# The Oral Hygiene Ability Instrument, OHAI

## Development of an instrument to assess the cause of poor oral hygiene self-care in older adults

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"Algot thinks his mouth is clean, and that he's doing what he's always done, but maybe he doesn't…"

*(Dental hygienist)*

# ABSTRACT

Oral hygiene is an important preventive measure to maintain good oral health in the growing group of older adults. Oral hygiene often deteriorates with age, but the causes of this at the individual level are rarely investigated. One reason of several may be that a multifactorial assessment instrument is missing. The aim of this thesis was therefore to develop and evaluate an instrument to assess the cause of any inability for older adults to manage daily oral care. The qualitative Study I aimed to identify factors that affect older adults' ability to manage oral hygiene. Focus group interviews (n = 4) were conducted with dental hygienists, occupational therapists, assistant nurses, and older adults. Data were analyzed using content analysis. The results were formulated into the core category "Oral hygiene is a complex activity" that is influenced by psycho-logical, functional, and environmental factors. Inclusion criteria for Studies II-IV were: 1) age ≥ 65 years, 2) at least one natural tooth or osseointegrated implant, and 3) ability to manage oral hygiene independently. Study II describes the development process of the Oral Hygiene Ability Instrument (OHAI), which comprised three phases: planning, construction, and evaluation. The construction phase was based largely on the results of Study I. The evaluation phase resulted in the reduction of OHAI from 47 to 33 items. OHAI came to consist of three parts: Part I – interview, Part II – clinical examination, and Part III – observation of the oral hygiene activity. Based on the results of Parts I-III, the rater (a dental staff member) conducts a summary assessment of the impact of ten factors (cognitive function, frailty, motivation, vision, fine motor skills, coordination knowledge of oral hygiene, spatial ability, oral clearance, and balance) on the individual's oral hygiene ability. Study III concerned the reliability of OHAI. Part I (interview) was tested for test–retest reliability on 37 older adults. Parts II and III were tested for intra-/interrater reliability. Four dental professionals assessed 15 films and intraoral photos of older adults undergoing OHAI assessment. Parts I and III were found to have acceptable-to-good test-retest and intra-/interrater reliability, respectively; however, five items in Part II displayed limited reliability. In Study IV, the OHAI was tested for criterion and construct validity in a stroke group (n = 50), a group with cognitive impairment (n = 49), and a group of general dental patients (n = 50). Criterion validity was analysed, with sensitivity/ specificity showing acceptable-to-good agreement. To test for construct validity, known-group validity analysis, factor analysis, and Rasch analysis were used. In general, OHAI demonstrated good criterion and construct validity. However, Study IV, like Study III, showed potential for improvement for some items, which meant that some minor changes were implemented in the OHAI to obtain a more robust and easier-to-use instrument. In conclusion, oral hygiene was found to be a complex activity that needs to be supported in different ways depending on the cause of the lack of ability. The development of the OHAI means that there now is a valid and reliable instrument for the assessment of the cause of an older adult's inability to manage oral hygiene.

**Keywords**: frail, measurements, older adults, oral hygiene, reliability, self-care, validity

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# SAMMANFATTNING PÅ SVENSKA

Munhygien är en viktig förebyggande åtgärd för att bevara en god munhälsa i den växande gruppen äldre personer. Det är vanligt att munhygienen försämras med åldern, men orsaken på individnivå utreds sällan. En orsak bland flera kan vara att ett multifaktoriellt bedömningsinstrument saknas. Syftet med denna avhandling var därför att utveckla och utvärdera ett instrument att använda i tandvården för att identifiera orsaker till bristande förmåga hos äldre personer att sköta sin munhygien. *Studie I* var kvalitativ och syftande till att identifiera faktorer som kan påverka äldre personers förmåga att sköta sin munhygien. Fyra fokusgruppsintervjuer med tandhygienister, arbetsterapeuter, undersköterskor och äldre personer genomfördes. Data analyserades med innehållsanalys. Resultaten formulerades till en kärnkategori, ”Munhygien är en komplex aktivitet”, som påverkas av psykologiska, funktionella och omgivande faktorer. Inklusionskriterier för Studie II–IV var: 1. Ålder ≥ 65 år, 2. Att ha minst en naturlig tand eller osseointegrerat implantat, 3. Att självständigt sköta sin munhygien. *Studie II* beskriver utvecklingen av Oral Hygiene Ability Instrument (OHAI), som genomfördes i tre faser: planering, konstruktion och utvärdering. Instrumentets konstruktionsfas baserades i hög grad på resultaten från Studie I. Utvärderingsfasen resulterade i att OHAI kunde minskas från 47 till 33 frågor/uppgifter. OHAI kom därmed att bestå av totalt 33 frågor/uppgifter uppdelat på tre delar: Del I: intervju, Del II: klinisk undersökning och Del III: observation av munhygienaktiviteten OHAI avslutas med att bedömaren (tandvårdspersonal) utifrån resultatet av Del I–III gör en summerande bedömning av tio olika faktorers påverkan på individens munhygienförmåga (kognitiv funktion, skörhet, motivation , syn, finmotorik, koordination, kunskap om oral hygien, spatial förmåga, oral självrengöring, balans). I *Studie III* undersöktes reliabiliteten hos OHAI. I intervjudelen (Del I) testades test-retest reliabiliteten på 37 äldre vuxna. I Del II och III av OHAI testades intra- och inter-bedömarreliabiliteten. Fyra tandvårdspersonal bedömde 15 filmer och intraorala foton som visade äldre personer när de bedömdes med OHAI. Del I visade sig ha acceptabel-till-god test-retest reliabilitet och detsamma gällde Del III avseende intra- och inter-bedömarreliabilitet. Dock visade fem frågor/uppgifter i Del II begränsad reliabilitet. I *Studie IV* testades OHAI för kriterie- och begreppsvaliditet i tre grupper: personer med stroke (n = 50), personer med kognitiv funktionsnedsättning (n = 49) och allmäntandvårdspatienter (n = 50). Kriterievaliditet analyserades med sensitivitet/specificitet. Överensstämmelsen var huvudsakligen acceptabel-till-god. För begreppsvaliditet användes known-group validitet, faktoranalys, samt en Raschanalys. Generellt visade OHAI en god kriterie- och begreppsvaliditet. Studie IV, liksom Studie III, visade dock på potential till förbättringar för vissa frågor/uppgifter, vilket innebar att mindre förändringar genomfördes i OHAI för att få ett mer robust och mer användarvänligt instrument. Sammanfattningsvis visade avhandlingsarbetet att munhygien är en komplex aktivitet som bör stödjas på helt olika sätt beroende på vad som orsakar den bristande förmågan. Utvecklingen av OHAI innebär att det nu finns ett validt och reliabelt instrument för bedömningen av orsaken till en äldre persons bristande förmåga att sköta munhygienen.

# LIST OF PAPERS

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

I. Grönbeck-Lindén I, Hägglin C, Gahnberg L, Andersson P. Factors Affecting Older Persons' Ability to Manage Oral Hygiene: A Qualitative Study. JDR Clin Trans Res 2017; 2: 223-232.

II. Grönbeck-Lindén I, Andersson P, Dahlin-Ivanoff S, Gahnberg L, Hägglin C. Development of an instrument to assess oral hygiene ability: the Oral Hygiene Ability Instrument. Gerodontology 2020; 37(1):19-27.

III. Grönbeck-Lindén I, Andersson P, Dahlin-Ivanoff S, Gahnberg L, Hägglin C. (2023) Evaluation of the Oral Hygiene Ability Instrument (OHAI) – Test of Reliability. Submitted.

IV. Grönbeck-Lindén I, Wenemark M, Andersson P, Dahlin-Ivanoff S, Gahnberg L, Hägglin C. (2023) Evaluation of the Oral Hygiene Ability Instrument (OHAI) – Test of Validity. Submitted.

# CONTENTS

# ABBREVIATIONS

| | |
|---|---|
| ADL | Activities of Daily Living |
| CH | Catharina Hägglin, dentist, associate professor |
| IGL | Ingela Grönbeck Lindén, dentist |
| LG | Lars Gahnberg, dentist, professor |
| PA | Pia Andersson, dental hygienist, associate professor |
| SDI | Synneve Dahlin Ivanoff, occupational therapist, professor |
| NOT-S | Nordic Orofacial Test-Screening |
| OHAI | Oral Hygiene Ability Instrument |
| OHRQoL | Oral health–related Quality of Life |
| QoL | Quality of Life |
| ROAG | Revised Oral Assessment Guide |
| ROC | Receiver operator characteristics |
| SKaPa | Svenskt Kvalitetsregister för Karies och Parodontit |
| WHO | World Health Organization |

# DEFINITIONS IN SHORT

| | |
|---|---|
| Frail (medically) | Older adults or aged individuals who are lacking in general strength and are unusually susceptible to disease or to other infirmity. (Morley 2013) |
| Frail older adults | Older adults with continued assistance from others (Ettinger 1984). |
| Functionally independent older adults | Older adults living independently in the community (Ettinger 1984). |
| Functionally dependent older adults | Older adults dependent on others for ADL (Ettinger 1984). |
| Older adult | Based on people's chronological age, defining older persons as those aged 60 or 65 years or over (United Nations 2019). In this thesis, an older adult is defined as 65 years or older. |
| Oral clearance | Here meaning the ability to self-clean after a meal, to transport away food and its decomposition products. |

# PREAMBLE

Oral health is an integral part of general health. As stated in the World Report on Ageing and Health (WHO 2015), “Oral health is a crucial and often neglected area of healthy ageing”. The growing group of older adults in the population has not appeared out of nowhere: they were once babies and, throughout their different stages of life, have had varied experiences, including ones related to oral health. Tooth retention has increased in older adults and most have natural teeth remaining, meaning that the need for dental care and prophylactic measures also has increased. Older adults are not a homogeneous group and most are able to take care of their oral health in a satisfactory way. Others may contract a disease early in their ageing, which affects their ability to maintain good oral health. Good oral health contributes to a good quality of life.

Over the course of my career, I have experienced a nod and a smile from an 85-year-old stroke patient with aphasia when new front teeth were in place, and a hug from a non-verbal woman when a loose tooth was removed. These brief moments made the work worthwhile. During my first years in public dentistry, I regularly visited a nursing home. It was populated with older women sitting at the entrance waiting for the week’s main event: “Here they come!” Most had complete dentures, and the work consisted of detecting abrasions or repairing cracked dentures. Over the years, the scenario has changed. More remaining teeth and an increased risk of caries and periodontitis in older and more fragile adults make the work a completely different challenge.

When I was given the opportunity to join Centrum för äldretandvård, CÄT (Centre of Gerodontology) first as an “informant” for groups of older adults in the community and then as a tentative researcher, I embarked on that path with a slightly trembling heart. Under the auspices of the National Clinic Research School, the research environment at Odontologen in Gothenburg, my research has taken me to many nursing homes, dental clinics, and private homes in Region Västra Götaland. Together with cheerful participants aged 65–100 years and incredible co-workers, a thesis has been created that concerns an assessment instrument, one that I hope and believe takes a small step toward improved oral health in the growing group of older adults.

