 6 years
Interdental cleaning	
<i>Do you regularly (every day) use interdental brushes?</i>	Yes, no
<i>Do you regularly (every day) use toothpicks?</i>	Yes, no
<i>Do you regularly (every day) use dental floss?</i>	Yes, no
Dietary habits	
<i>How many times/days do you eat or drink something between your main meals?</i>	0-9 times, more than 10 times/day
<i>Do you drink a soft drink, energy drink or lemonade/juice between meals?</i>	Every day, often (several times/week), sometimes, never
How do you today perceive the appearance of your face, mouth, teeth, and tooth replacements (dentures, crowns, bridges, implants)?	0 (very dissatisfied)-10 (very satisfied), summarized
<i>Appearance of your face</i>	
<i>Appearance of your profile</i>	
<i>Appearance of your mouth (smile, lips, visible teeth)</i>	
<i>Appearance of your teeth</i>	
<i>Shape of your teeth</i>	
<i>Color of your teeth</i>	
<i>Appearance of your gums</i>	
<i>Whole appearance of your face, mouth, teeth</i>	
Do you feel dry in your mouth?	Never, occasionally, often, always

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How often in the last year have you experienced the following situations because of problems with your teeth, mouth, or dentures:

Very often, fairly often, sometimes, hardly ever, never, question do not apply to me, merged pairwise, or summarized.

Functional limitation

Had trouble pronouncing words

Sense of taste worsened

Physical pain

Had painful aching in your mouth

Found it uncomfortable to eat foods

Psychological discomfort

Been self-conscious

Felt tense

Physical disability

Had an unsatisfactory diet

Had to interrupt meals

Psychological disability

Found it difficult to relax

Been embarrassed

Social disability

Been irritable with other people

Had difficulty doing usual jobs

Handicap

Felt that life in general was less satisfying

Been totally unable to function

Do you think your state of health prevents you from doing things you want to do?

Not at all, partly, greatly

How do you assess your overall state of health?

Good, average, bad

How do you perceive your health compared to others of your age?

Better, similar, worse

Which disease or condition (do you have)?

Free text

Ability to chew tough foods

0 (no limitation)-10 (Major limitation)

Perceived ability to chew

Good, fairly good, fairly poor, poor

Appendix 3. Interview guide, papers III and IV

Excerpt from the semi-structured interview guide used for data collection in papers III and IV (in Swedish). The questions are numbered, and below each question are examples of probing/follow-up questions used as support for the interviewer.

Område: CPAP-användning

Vi ska prata om tre större områden idag som jag har valt att kalla: CPAP-användning, allmän munhälsa och egen munhälsa. Det första området handlar om din sömn och om din CPAP-användning. Hur du sover och om du har några problem med din sömn kan variera över tid och det varierar också mellan personer. Under vissa perioder i livet är sömnen bra men sömnen kan under perioder bli sämre och dålig sömn kan påverka olika delar i livet som dina vanor, ditt beteende och hur du agerar i olika sammanhang som med arbetskamrater eller tillsammans med familj och vänner. Ibland kan det vara en specifik händelse som antingen har förbättrat eller försämrat sömnen.

1. Vill du berätta om din sömn.
 - a. *Sömn nu? Berätta om hur mådde du innan du fick CPAP? Hur sov du då?*
 - b. *Sömnproblem utöver sömnapné? Insomni? Vakna nattetid? Svårt att somna om?*
 - c. *Intressant berätta mer...*
 - d. *I början pratade du om...berätta mer om X*
2. Vill du berätta om din CPAP-behandling
 - a. *Hur länge?*
 - b. *Typ av mask? Ev. byten av apparatur/mask?*
 - c. *Intressant berätta mer...*
 - d. *I början pratade du om...berätta mer om X*
 - e. *Nu har du berättat om X, kan du berätta hur du ser på... (ex. kost, beteende och vanor)*

(...)

Område: Egen munhälsa, kost, tandvård

Det tredje området handlar om hur du ser på din egen mun och dina tänder då vi alla bär med oss olika erfarenheter som kan påverka våra vanor, vårt beteende och vad vi tycker är viktigt när det gäller munnen och tänderna. Området kan också belysa olika sätt att se på munnen och tänderna när det gäller olika tidpunkter i livet som före och efter du påbörjade din CPAP-

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behandling och specifika händelser som du kommer ihåg som har påverkat hur du ser på din mun och dina tänder.