# INTRODUCTION

The oral cavity is an important part of the body and contributes greatly to personal identity. The mouth enables many important human abilities, such as speech, the ability to eat, and the ability to show tenderness and intimacy. The importance of the mouth in this regard should not be neglected later in life. In 2016, the World Dental Federation introduced a new definition of oral health: "Oral health includes the ability to speak, smile, smell, taste, touch, chew and swallow. Without pain, discomfort and diseases of the craniofacial complex, be able to convey emotions through facial expressions" (Glick et al. 2017). This definition emphasizes the complexity of oral health, including three key components: disease and condition, physiological function, and psychosocial function.

## OLD AGE AND LONGEVITY

Demographic data clearly show that the proportion and number of older adults in Sweden and globally are increasing (Ritchie et al. 2023). In Sweden, 25.5% of the population is aged 60 years or over (Statistics Sweden 2022), making the country a "super-ageing society" like, for example, Japan, Germany, Finland, and Italy (Muramatsu & Akiyama 2011). The age group that is increasing the most is the group aged 80 years and older, which is expected to increase by 25% by 2030 (Statistics Sweden 2022). The average life expectancy is also increasing, and Sweden is among the countries with the highest average life expectancy in Europe. Reaching old age often means that morbidity occurs during the course of life. In terms of general health, just under half of the members of the oldest group – aged 80 years and older – consider themselves to be in good health (Statistics Sweden 2022).

Old age, or senescence, has a twofold definition: it is the last part of the normal lifespan as well as an age group or a segment of the oldest in a population. Older adults have traditionally been defined by their chronological age, that is, those aged over 60 or 65 years, according to the UN and researchers in the field (UN 2019). In Sweden, the average retirement age is 65 years, even though many individuals who have reached age 65 do not define themselves as old (Swedish Pensions Agency 2022). Added life years give opportunities to continue working and to participate in social activities that improve the quality of life. For others, illness, a worn-out body, and mental changes put an end to the life that used to be (Murray et al. 2015). It would have been better if instead

of chronological age, functional age could have been used to a greater degree. Functional age represents a balance of biological, social, and psychological age (Sharkey 1987).

## ORAL HEALTH IN OLDER AGE

Over the years, the oral health of the population of older adults in Sweden has improved. The oral health of the Swedish population is generally good. One parameter of good oral health and dental status in a population is the number of retained teeth. In 2022, among persons 80-89 years of age in Sweden, fewer than 5% were edentulous and 60% had 20 or more teeth (National Board of Health and Welfare 2020).

In Sweden 56% of the adult population above 23 years of age visited dental care in 2018. A relatively high proportion (70%) of those aged 70-79 years have regular dental visits, but from the age of 80 years there is a gradual decrease in dental visits (National Board of Health and Welfare 2020; Grönbeck Lindén et al 2016). It has been reported by dental staff that older adults may be reluctant to visit the dentist/dental hygienist due to factors such as income, social support, or perceived poor health, and often reschedule or postpone appointments and treatments (National Board of Health and Welfare 2020; Tu et al. 2023). After a long gap in contact with dentistry, there can be a significant need for dental care, which can be both tiring and costly for the older adult.

The Swedish quality registry for caries and periodontal disease (SKaPa) and Statistics Sweden depict older adults as being at risk of poorer oral health. The caries frequency decreases up to the age of 60, but then increases in older adults (SKaPa 2022; Statistics Sweden 2022). Periodontitis is the sixth most common disease in the world (Kassebaum et al. 2014). The percentage of individuals with marginal bone loss increase with age. Despite this, studies show that gingivitis, marginal bone loss, and the number of pockets has been decreasing over time in the population of older adults in Sweden (SKaPa 2022, Norderyd et al.). Preventive dental care measures that are crucial for the oral health of older adults also decrease with age (SKaPa 2022).

Preventive dental care measures that are crucial for the oral health of older adults also decrease with age (SKaPa 2022). The combination of reduced dental visits and increasing oral disease in the ageing mouth is important to pay attention to. A lasting dental contact and targeted prophylactic measures

are important for a healthy mouth. Ageing itself is not a risk factor for poorer oral health, but what ageing entails can cause previously good oral health to deteriorate rapidly (MacEntee et al. 1993).

## SOME FACTORS RELATED TO ORAL HEALTH

A reciprocal relationship is seen between oral health and general health: systemic diseases can degrade oral health and poor oral health can degrade general health (Ástvaldsdóttir et al. 2018).

Several medical conditions that are common later in life can contribute to poorer oral health. A stroke can, for example, severely impair various functions such as mobility and memory. A severe stroke can result in neglect of half the body, strongly influencing the ability to care for the mouth (Campbell & Khatri 2020). Diabetes affects oral health in different ways (Borgnakke 2019). A study by Kocher et al. (2018) shows a connection between diabetes and periodontitis, as both are chronic inflammation-based diseases. Diabetes can reduce saliva flow, which in turn can trigger caries damage (Carramolino-Cuéllar et al. 2018).

Failing cognition also influences oral health, as the older adult may forget to brush or even forget how to do so. This can lead to periodontal damage and tooth loss, which impairs the ability to chew (Sheiham & Steele 2001). Nakamura et al argues in a review article that oral health can affect cognitive disorders although the causal relationship is not clear (Nakamura et al 2021). However, it has been noted that lack of teeth and poor dental status make chewing difficult, and that the blood flow to brain tissues may thereby be reduced due to inactivity and give cognitive decline as a result (Nilsson et al 2018). In a recently published study, periodontitis was associated with future ischemic heart disease (Bengtsson-Wallin et al. 2021). Periodontitis may also cause diabetes-related complications in diabetic patients with poor metabolic control (Borgnakke 2019). Furthermore, a common complication of poor oral hygiene is the inhalation of sputum or plaque, which can cause potentially severe aspiration pneumonia; this is in many cases fatal for a frail older adult (Khadka et al. 2021; Sakai et al. 2016).

Subjectively experienced dry mouth increases with age and is predominant in women (Field et al. 2001). Subjective and objectively assessed dry mouth are

seen as two different conditions (Hopcraft & Tan 2010). Objectively assessed dry mouth does not seem to increase with age, but when present can give rise to caries as well as to plaque retention and retained food residues. Medications cause dry mouth to varying degrees. Older adults often take several medications, and one or more of these may have a component negatively affecting saliva flow (Adolfsson et al. 2022). Dry mouth is the third most reported adverse effect of medication (Villa et al 2016).

Social risk factors for poor oral health include a change in life situation, such as losing a spouse. This can lead to involuntary loneliness and depression, which often has a major impact on daily life activities. Approximately 10% of older adults in Sweden experience loneliness (Dahlberg et al. 2018). Socioeconomic factors such as education and income are also of importance for oral health (Slack-Smith et al. 2023).

## FRAILTY

There is great heterogeneity with large individual differences among older adults, who range from healthy to severely frail (Jaul & Barron 2021). Different factors during the life course influence older adults in different ways (Ettinger & Marchini 2020). Most older adults do not experience functional problems or frailty until after the age of 80, although chronic diseases do occur (Espinoza et al. 2018). Yet, in older adults, the body's resistance to illness or trauma, both physical and mental, is reduced (Clegg et al. 2013).

At a consensus conference in 2013, two ways of defining frailty were discussed: frailty and physical frailty, which are strongly related but not interchangeable concepts. Consensus was reached to define physical frailty as a result of the biological ageing of the body accompanied by decreasing reserve capacity (Morley et al. 2013). A second definition was a broader definition capturing a larger group. Here, the concepts of morbidity, physical frailty, and activity capacity were merged, and physical frailty became part of the concept (Rockwood 2016).

In a model proposed by Ettinger & Beck (1984), frailty in older adults is assessed according to dependency on assistance. In dental care, "frail" means that the person in question may have become somewhat unstable, may need an alarm, but is not dependent on help from others continuously, while in nursing care and healthcare, "frailty" is a more severe condition (Morley et al 2013). The concept of frailty can therefore be experienced as confusing when dental

care and healthcare meet. Otherwise, in the Ettinger & Beck model from 1984, as in other models of frailty, changes can occur quickly, but when it comes to oral health, the symptoms can be stopped and, in some cases, prevented if prophylactic measures are taken in time. In this thesis the frailty concept according to Ettinger is used, but also the medical term frailty (Morley et al 2013) depending on the context. Figure 1 shows a common picture of oral hygiene in older adults based on the different levels of dependence proposed by Ettinger in 1984.


*Figure 1. Oral hygiene in older adults at different stages of dependency. After a model by R. Ettinger. Design by L. Gahnberg. Photos IGL.*

## ORAL HYGIENE

Oral hygiene is of great importance for good oral health and commonly described as the practice of keeping the oral cavity clean and free of disease (Lindenmüller & Lambrecht 2011). Poor oral hygiene is more common the more functionally dependent you become (Figure 1). In a study by Strömberg et al. (2012) on older adults with substantial needs of home nursing, half as many were found to have acceptable oral hygiene as compared to older adults with moderate needs. Poor oral hygiene was associated with being male and having high plaque scores, gingivitis, and more caries. Regular dental care, good saliva secretion, and good oral hygiene habits increased the chance of not developing caries (Strömberg et al. 2012).

Oral hygiene activity includes several parts. It can constitute brushing one's teeth twice a day with fluoride toothpaste and cleaning between the teeth with suitable aids. Extra fluoride supplements, such as mouth rinse or high-fluoride toothpaste, are important for older adults. Older adults may have difficulties in performing oral hygiene due to decreased fine motor skills, in which case electric toothbrushes and special grips can be used. When dry mouth is present, good oral hygiene is necessary. In addition, saliva stimulants or dry mouth

lubricants can be used (National Board of Health and Welfare 2019; Srinivasan 2014).

## INSTRUMENTS FOR ASSESSING ORAL HYGIENE IN OLDER ADULTS

To assess the inability of oral hygiene self-care for older adults, and the cause of this inability, few instruments are available for dental professionals in clinical practice: the Toothbrushing Ability Test (TAT) (Felder et al. 1994), the Activities of Daily Oral Hygiene Index (ADOH) (Bauer 2001), and the Oral Hygiene Performance Test (OHPT) (Doherty et al. 1994). These instruments each assess only a single factor. To our knowledge, no multifactorial instrument with which to assess oral hygiene self-care ability and the causes of impaired oral hygiene has been developed.

Poor oral hygiene is not a necessary consequence of frailty or old age, but there is a relationship between these two factors (Tôrres et al. 2015). A lot can happen between two dental visits – diseases can occur, medications can be started, or the life situation can change – which can affect the older adult's ability to perform good oral hygiene. It is therefore crucial that dental professionals not only detect deteriorating or poor oral hygiene among older adults but also investigate the cause as early as possible, as these adults are in the risk zone for developing impaired oral health.

# AIM

The overall aim of this thesis was to develop and evaluate an instrument to assess the cause of any inability for older adults to manage daily oral care.

## SPECIFIC AIMS

### STUDY I

To investigate and identify factors that may affect older adults' ability to perform oral hygiene self-care.

### STUDY II

To describe the development of a standardized instrument to assess older adults' ability to self-manage oral hygiene, possible cause(s) of impaired oral hygiene, and need for help and support.

### STUDY III

To determine the reliability of the Oral Hygiene Ability Instrument.

### STUDY IV

To evaluate the validity of the Oral Hygiene Ability Instrument.

# MATERIAL AND METHODS

This thesis is based on a qualitative study (Study I) intended to identify factors that affect an older adults' oral hygiene self-care, and an explorative study (Study II) describing the development of an instrument, namely the Oral Hygiene Ability Instrument (OHAI), for assessing the cause of poor oral hygiene in older adults. Study III tests the reliability of OHAI and Study IV its validity. Figure 2 shows an overview of the designs of and participants in the four studies.

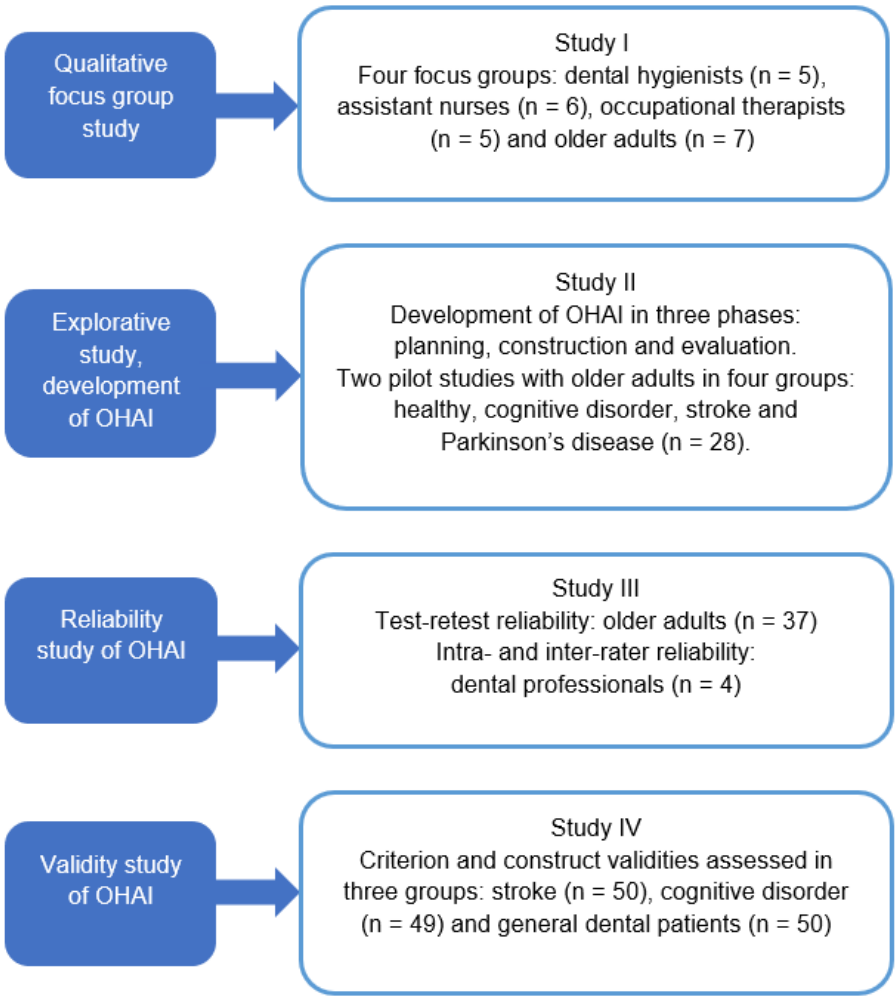



*Figure 2. Overview of study design and participants in Studies I–IV.*

The design, construction, and evaluation of the instrument were inspired by a model constructed by Benson and Clark in 1982 that comprises four phases: Phase 1, planning; Phase 2, construction; Phase 3, evaluation; and Phase 4, validation. In this section, the development process for OHAI is described based on these four phases, as shown in Figure 3.

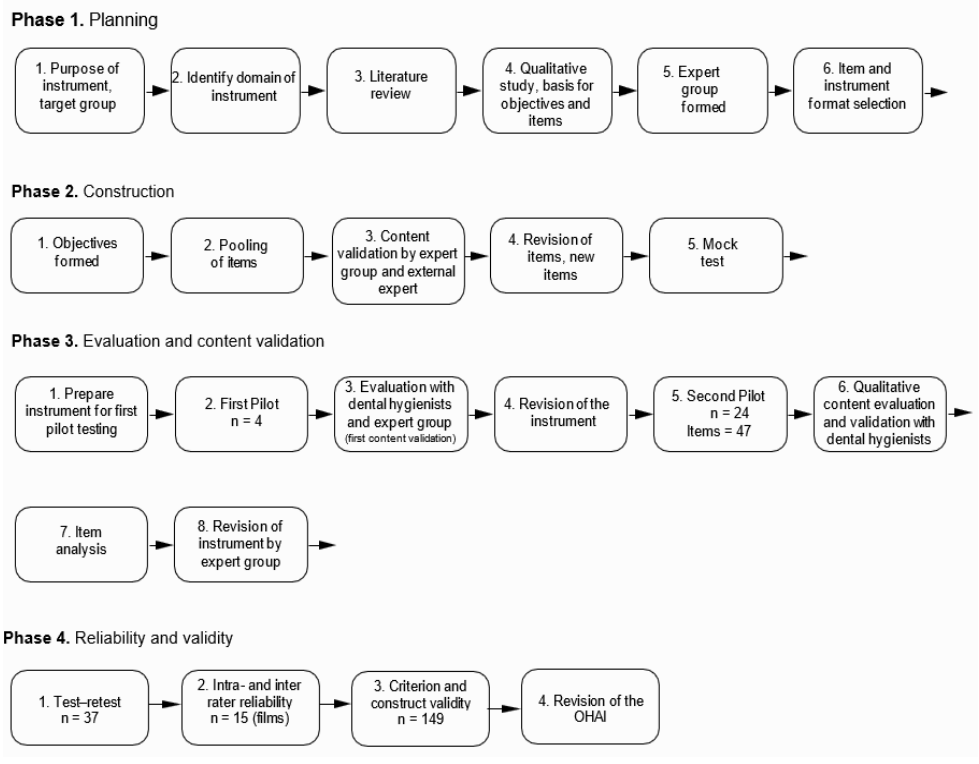



*Figure 3. Flow chart of the OHAI development process, inspired by guidelines proposed by Benson and Clark (1982): Phase 1, planning; Phase 2, construction; Phase 3, evaluation; and Phase 4, validation.*

# PHASE 1: PLANNING

## The instrument's purpose, target group, and domain

At a network conference of the Centre for Gerodontology, Region Västra Götaland, Sweden a question was raised as to whether there was any instrument for assessing the cause(s) of poor oral hygiene. Does such an instrument even exist? This question was one reason why the work on this thesis started.

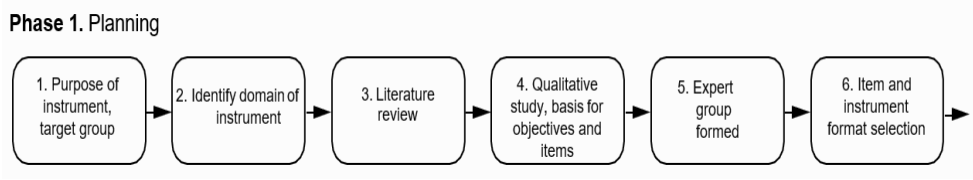



*Figure 4. The parts included in Phase 1, planning.*

The first task was to decide what kind of instrument we were looking for: (1) what *the purpose* of such an instrument would be and what *target group* it would address, and (2) what *the domain* of the instrument would be (Figure 4). It was determined that the purpose of the instrument would be to assess the possible causes of poor oral hygiene. The target group was defined as older adults ≥ 65 years of age with any teeth or any kind of prosthetic device. The domain was defined as the complexity of oral hygiene skills in older adults as experienced by dental staff working with this group (network conference participants). These first steps are addressed in Study II.

## Literature search

In Study II, (3) a literature search was conducted in PubMed, Scopus, and Google Scholar using keywords such as “oral assessment”, “oral hygiene ability”, “oral hygiene ability instrument”/ “index”/ “assessment”, “oral hygiene” AND “older adults”, “instrument” AND “ADL” AND “oral hygiene”. The literature search yielded many hits for the keywords used, but few that applied to instruments intended for older adults caring for their oral hygiene independently. Most available instruments are intended for older adults in hospitals or nursing homes and target nursing staff. Three observational instruments were found that assess the ability of older adults to independently manage oral hygiene (Bauer 2001; Doherty et al. 1994; Felder et al. 1994). In summary, no instrument was found that was taking into account several factors that can affect the oral hygiene ability of older adults who manage their oral hygiene independently. Nor were any studies found that examine what causes difficulties for older adults in managing their oral hygiene. Before any instrument could be developed, these factors and causes needed to be investigated in a separate study. The literature search led to (4) a qualitative study (Study I) being conducted (Figure 4).

# Qualitative study: Study I

## Study design

The aim of Study I was to identify factors that could influence the oral hygiene self-care ability of older adults. A focus group study was planned and conducted to gather experiences and facts about the topic. There was a certain pre-understanding of factors that could affect an older person's self-care ability in terms of oral health, but additional knowledge was needed. The study applied an inductive approach and was followed by a content analysis.

Study population

The focus groups contained 23 participants in total, divided into four groups:

- dental hygienists working in public or specialized dental care ($n$ = 5)
- assistant nurses working in geriatric or dementia wards ($n$ = 6)
- occupational therapists working in geriatric medicine or stroke wards at a hospital ($n$ = 5)
- older adults attending a meeting point for older adults ($n$ = 7).

The rationale behind the group selection was that the selected professionals should work mostly with older adults and have at least five years of experience in their professions. The older adults should be over 70 years of age and not have cognitive problems, aphasia, or hearing problems. The invitation to participate in the study was sent to the heads of the respective work groups. The information was disseminated at a workplace meeting and interest in participating was reported to the study coordinator (IGL). Potential participants for the group of older adults were asked about their interest in participating in the study by the coordinator of a municipality's meeting point for older adults. The expressions of interest were forwarded to the study coordinator.

## Procedure: interviews

The focus group interviews were conducted in 2014 on the Swedish west coast. The first and second authors (IGL and CH) carried out the interviews as moderator and observer, respectively.

The question in focus during the interviews was:

> What factors, in addition to motor skills, influence an older adult's ability to manage oral hygiene?

Subsequently, open-ended follow-up questions were used to keep the focus on the main question.

The interviews were conducted as a conversation in which the participants could discuss matters freely. Follow-up questions (from an interview guide) were asked if the conversation got off track. The interviews, which lasted approximately 60 minutes, were audiotaped and transcribed verbatim for further qualitative content analysis (Graneheim & Lundman 2004). The data collection was completed after four interviews, as the material was rich and judged to be sufficient for analysis. A conventional manifest and latent analysis was used to interpret the transcribed interviews (Graneheim & Lundman 2004; Hsieh & Shannon 2005). The data were analysed by three of the authors jointly (IGL, CH, and PA). The analysis took place in several stages and was discussed vigorously during the course of the work.