3. Berätta om hur du ser på din mun och dina tänder
4. Berätta om hur du ser på faktorer som påverkar din mun och dina tänder.
 - a. *Intressant berätta mer...*
 - b. *I början pratade du om...berätta mer om X*
 - c. *Nu har du berättat om X, kan du berätta hur du ser på... (ex. kost, beteende och vanor)*
5. Om du tänker på din CPAP-behandling, berätta om hur du ser på din mun och dina tänder sedan du påbörjade din behandling
 - a. *Intressant berätta mer...*
 - b. *I början pratade du om...berätta mer om X*
 - c. *Nu har du berättat om X, kan du berätta hur du ser på... (ex. kost, beteende och vanor)*

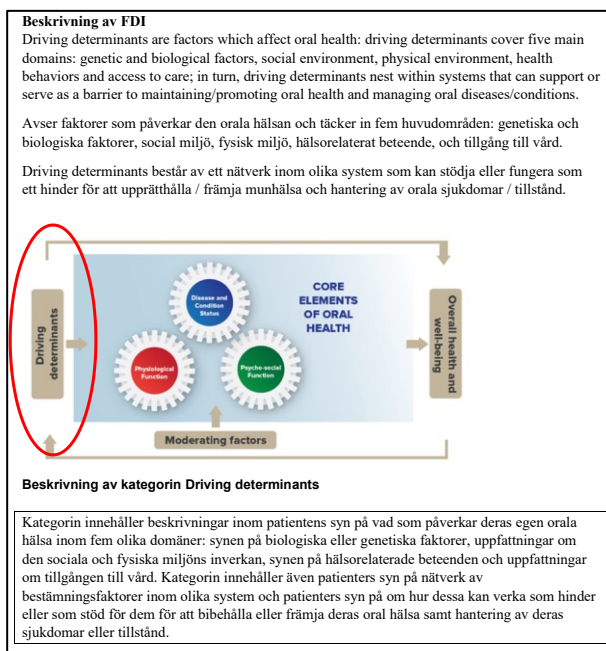
Specifika händelser där CPAP-behandlingen påverkat munhälsan eller åtgärder när CPAP:en påverkat munhälsan

- *Beskriv händelsen i detalj (var, vem, när)*
- *Berätta om händelsen som medförde denna åtgärd?*
- *Konsekvenser (positiva/negativa)?*
- *Tankar om det som hände (vid tillfället och efteråt)?*
- *Känslor om det som hände (vid tillfället och efteråt)?*
- *Vad gjorde du? Åtgärder?*
- *Hantering av liknande situationer (agerande/beteende)*

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Appendix 4, The code book, paper III

Excerpt from the code book used in paper IV for initial extraction of meaning units (in Swedish).



Synen på genetiska/biologiska faktorer

Inkluderar beskrivningar om synen på genetik (ex. arv) och biologiska faktorer (ex. bakterier, allmänna sjukdomar, saliv, medicinering osv). Ska innehålla en beskrivning om hur de ser på hur detta kan påverka eller har påverkat dem.

Synen på social miljö

Inkluderar beskrivningar om synen på hur deras sociala miljö (ex. familj, vänner, bekanta, generell syn i samhället) har påverkat eller kan påverka dem.

Synen på fysisk miljö

Inkluderar beskrivning om hur de ser på hur den fysiska miljön (ex. där de bor, där de har bostad, förhållanden i den närliggande miljön). Ska innehålla en beskrivning av hur de ser att den fysiska miljön kan eller har påverkat dem.

Synen på hälsorelaterade beteenden

Inkluderar beskrivningar om hur de ser på sina orallhälsorelaterade beteenden (ex. oral hygien, vad som har påverkat deras vanor, vad som påverkar deras vanor nu, kan även innehålla diet, fysisk aktivitet eller liknande, möjliggörare och barriärer för att upprätthålla god munhygien). Ska innehålla beskrivningar om vanor och hur de ser att det har eller kan påverka dem.

Synen på tillgång till vård

Inkluderar beskrivningar om hur de ser sin tillgång till tandvård (ex. finns/fanns det möjlighet till besök, regelbundna besök, möjlighet till regelbundna besök, vilja att besöka). Ska innehålla beskrivningar om hur de ser på faktorer som påverkar deras möjlighet/vilja att besöka tandvården.

*“En ny port mot det Otroliga, det Möjliga, en ny dag där allting kan hända
om man inte har nånting emot det.”*

Tove Jansson

The multifaceted concept of oral health

– studies on a Swedish general population and perspectives of persons with experience of long-term CPAP-treated obstructive sleep apnea

The overall aim of this thesis was to deepen the understanding of how the World Dental Federations [FDI] theoretical framework of oral health can be applied in a general population and how oral health is experienced in a specific population of persons with increased risk for adverse oral health. By using the FDI's theoretical framework as basis for exploration, the multifaceted concept oral health was investigated and explored with quantitative and qualitative methods.

Oral health is a changeable part of our overall health and well-being as it contributes to essential everyday functions. It can be affected by numerous determinants, where continuous positive airway pressure [CPAP]-treated obstructive sleep apnea [OSA] could be one. The findings in this thesis showed that the FDI's theoretical framework can be applied in a general population by using both clinician and person reported measures, but also how different components of oral health can affect each other. Moreover, the findings provided deeper knowledge on oral health determinants, experiences, and management of oral health related difficulties through the lens of persons with experience of CPAP treatment. As CPAP treatment can affect physical, functional, and psychosocial aspects of oral health, it could be considered an oral health determinant. Altogether, by combining the findings in the sub-studies, this thesis provides a deeper understanding of how oral health can be applied, described, explained, experienced, or viewed in different populations and from different perspectives.



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