To ensure that the factors and categories found in Study I were relevant to the objective of the instrument, an expert group (expert group 1) was used comprising nine senior staff members: odontology was represented by two dentists and two dental hygienists; a senior psychologist and researcher with extensive knowledge of anxiety and pain participated, as did an occupational therapist with deep knowledge of ADL instruments; three researchers from nursing, nutrition, and later life care also participated, contributing their knowledge. Individual meetings were held on one occasion with these experts. If questions arose, new contact with the experts was sought.

## Expert group for selection of items and instrument format

The findings of the qualitative study, Study I, were intended to form the basis of the instrument under construction and be used in selecting the items and their formats (Figure 4). When constructing the instrument (5) expert group 2 was formed, comprising three dentists, one dental hygienist, and one occupational therapist (CH, IGL, LG, PA, and SDI). Four of these group members had extensive research experience within, for example, gerodontology, oral health, public health, geriatrics, and cariology. Meetings were held with the experts when (6) the selected items and instrument format were discussed and suggestions for changes were made (Figure 4). The instrument was structured in three parts: Part I, interview; Part II, clinical examination; and Part III, observation of ADL.

# PHASE 2: CONSTRUCTION

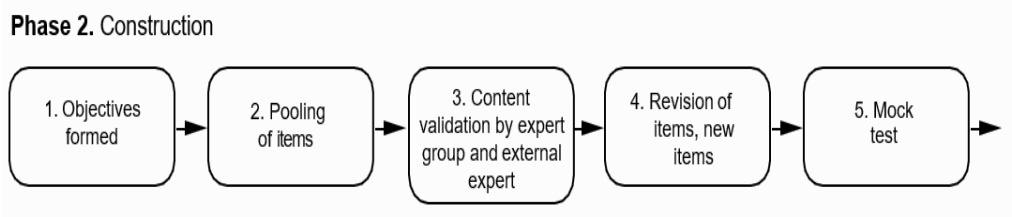



*Figure 5. The parts included in Phase 2, construction.*

## Formulation of objective, pooling of items, content validation and revision

The instrument should have (1) *the objective* to assess the cause(s) of an older adult's impaired ability to manage oral hygiene independently (Figure 5). In the first version, the objective was formulated as "to assess an older adult's ability to manage daily oral hygiene". This was revised at a relatively early stage to "should assess the cause(s) of an older adult's impaired ability to manage oral hygiene independently" (see Discussion). The qualitative study (Study I) served as the basis when items were to be selected. For Part I, most items came from other instruments concerning quality of life (QoL) and frailty (Ekbäck 2008; National Board of Health and Welfare 2022). For Part II, five items were selected from the Nordic Orofacial Test–Screening (NOT-S) examination part (Bakke et al. 2007). NOT-S contains an interview part (15 items) and an examination part (six items) and is intended to assess orofacial dysfunction. Two items in Part II were selected from the Revised Oral Assessment Guide (ROAG), which is a well-established oral health risk-assessment instrument for use by nursing care professionals (Andersson et al. 2002). ROAG contains nine items, including the single-item mirror test (Henricsson 1994). The items in question can be seen in Table 1. For Part III, the items were formulated by the authors.

A (2) *pool of items* was now present and item selection was discussed and supported by the expert group 2. At this stage, an external expert on questionnaires and statistics was attached to the project, and, together with the expert group 2, helped perform (3) *content validation* of the items and response options, resulting in some (4) *revision*. For some of the items that had been reused from other instruments, the response options were slightly modified to fit the instrument under construction. Some items were reworded and a few

new items were developed. When consensus was reached, the first version of the OHAI had 47 items (Table 1).

*Table 1. The OHAI in its first version with 47 items in abbreviated form, divided into three parts. The response options are given as footnotes. Items in light grey were removed in phases 2 and 3, whereas the items in bold were added. The 33 numbered items were used in the validation and reliability studies (Studies III and IV). Items selected from the NOT-S and ROAG instruments are labelled specifically.*

| | | |
|---|---|---|
| Part I. Interview | Do you manage oral hygiene by yourself? | 21. Function: lick lips[15] (NOT-S) |
| Background, social context | Last dental visit | 22. Function: puff up cheeks[16] (NOT-S) |
| 1. Medication (names) | Satisfied with your teeth? | Oral hygiene (ROAG) |
| 2. Diseases (names) | 13. Knowledge of oral hygiene[10] | 23. Mirror test: oral dryness[17] (ROAG) |
| 3. Disabilities (names) and balance problems, y/n[1] | Teeth covered with plaque | 24. Dental status: position of teeth, missing teeth[18] |
| 4. Housing[2] | When brushing/picking, how often: 14. Pain[11] | 25. Dental status: prosthetics, dentures[19] |
| 5. Living conditions[3] | 15. Disgust or gagging[11] | Part III. Observation ADL |
| Marital status | 16a. Bleeding when brushing/picking, y/n[1] | Open toilet bag |
| Loss of spouse | 16b. If yes, what do you do?[12] | 26. Pick up toothbrush[20] |
| Number of social contacts | Interdental cleaning aid, which one? | Remove protective plastic on toothbrush |
| 6a.* Help with shopping, y/n[1] 6b.* Help with personal hygiene, y/n[1] | How often: Have to drink to swallow food | 27. Pick up toothpaste[20] |
| | 17. Problem swallowing dry food[11] | 28. Unscrew cap[20] |
| 7. Perceived loneliness[4] | 18. Problems with dry mouth[11] | 29. Apply toothpaste[20] |
| 8. Experienced life situation[5] | 19. Problems chewing hard food[13] | Bring toothbrush to mouth |
| Dental care and dry mouth | Part II. Clinical examination | 30. Brush teeth[20] |
| 9. Regularity of dental care[6] | Oral function, dental status, and dry mouth | 31. Pick up interdental brush[20] |
| 10. Who handles contacts with the dental service?[7] | 20. Function: clench jaws (NOT-S) | 32. Use interdental brush[20] |
| 11. Importance of oral health[8] | Gape as much as you can (NOT-S) | 33. Rinse mouth[20] |
| 12. Frequency of oral hygiene[9] | Stick out your tongue (NOT-S) | |

**The item 6a, b was in 47 item version two separate items with several response options*

***Response options:***
*[1] Yes/no*
*[2] Own accommodation; Short-term accommodation; Alternating accommodation (nursing home/at home); Nursing home*
*[3] Lives alone; Lives with a partner (husband, wife, common-law partner); Lives with children or other relatives; Has a partner, but lives separately*
*[4] Yes, often; Yes, every now and then; No; Don't know/no opinion*
*[5] Very satisfied; Quite satisfied; Quite dissatisfied; Very displeased*
*[6] Regularly-at least once a year; Regularly-less often than once a year; Irregularly; Emergency visits only; Not at all*
*[7] Myself; Relative/friend; Care staff; Not relevant, has no dental contact*
*[8] Very important; Quite important; Not particularly important; Not at all important*
*[9] More than twice/day; Twice/day; Once/day; Less often than once/day*

[10] *Very confident; Fairly confident; Quite uncertain; Very uncertain*
[11] *Never; Seldom; Often; Always*
[12] *Proceeds as before; Proceeds more cautiously; Stops*
[13] *Yes, without any difficulty whatsoever; Yes, with some difficulty; Yes, with great difficulty; No, not at all*
[14] *Clear activity is recorded when two fingers are held on the jaw muscles on both sides; Some activity; No activity; The patient does not cooperate*
[15] *Can bring the tip of the tongue along the lips and reach the corners of the mouth; Partially copes with it; Cannot; The patient does not cooperate*
[16] *Can inflate cheeks without leakage of air or making noise; Pass partially (less than 3 sec); Cannot; The patient does not cooperate*
[17] *Glides easily; Glides sluggishly; Does not glide at all*
[18] *Good biting conditions; Single dental gaps and/or broken teeth and/or crowding; Poor bite conditions, many missing and/or broken teeth*
[19] *Own teeth in good condition (also crown/bridge fitted); Own teeth in poor condition; Partial dentures or implants; Full dentures in one or both jaws*
[20] *Copes easily; Copes with some difficulty; Copes with help; Can't cope at all*

During the construction phase, the props needed to carry out the investigation were chosen. These should be easy to transport if the examination is to take place outside the dental clinic. A mouth mirror, hand mirror, probe, and flashlight are needed to assess oral status. At this stage, a toiletries bag was used to hold the items needed for performing oral care: a toothbrush, toothpaste, hand cream, a hairbrush, and a comb. The hand cream, hairbrush, and comb were included to determine whether vision and/or cognitive ability affected the choice of props.

## Mock test

After the items and the format of the instrument were decided on, (5) a mock test was conducted with a dentist who was used to working with older adult patients and who, in this situation, would act as a frail older adult and try to understand how such a person would experience the situation and the questions and tasks it involved.

# PHASE 3: EVALUATION AND CONTENT VALIDATION

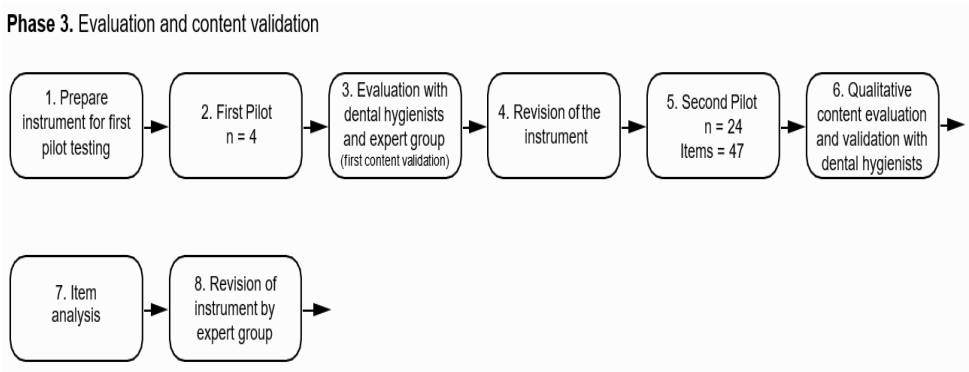



*Figure 6. The parts included in Phase 3, evaluation and content validation.*

## Preparation of instrument and first pilot study, evaluation and revision

To test and further improve the items and to reduce their number, the instrument was (1) *prepared for a first pilot study* (Figure 6). Four participants were identified and invited. The inclusion criteria were to be ≥ 65 years old and have at least one natural tooth or osseointegrated implant and be able to independently perform daily oral hygiene. Two participants lived independently and two lived in nursing homes. Different examination settings were tested by assessing two of the participants in a hospital ward, one in a nursing home, and one in a dental clinic. In (2) *the first pilot study*, OHAI, which then consisted of 47 items, was tested by two dental hygienists, one working in general dental practice and the other in specialist dental care with older adults. They were supported by the study coordinator (IGL). After completing the assessments, the dental hygienists were interviewed about how they experienced using the OHAI and its items. The interviews were then (3) *analysed by the expert group 2*, and the instrument was (4) *revised* as required. There was no reduction in the number of items, just some minor revisions of items and answer options.

## Second pilot study, qualitative content validation, item analysis and revision

A (5) *second pilot study* was conducted with 24 older adults in four groups (Table 2). With the four selected groups, we expected to capture most of the factors influencing oral hygiene in older adults as well as having a reference

group. Inclusion criteria were the same as in the first pilot study. Three dental hygienists (of which two took part in both pilot studies) performed the assessments.

*Table 2. Characteristics of the participants in the first and second OHAI pilot studies, merged (n = 28).*

| Group | Stroke | Cognitive disorder | General dental patient | Parkinson's disease | Total |
|---|---|---|---|---|---|
| Number (*n*) | 6 | 8 | 8 | 6 | 28 |
| Female gender (%) | 33 | 59 | 50 | 50 | 46 |
| Mean age (years) | 81.8 | 89.0 | 81.4 | 70.3 | 81.3 |

A qualitative interview was conducted with the three dental hygienists by the study coordinator/dentist following an interview guide. The dental hygienists were interviewed about their experience using the instrument and their views of the items. Open questions were used, for example: "How did you feel asking the questions?" and "How did the participant react to the questions?" The answers were mostly positive, such as: "I thought it was fun to use the instrument. A lot of questions, though! It would be good to have a shorter instrument … but it was good." A (6) *content analysis* (Graneheim & Lundman 2004) was performed on the material by the expert group 2 to evaluate the content validity. The expert group 2 then performed an (7) *item correlation analysis* and (8) *revised* OHAI again based on the results of the qualitative interviews (Figure 6).

After the revision (described in the Results section), the OHAI had 33 items. Table 1 presents the OHAI with all items, showing which items were removed and which items were added.

## PHASE 4. RELIABILITY AND VALIDITY

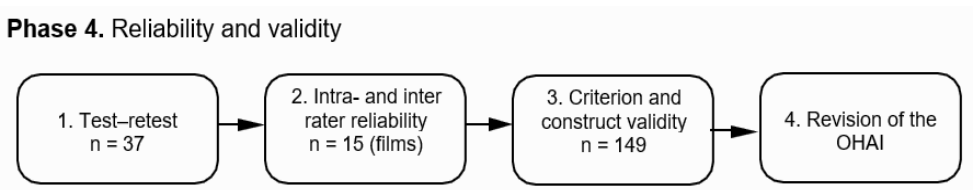



*Figure 7. The parts included in Phase 4, validation.*

The reliability and validity of OHAI and a final revision were tested in Studies III and IV, conducted in Region Västra Götaland, 2019-2022. Both studies used the same OHAI version.

## Instrument: OHAI

The OHAI version with 33 items, which was formulated in Phases 1-3 and used in Studies III and IV, is attached in Swedish (see Appendix 1) and shown in an abbreviated form in Table 1.

In OHAI Part I (interview), eight questions address background data and social context (items 1-8). The interview part continues with questions regarding dental care (items 9-13), feelings of pain, disgust, and/or gagging and fear of bleeding during oral hygiene procedures (items 14-16). The last items in this part address dry mouth (items 17, 18) and oral function (item 19) (Table 1).

OHAI Part II (clinical examination) includes items relating to muscular and spatial oral function (items 20-22) and oral dryness, which is assessed with the "mirror test" (item 23). Two items concern dental status (items 24, 25).

In OHAI Part III (observation of the ability to perform oral hygiene – ADL), a normal oral hygiene procedure, in which an older adult brushed their teeth and used interdental aids, was observed (items 26-33, Table1).

The last summarizing part is described and analysed in Study IV. The raters' assessment covers ten influencing factors/conditions that cause "no", "some", or "major" problems for older adults when managing oral hygiene. The raters then assess the degree to which the factors/conditions affected oral hygiene in the Part I-III assessments. The ten factors/conditions were captured in the qualitative Study I and formulated by the authors.

## Test–retest reliability of part I, interview: Study III

### Sample

The test-retest reliability was assessed in a subsample ($n$ = 37) of the 149 participants presented in the "Material and methods" section of Study IV. The inclusion criteria were the same in Study II–IV: ≥ 65 years of age with at least one natural tooth or osseointegrated implant and able to independently perform daily oral hygiene. The sample comprised three separate groups: the stroke ($n$ = 14), cognitive disorder ($n$ = 8), and general dental patient ($n$ = 15) group. One dental clinic, two nursing homes, and two meeting places for older adults

with stroke/cognitive disorders were included in Study III. The participants from the public dental clinic (i.e., the general dental patient group) were invited to participate in conjunction with ordinary visits. The members of the stroke group volunteered after receiving information at a stroke rehabilitation centre. The members of the cognitive disorder group were invited to participate by a nurse at a nursing home; if necessary, a relative was informed about the study and was welcome to be present at the examination.

### Procedure

The test-retest reliability was tested for 16 items (items 4-19) in the interview part of OHAI (Part I). The test–retest study was conducted by four dental professionals, namely one dentist, one dental hygienist, and two dental nurses, who, after two weeks, called the participants on the phone for a second interview using the same items.

## Intra- and interrater reliability: Study III

For intra- and interrater reliability, Part II (items 21-24) and all of Part III (items 26-33) were investigated. Fifteen video recordings with attached photos of dental status had been produced in advance. The "actors" were three dentists, two participants from the general dental patient group, and four other older adults who volunteered to be video recorded. The two participants from the general dental patient group played themselves, while the other "actors" assumed different characters, for example a person who has had a stroke, a person who has a cognitive disorder, and a healthy older adult. Some of the actors were video recorded twice, in different roles. Four raters (the same as in the test-retest study) watched and assessed the video recording twice, two weeks apart, to analyse intra-rater reliability. The scores from the first assessment were compared between the four raters to test interrater reliability.

## Criterion and construct validity: Study IV

### Study sample

The study population comprised 149 older adults from three clinically separate groups: stroke ($n$ = 50), cognitive disorder ($n$ = 49), and general dental patient ($n$ = 50). The study population was recruited from two stroke/rehabilitation center, six nursing homes, and one public dental clinic. The study sample was recruited with the help of nurses, physiotherapists, and dental staff in Region Västra Götaland. Inclusion criteria were to be ≥ 65 years old, to have at least one natural tooth or osseointegrated implant, and to be able to care for one's oral hygiene without help.

The raters included in the studies were one dentist, two dental hygienists, and two dental nurses, all of whom had extensive experience of work in dental practice and work with older adults.

### Procedure

The examinations were conducted at various dental clinics, in a room at a meeting centre, and in some cases in the participant's nursing home room or, for those living at home, in their kitchen or bathroom.

First, the participants were assessed with OHAI by one of the five raters in the study. This was followed by examinations using eight different gold-standard instruments for the assessment of criterion validity. These examinations were conducted by the study coordinator.

## Gold-standard instruments

No existing instrument could be used as a gold-standard/reference instrument for the whole OHAI. Instead, eight different instruments were used in testing criterion validity by comparing them with OHAI items intended to capture different factors/conditions affecting oral hygiene ability. These eight "gold-standard" instruments were also chosen to be simple enough that most participants could use them, as well as not too time-consuming or tiring. These instruments were as follows (for full descriptions of the measurements, see Appendix 2):

- Cognitive impairment was defined as ≤ 24 points on the Mini Mental Test (MMSE-SR) scale (Folstein et al.1975).
- The Modified Schirmer Test (MST) was used as a measure of unstimulated salivary flow (Schoppmeier et al. 2022).
- Hue-Check Gum (Hue) (Schimmel et al. 2007) was used to measure chewing function. This test includes the evaluation of chewing efficiency by judging the color mixture and bolus formation of two different-colored gums using a subjective assessment scale.
- The Nine-Hole Peg Test (NHPT) (Oxford Grice et al. 2003) was used in Study III to measure the dexterity of the dominant hand.
- Hand strength was measured using a North Coast hand dynamometer (NC) on the dominant hand as a measure of weakness (Bohannon et al. 2006)

- The Timed Up and Go (TUG) (Podsiadlo & Richardson 1991) instrument was used to assess balance during sitting, rising, walking, and sitting down again.
- To measure frailty, the four-item FRESH instrument (Eklund et al. 2016) was used, and participants were considered at risk of frailty if they answered "yes" to two or more of the four items.
- Visual acuity was measured using the KM chart at a distance of 1.5 meters (Hedin & Olsson 1984).

Construct validity was evaluated using known-group validity (Parts I-III), principal component factor analysis (Part I; items 9, 11-19), and Rasch analysis (Part III) on the data collected from the 149 participants.

## Revision: Study IV

The reliability tests in Study III and the criterion and construct validity analysis in Study IV aimed at examining the need to revise the instrument to make it better and more user friendly.

# DATA ANALYSES

The methods of analysis used in Studies I-IV are presented in Table 3.

## Statistical methods

In Studies I-IV, descriptive statistics were used to present mean values, frequency distributions, percentages (%), standard deviations (SD), ranges, and confidence intervals (95% CI).

In Study III, Percent agreement (PA) and Krippendorff's alpha were used to indicate agreement. PA ≥ 75% was considered acceptable. For Krippendorff's alpha, a value of ≥ 0.667 was considered acceptable and a value of ≥ 0.800 was considered good. Svensson's method (Svensson 1998) was used to analyze systematic and occasional disagreement among raters; relative individual variations were also analyzed.

For analysis of differences between study groups in Study IV, the chi-square test ($\chi^2$), Kruskal-Wallis (KW) test, and the Mann-Whitney U (MW) test (for post hoc testing) were used.

Study IV also included a factor analysis (principal component analysis) of Part I (items 9, 11-19) and a preliminary Rasch analysis of Part III, observation (items 26-33) for further construct validity analyses.

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS), version 26.0. For Rasch analysis, Rumm2030+ was used. For Svensson's method, free software was used (Avdic & Svensson 2010). Statistical significance was considered at $p < 0.05$ for all analyses.

### Missing data

In Study IV, data from 147-149 participants were registered for most items. Two exceptions should be mentioned. Item 20 "bite hard" was considered difficult to assess by the assessors and data are missing for 40 participants. For the summary part of the raters' assessment, 122 assessments are missing for the "vision" item due to a misunderstanding. Only 49 participants were included in the cognitive disorder group. One participant was excluded because she was found not to fulfil the inclusion criteria.

## Qualitative methods

In Study I, a qualitative manifest and latent content analysis (Graneheim & Lundman 2004; Hsieh & Shannon 2005) was applied. The interviews generated an extensive body of text that was read through carefully several times by the three authors. The data analysis was carried out in close cooperation between the three authors (IGL, CH, and PA) to prevent bias in interpreting the recorded data.

*Table 3. Methods used for analyses in Studies I-IV.*

| Study | Statistical methods | Qualitative methods |
|---|---|---|
| I | Descriptive statistics | Content analysis according to Graneheim and Lundman (2004)<br>Hsieh & Shannon (2005) |
| II | Descriptive statistics<br>Spearman's rho | Content analysis according to Graneheim and Lundman (2004)<br>Hsieh & Shannon 2005 |
| III | Descriptive statistics<br>Percent agreement (PA)<br>Krippendorff´s alpha<br>Systematic and occasional disagreement according to E. Svensson (1998) | |
| IV | Descriptive statistics<br>Chi-square test ($\chi^2$)<br>Kruskal–Wallis (KW)<br>Mann–Whitney U (MW) tests<br>Percent agreement (PA)<br>Sensitivity/specificity<br>Spearman's rho<br>Factor analysis (principal component analysis)<br>Rasch analysis | |

# ETHICAL CONSIDERATIONS

The studies were approved by the Regional Ethics Board of Gothenburg, Sweden, and complied with the World Medical Association's 2013 Helsinki Declaration.

Study I (2014-05-22 Dnr 158-14).

Study II (2016-06-15 Dnr 419-16).

Studies III and IV (2018-06-25 Dnr 298-18 and 2020-01-26 Dnr 2019-06574).

In the invitation letter, participants were informed that participation was voluntary, that they could withdraw from the study at any time, and that confidentiality was guaranteed during data processing. For older adults with cognitive impairment, the nurse on site received the information about the study and asked the residents and, when applicable, their relatives about participation. On the day of the interview, each participant also received this information orally and they themselves or a related person signed a consent form. If any participant regretted their participation on the study day, no attempt was made to change the participant's mind.

When any suspected oral-health or health morbidities and/or problems were discovered during the OHAI examination, these were communicated to the participants, relatives, and/or healthcare staff. If help was needed to contact dental care, this was provided by the study coordinator (IGL). In addition, the coordinator and assessors who participated in these studies had extensive experience working with older adults.

# RESULTS

## STUDY I – PHASE 1

Study I was a qualitative study and part of Phase 1, the planning of the instrument, aiming to identify factors that could influence the oral hygiene self-care ability of older adults. In the focus group interviews with dental hygienists, occupational therapists, assistant nurses, and older adults regarding what factors affect an older adult's ability to manage oral hygiene, many different factors and perceptions of these factors emerged. The group of occupational therapists emphasized the complexity of performing oral hygiene when diverse functions such as initiative, cognition, and balance must be coordinated. This fact is reflected in the core category "Oral hygiene – a complex activity", which was formulated during data analysis based on the latent content of the text. The factors that emerged during the focus group interviews fall into three main categories: the psychological, environmental, and functional dimension (Figure 8).

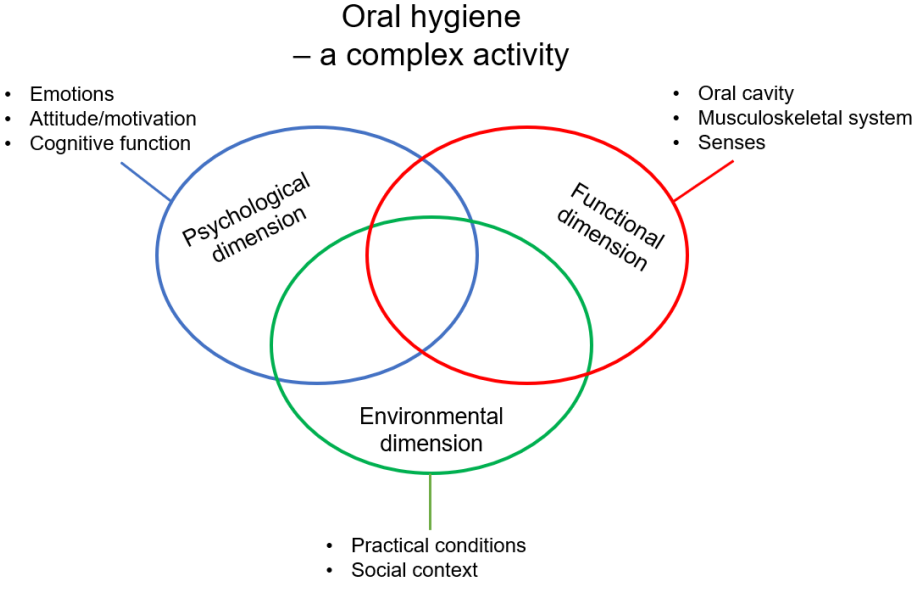



*Figure 8. Examples of dimensions and factors found to interact and influence oral hygiene.*

The psychological dimension describes three subcategories of factors: attitude/motivation, emotions, and cognitive factors. The toothbrushing activity was highlighted by the occupational therapists as a very good indicator of whether older adults' initiative is affected, as one occupational therapist described: "You know and can brush your teeth – but from thought to action is a long step". That emotions could affect the ability to perform oral hygiene was discussed vigorously. The group of older adults described significant feelings of discomfort and disgust when food residues stuck to the interdental brushes; also significant was their fear of pain and bleeding when brushing and picking their teeth, and when toothpicks or interdental brushes got stuck between their teeth. All three interviewed professional groups mentioned that grief could contribute to a loss of interest in oral health, because everything was overshadowed by being alone. Cognitive ability was also an issue discussed in all four groups. Forgetfulness was a part of ageing that prompted discussion. Forgetting to brush one's teeth, or forgetting how to brush, was common, according to the assistant nurses.

The environmental dimension has two subcategories: practical conditions and social context. Practical prerequisites can mean being dependent on a relative to buy oral hygiene products, or that the bathroom must be adapted if one needs to sit down when brushing one's teeth. The expert group 1 emphasized that being part of a social context also meant trying to maintain the ability to take care of oneself, to show relatives and friends that life is "good enough" and that one has not become a burden to anyone. The effect on oral hygiene of losing a spouse, that is, loss of social support and pressure, was also raised by both the expert and professional groups. The group of older adults was very clear that what was learned as a child is retained for a long time, and that everyone tries to stay independent as long as possible.

The functional dimension contains the subcategories of the oral cavity, muscular ability, and the senses. Dry mouth, plaque retention, and the ability to sense food remaining in the mouth after finishing a meal were discussed. Vision and numbness in the fingers were also stated to be important factors affecting oral hygiene. Balance was a factor that was touched upon by all groups. An occupational therapist gave an example: "If you can't control your upper body when you stand up, then lifting one arm is enough to make you fall". Bending over to spit in the sink could then be impossible.

Figure 8 shows the core category, the three main categories, and eight subcategories. The figure also shows that the categories are often not

completely independent but influence one another. A stroke, for example, is a factor that may affect all the included dimensions. Often the balance and/or fine motor skills become greatly impaired by a stroke, making it difficult to stand at the sink and even to brush one's teeth. This belongs to the functional dimension. A stroke may also affect the psychological dimension to the extent that depression and impaired memory are common consequences of the disease. Becoming dependent on others and, for example, not being able to buy one's own oral care products belongs to the environmental dimension, which also includes adapting the bathroom to be able to sit down while brushing one's teeth.

## STUDY II – PHASES 1, 2, AND 3

The first two phases, planning and construction, in the development of OHAI resulted in a three-part instrument included 47 items (Table 1), as follows:

- Part I, an interview questionnaire concerning demographics, health, medications, dental care, and perceived dry mouth
- Part II, a brief clinical examination of oral function, dental status, and dry mouth
- Part III, observation of ADL regarding oral hygiene (e.g., tooth brushing and interdental cleaning).

Phase 3, evaluation, began with a mock test of the first version of OHAI. The assessment was found to take approximately 20 minutes. The test subject had no objections to the instrument and provided only positive feedback on being tested with OHAI.

The mock test was followed by two pilot studies in which the four raters who were interviewed found the instrument easy to use. The questions in the interview part were generally considered relevant and the clinical examination and observation parts were considered unproblematic, although the dental hygienists argued for the instrument to be shortened.

Quote:
"Good fun – they thought it was fun to stick out their tongue and imitate me."

*(Dental hygienist on a dementia ward)*

A relevant comment came from a dental hygienist on a stroke ward, regarding the use of a toiletries bag for the oral hygiene products. At home, such a bag is not normally used, making its use unnecessarily difficult for the participant. The oral hygiene products were instead placed in an open plastic box (see picture below).

After the two pilot studies, based on the results of the interviews and an item correlation analysis, the expert group 2 revised the OHAI (Table 1). In Part I, the interview part, the items marital status, loss of spouse, and number of social contacts were replaced with the item living conditions, with the response options: “lives alone”, “lives with a partner”, “lives with children or other relatives”, and “has a partner but lives separately”. For the purpose of further capturing isolation and sadness, a question about perceived loneliness was also added (Table 1). Help with shopping and help with personal hygiene were presented as two items in the first versions of OHAI; these two items are now presented as one item with a and b subordinates and with two response options (i.e., yes/no) instead of several. Regarding dental visits, it was decided that one question was enough and that the question about the last dental visit was the least important and could therefore be removed, while the question about regularity of dental care visits was retained. It was initially decided that the question “Is oral health important?” would be removed, as most participants in the pilot studies answered “very important” or “important”. This decision was later re-evaluated, as the question was considered important for measuring motivation to maintain oral hygiene, so the item was retained. Instead, it was

decided that the question “Are you satisfied with your teeth?” should be removed, as it displayed a ceiling effect and did not add anything regarding oral hygiene ability. Regarding the three perceived dry mouth items in OHAI Part I, the items “Do you need to drink to swallow food?” and “Do you have problems swallowing dry food?” were found to be interchangeable, so it was decided to keep only the second item. The item “What aid is used for interdental cleaning?” was also removed. This question was asked outside the protocol, when it was time to use interdental cleaning in the observation part.

In Part II, clinical examination, two items were removed: stick your tongue out as far as you can and gape as much as you can, because these movements are partly covered by the item lick around the lips and because the responses to these three questions were very similar. In Part II, the “Oral hygiene (ROAG)” item “Are the teeth covered with plaque and food scraps?” was removed, as was “Do you manage your oral hygiene by yourself?” from Part I. These two questions are now not included in OHAI, but are screening questions to be asked to determine whether the OHAI assessment is suitable in a given case.

In Part III, the observational part, three items were removed after the pilot studies. Open the toiletries bag was removed. As previously mentioned, this is not a common procedure in connection with oral hygiene; it also correlated highly to unscrew the cap from the toothpaste tube (rho = 0.718). The items remove the protective plastic around the toothbrush and bring the toothbrush toward the mouth were also removed as they correlated highly to several other items and thus added little information.

The two pilot studies led to the removal of 15 items and the addition of two. The version of OHAI developed in Study II consequently had 33 items (Table 1) and two screening questions. The screening questions were used in the reliability and validation studies.

## STUDY III – PHASE 4

In Phase 4, validation, a reliability study of the new 33-item version of OHAI was performed, including a test-retest study of Part I of OHAI and an intra- and interrater reliability study of OHAI Parts II and III.

The test–retest reliability study of OHAI Part I included 37 participants from three groups: the stroke (n = 14), cognitive disorder (n = 8), and general dental patient (n = 15) group. The mean age was 76.2 years, the groups comprised of

62% women, and most participants lived independently (95%), some supported by home care services. Of the 19 OHAI Part I items, all but items 1-3 (Table 1) were included in the test-retest study.

The percent agreement (PA) exceeded the threshold value of ≥ 75% for all but three of the 16 items: knowledge of oral hygiene (item 13), pain when brushing and picking (item 14), and perceived dry mouth (item 18) (Table 1). Krippendorff's alpha gave acceptable to good values except for pain when brushing and picking (item 14), which had a very low value of 0.26. The analysis showed low values for all items regarding relative position (RP), relative concentration (RC), and occasional individual disagreement (RV), according to the method developed by Svensson. This is desirable for a stable set of items.

To determine the intra-rater reliability of OHAI Part II (clinical examination) and Part III (observation), four raters assessed 15 films resulting in fairly good to good PA values for most items. Items 20 and 23 were excluded, however, as they needed palpation and to feel resilience. Raters A, B, and C had one low PA value each in Part II (biting conditions for raters A and B, and dental status for rater C), while rater D had low values for all items in Part II. For rater A and D, systematic disagreement of RP was found for the item biting conditions (Figure 9) in Part II. Also, in Part II, Krippendorff's alpha values were low for raters C and D for the items biting conditions and dental status, and for rater D in Part III for apply toothpaste.

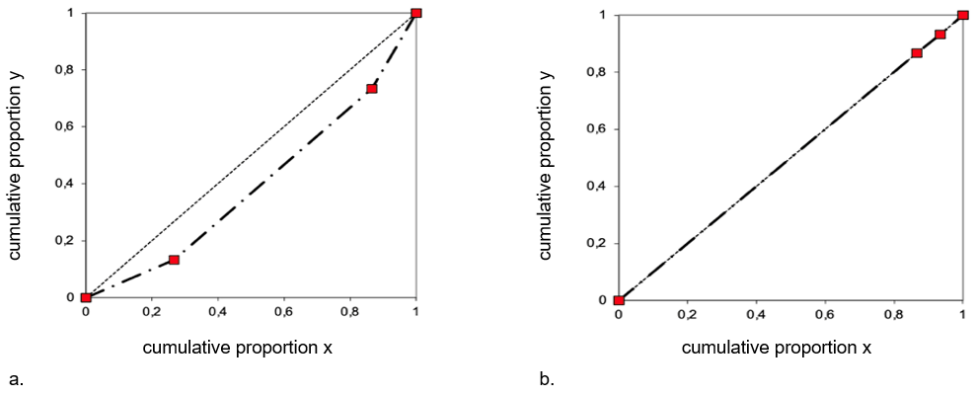



*Figure 9. a) ROC curve showing systematic disagreement (RP) for the item biting conditions for rater D; b) ROC curve showing no disagreement for the item pick up toothpaste for rater D in the intra-rater reliability test for Part II.*

Interrater reliability for Parts II and III of OHAI was assessed for the same four raters A-D. Regarding agreement, Krippendorff's alpha values were good for nine out of 12 items as they were above the limit of alpha ≥ 0.667. Three items in Part II, namely biting conditions, dental status, and rinse mouth, displayed limited reliability with values below the limit of alpha ≥ 0.667. The dental status value was found not to be statistically significant. OHAI Part III (observation) displayed good intra- and interrater reliabilities.

# STUDY IV – PHASE 4

In Study IV, 149 participants in three separate groups – the stroke (n =50), cognitive disorder (n = 49), and general dental patient (n = 50) group – were assessed with the OHAI regarding validity (Phase 4). Content validity was investigated and found to be good in the previous study of the 47-item version (Study II); in Study IV, criterion and construct validity were assessed.

The average participant age was 80.6 years, and the cognitive disorder group was significantly older than the two other groups (Kruskal-Wallis, KW: $p < 0.001$). In total, 59% of participants were women and there were no statistically significant gender differences between the groups. It was more common to live with a partner in the general dental patient group (64%) than in the stroke (42%) or cognitive disorder (18%) groups ($\chi^2$: $p < 0.001$). The majority (84%) in the cognitive disorder group lived in nursing homes, versus 46% in the stroke group and 2% in the general dental patient group ($\chi^2$: $p < 0.001$). The number of medications was higher in the stroke group (mean: 5.0) than in the cognitive disorder group (mean: 2.9) and the general dental patient group (mean: 3.4) (KW: $p < 0.001$). The number of diseases was also higher in the stroke group (mean: 2.0) than the cognitive disorder group (mean: 1.7) and the general dental patient group (mean: 1.5) (KW: $p = 0.012$).

## Criterion validity

Criterion validity was assessed in terms of sensitivity and specificity using eight gold-standard instruments. Good sensitivity and specificity were found for the OHAI frailty items (4, 6a/b, 10, and 26-33, Table 1) relative to the gold-standard instruments FRESH (76% and 83%, respectively) and Timed Up and Go (TUG) (75% and 81%, respectively). For OHAI items 28-33 capturing fine motor skills, high sensitivity of 79% was found relative to the gold-standard instrument NC capturing grip strength. Also, the gold-standard Hue-Check Gum (Hue) instrument measuring chewing function as part of oral clearance

displayed good sensitivity (82%) relative to the oral function/status items 21-22 and 24, but low specificity (45%). The best sensitivity (85%) was found for the anamnestic item 3 assessing balance and the gold-standard instrument TUG.

## Construct validity

To assess construct validity, the first analysis tested for known-group validity. A difference between the study groups was expected for most of the ten influencing factors/conditions that had been found to affect oral hygiene ability. The stroke group had more problems with balance, fine motor skills, and to some extent oral clearance. The cognitive disorder group had the most problems with cognitive function, frailty, and spatial ability. In the general dental patient group, the only major problem measured concerned balance, with 50% reporting problems with it. Two factors did not differ significantly among the groups, namely oral clearance and emotions.

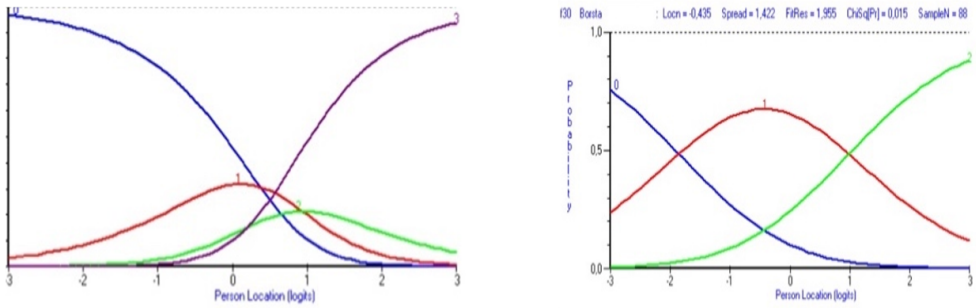
For further validation of the OHAI items used to capture the different influencing factors, the gold-standard instruments were also analysed for known-group validity. This analysis gave roughly the same picture, especially in that the stroke and cognitive disorder groups were significantly more affected by the influencing factors than was the general dental patient group.

The next construct validity analysis to be performed was a factor analysis of Part I (items 9, 11-19, Table 1). The analysis generated three clear factors:

- routines for dental care (items 9, 11-13)
- problems with brushing (items 17-19)
- oral function (items 14-16).

The eigenvalues were 1.69, 1.53, and 1.40, respectively, for these three factors, which together explained 54% of the variance.

The final construct validity analysis was a preliminary Rasch analysis of OHAI Part III (items 26-33 Table 1). The analysis showed that the Rasch model fit the items in Part III reasonably well, but clear signs of disordered thresholds were found due to problems with the four response options for the items in Part III. A change in response options, combining the two middle alternatives “manage with some difficulty” and “manage with help”, was found to improve the model (Figure 10).




a. b.

*Figure 10. Rasch model of OHAI Part III with a. four response options and b. with three response options, showing the improvement in Rasch model B when the two intermediate response options are combined.*

## The raters' summary assessment part

The last part of OHAI to be assessed was the raters' summary assessment. In this part, the raters assessed the degree to which the ten influencing factors, validated above, caused problems for older adults managing their oral hygiene. These ten factors can be said to provide a summary of the OHAI assessment. These factors are: cognitive function, fine motor skills, frailty, vision, motivation, spatial ability, oral clearance, coordination, knowledge of oral hygiene, and balance. The correlations among the raters' assessments of the degrees to which the factors/conditions affected oral hygiene and the OHAI items intended to capture the specific factors/conditions were moderate-to-good for nine of the ten factors; motivation, however, turned out to have a low correlation (rho: 0.20).

In the raters' assessment part, analysis of between-group differences showed that the stroke group was assessed to have significantly more impaired oral hygiene due to problems with fine motor skills and balance than the other two groups. The cognitive disorder group was assessed to have significantly more problems with oral hygiene due to problems with cognitive function and factors close to cognitive function, such as motivation and knowledge of oral hygiene, than the other groups. The oral hygiene of the cognitive disorder group was significantly more affected regarding all the influencing factors/conditions compared to the general dental patient group, and the same applied to the stroke group except for the motivation and knowledge of oral hygiene factors. In the general dental patient group, only a small proportion

was assessed to have problems with oral hygiene due to any of the influencing factors, with the only factor to have high values being balance (28%).

## CHANGES IN OHAI FOLLOWING THE EVALUATION

Finally in Phase 4, given the results of the reliability (Study III) and validity (Study IV) analyses, some minor changes needed to be made in the OHAI.

- The anamnestic question about disabilities (item 3, Table 1) lacked specific questions about problems with memory and fine motor skills and therefore needed to be reformulated to be clearer (Table 4).
- It was decided to omit item 20, clench jaws. The item was hard for the raters to assess and items 21 and 22 were considered sufficient to assess oral function. The number of items in OHAI was thus reduced to 32.
- Given the results of the intra- and interrater reliability tests in Study III, item 25 regarding dental status needed reformulation to be easier to assess (Table 4).
- In Part III, answer options were reduced to three, given the outcome of the preliminary Rasch analysis in Study IV (Table 4).
- In the raters' summary assessment part, the question and response options needed to be reformulated to be clearer.
- In the raters' summary assessment part, the percent agreement between fine motor skills and coordination was 98%. It was therefore decided to merge these two influencing factors into one. This reduced the number of influencing factors/conditions to nine, but a new factor, emotions, was added based on items 14-16 in Part I (Table 1). The number of factors therefore remains ten.

*Table 4. The revision of OHAI after the reliability and validity analyses in Studies III and IV, shown as "before" and "after" according to the revised items.*

| OHAI | Before validation | After revision |
|---|---|---|
| **Part I**<br>Item 3 | 3. Do you have a disability and/or problems with balance?<br>No<br>Yes, a disability, namely …<br>Yes, problems with balance, namely … | 3. Disabilities:<br><br>a. Do you have reduced mobility in your hands?<br>Response options:<br>a lot, quite a lot, moderately, a little, not at all<br><br>b. Do you have problems with your balance?<br>Response options:<br>a lot, quite a lot, moderately, a little, not at all<br><br>c. Do you have problems with your memory?<br>Response options:<br>a lot, quite a lot, moderately, a little, not at all<br><br>In case of memory problems: Do you have any diagnosis linked to your memory problems?<br>If YES, which one: ... |
| **Part II**<br>Item 20<br><br>Item 25 | First, I want you to clench your jaws as hard as you can<br><br>Dental status (multiple answers possible):<br>Own teeth in good condition<br>Own teeth in poor condition<br>Partial dentures or implants<br>Full dentures in one or both jaws | Omitted<br><br>Dental status (multiple answers possible):<br>a. Own teeth (with or without fixed prosthetic replacements) Yes/No<br>b. Implants Yes/No<br>c. Partial dentures Yes/No<br>d. Full dentures in one or both jaws Yes/No |
| **PART III**<br>Response options | Manage easily<br>Manage with some difficulty<br>Manage with help<br>Cannot manage | Manage easily<br>Manage with some difficulty<br>Cannot manage |
| **Raters' summary assessment part**<br>Question<br><br><br>Response options | How do you assess that each of the factors below affects the patient's oral hygiene?<br><br>No problems<br>Some problems<br>Large problems | Your assessment of the degree to which the patient's oral hygiene are affected by the factors below:<br><br>Not at all<br>Somewhat<br>Very |
| | Fine motor skills<br>Coordination | Fine motor skills/coordination |
| | — | Emotions |

# MAIN FINDINGS

- Oral hygiene in older adults proved to be a complex activity that can be affected by many different factors/conditions.

- A new instrument for assessing the cause(s) for the inability to manage oral hygiene independently has been developed, the Oral Hygiene Ability Instrument (OHAI).

- The OHAI proved to be reliable and valid.

- The older adults involved in the studies were positive about the OHAI – the time they got and the conversation the questions led to. They felt included and absorbed the oral hygiene information more easily when it was given in a calm, person-centered environment, compared to the examinations they were used to.

- Two factors found to have major impact on oral hygiene ability, but rarely considered in connection with oral hygiene, are balance and frailty.

# DISCUSSION

The overall aim of this thesis was to develop and evaluate an instrument with which to assess the cause of any older adult's inability to manage daily oral care. Our main finding is that we could successfully, together with dental staff and older adults themselves, develop a valid, stable, and reliable instrument that may be a valuable tool in prophylactic work with older adults, namely the Oral Hygiene Ability Instrument (OHAI). This instrument can be a helpful tool in identifying the specific factors that affect older adults' abilities to manage their own daily oral hygiene.

Oral hygiene was found to be a complex activity, and many factors must be considered when assessing an older adult's ability for oral self-care. All these factors must also be considered when developing an instrument with which to assess the ability for oral hygiene self-care. When a new instrument is to be developed, it is important to listen to points of view from the group in which it is to be used (Iwarsson et al. 2019). The participants involved in the present studies were positive about the OHAI, about the time they spent with the raters (dental professionals), and about the conversations the questions led to. They felt included and they better absorbed the information provided. Various instruments have been developed over the years to measure older adults' ability to manage oral hygiene. A few studies have investigated the relationship between oral hygiene and, for example, fine motor skills (using the OHPT test; Doherty et al. 1994), cognitive ability (Chen et al. 2017), and functional dependency (using ADOH; Bauer 2001). No previous study has explored whether the problem of impaired oral hygiene could be multifactorial.

To our knowledge, the newly developed OHAI is the first to take account of the complexity that oral hygiene presents to older adults. The OHAI development process was inspired by a model proposed by Benson and Clark (1982). This model of instrument development comprises four phases, according to the guidelines: Phase 1, planning; Phase 2, construction; Phase 3, evaluation; and Phase 4, validation. The development of OHAI will be further discussed below with a focus on these four phases.

## PHASE 1: PLANNING

In the literature search, a few instruments were found that assess the relationship between fine motor skills and oral hygiene in different ways (Bauer 2001; Doherty et al. 1994; Felder et al. 1994). Two of these instruments were developed for use in nursing homes. In this context, it was also discovered that no one has studied what affects older adults' ability to manage their oral hygiene. The literature search made it evident that a more complete instrument comprising multiple factors could be of value. To investigate what factors could be worth incorporating in a new instrument, a focus group study (Study I) was performed. This study identified a number of factors other than fine motor skills that affect the ability of older adults to perform oral self-care. These factors were ordered in three main dimensions, namely the psychological, environmental, and functional dimensions, along with an overall core category, Oral hygiene – a complex activity.

The results of Study I show that the older adult may have a single problem related to one of the dimensions or several problems relating to all three dimensions. Both scenarios illustrate the complexity of the problem, and in both cases, the maintenance of oral hygiene may fail. The focus group study showed that a comprehensive instrument is needed to identify older adults with difficulties managing their oral hygiene, as well as to identify the causes of these difficulties. A future aim of this project was thus to develop such an instrument.

## PHASE 2: CONSTRUCTION

In Phase 2, the purpose of the instrument was revised from assessing both 1) the ability to manage oral hygiene and 2) the cause(s) of reduced ability to manage oral hygiene in older adults, to address only the latter objective. This change was made because the instrument would only be used when poor oral hygiene has already been detected, to find out the cause. To assess whether the mouth is clean, several plaque indices are already available (CAPP 1995).

This shift in objectives led to the removal of two items intended to be part of the instrument: items concerning 1) the presence of plaque and/or food scraps or gingivitis and 2) the independent self-management of oral hygiene. In Phase 4, validation, these two items were instead intended to be used as screening questions. The two screening items were, however, ultimately not included in the instrument. Instead of assessing poor oral hygiene using the item about the

presence of plaque and/or food scraps from the ROAG instrument (Andersson et al. 2002), other items, plaque indices, or gingivitis indices can be chosen. The screening item about the independent self-management of oral hygiene shows whether OHAI is to be used. If an older adult has poor oral hygiene despite receiving assistance with it, it is the person helping the older adult with oral hygiene who should receive information and training about caring for another person's oral hygiene. Regular check-ups by a dental professional should therefore be part of the routine (Wårdh et al. 2011).

When OHAI was developed there were concerns that the dental professionals in the expert group 2 had to narrow a view of the instrument. An external expert on questionnaire methodology was therefore brought in to help with the organization of the questions and answer options (Wenemark 2023).

The instrument developed came to consist of three parts to capture the complex task that oral hygiene may represent for older adults: an interview questionnaire, a brief clinical examination, and an observation of ADL regarding oral hygiene. The rationales for the selected OHAI items can be discussed. Part I, the interview part, contains items about medication, illness and disability, and cognitive problems; items about loneliness, dental care routines, quality of life, and dry mouth are also included. The items about shopping and personal hygiene are important to capture signs of incipient frailty. Shopping is often one of the first things for which support is needed, providing an early warning of progress toward frailty (National Board of Health and Welfare 2019).If the instrument is to be used at a dental clinic, some questions in Part I (e.g., about diseases, medications, and jaw joint problems) may already be included among the anamnestic questions that are routinely asked, and therefore do not need to be asked again. Important factors rarely asked about in dental care are loneliness and quality of life. It is reported that feelings of loneliness are common among older adults. In Sweden, about 10% of older adults aged ≥ 70 years feel lonely (Dahlberg et al. 2018). Loneliness has been shown to affect other important factors, such as motivation and willingness, which in turn are known to be able to influence oral hygiene routines (Ågren & Pavlidis 2023). Loneliness can be affected by the loss of a spouse and friends, family patterns, or by various life events such as illness or decreased mobility. The move from independent living to a nursing home often produces a strong feeling of loss of autonomy (Henning et al. 2022).

Part II of OHAI is a brief clinical examination regarding oral function, dry mouth, and oral status. For the instrument these items are important for

exploring the oral clearance aspects of oral hygiene. Here, oral clearance means the ability to self-clean one's mouth after a meal, to transport away food and its decomposition products (Lingström & Fjellström 2008). Being able to feel food residues, prevent pocketing, and prevent food scraps being left between the teeth or in the buccal corridor depends, among other things, on the musculature of the lips and tongue and on the ability to feel that there are food residues (Schimmel & Abou-Ayash 2020). Oral stereognosis, or the ability to feel and detect objects in the mouth, decreases with age and also depends on dental status (Jacobs et al. 1998; Kamarunas et al. 2015; Landt & Fransson 1975; Park 2017). Poor dental status reduces the ability to detect food residues and foreign objects in the mouth. If one's oral status is poor and teeth are in poor condition, with many dental gaps or a short dental arch, one's oral function and ability to keep the mouth clean will be worse (Bakke et al. 2007). Very crowded dentition is hard to keep clean and may give rise to problems with gingivitis or even periodontal damage (Trombelli et al. 2018). Dry mouth is an important issue for many older adults and affects oral clearance, as food will remain for a long time in the oral cavity (prolonged meals) (Gabre et al. 2005). Dry mouth increases the risk of caries development (Ástvaldsdóttir et al. 2018). Having a dry mouth can also make it difficult to speak and swallow; meals become more difficult, and all this significantly affects the quality of life (Affoo et al. 2015; Gerdin et al. 2005). Saliva flow is stimulated by chewing (Dawes & Kubieniec 2004). There is also an age-related reduction in i.a. mucins and the viscosity of the saliva that becomes lower (Vandenbergh-Descamps et al. 2016; Xu et al. 2019). Reduced amount of saliva, poorer viscosity and oral stereognosis mean e.g. that food residues can more easily get stuck on and between the teeth.

## PHASE 3: EVALUATION AND CONTENT VALIDATION

The two pilot studies included four groups of older adult subjects: stroke, Parkinson's disease, and cognitive impairment groups, as well as a group of general dental patients. The three disease groups were chosen because these illnesses are common at older ages (Armstrong & Okun 2020; Campbell & Khatri 2015; Iadecoda et al. 2019) and are known to affect oral hygiene in different ways. Cognitive impairment is associated with forgetting to brush and even forgetting how to perform oral hygiene procedures. The cognitive impairment group experiences the continuous worsening of their disease. Parkinson's disease is often related to problems with tremors and muscle fatigue, and may also be accompanied with cognitive impairment. The disease involves gradual deterioration, often with relapses (Siciliano et al. 2018).

Among persons who have had a stroke, the most severe symptoms – such as muscular symptoms (e.g., paralysis and loss of sensation), depression, and fatigue – are usually seen in connection with the stroke occurrence, but there is often potential for improvement (Ajwani et al. 2017; Campbell & Khatri 2020). However, symptoms often remain to some extent and can greatly affect the ability to take care of oral hygiene.

The dental hygienists were generally positive about the instrument being developed. Dental professionals may feel uncomfortable with some of the items, such as the items on loneliness or the item on life situation. In the present studies, however, no participant was unwilling to respond to these items; on the contrary, participants opened up and conversed about these issues. The items about help with shopping and personal hygiene also seemed unusual to the dental hygienists, but no participant was said to have reacted negatively to them. The interaction between an older person and health-care professionals is important and sometimes overlooked. A praxis that includes better communication and more person-centered care to improve the communication is needed, and dialogues should be prioritized to ensure better quality of care (Persson et al 2021).

The study participants were also said not to mind being observed while brushing their teeth; on the contrary, they apparently enjoyed performing the activity. This activity captures a range of factors, such as fine motor skills, cognitive ability, motivation, spatial ability, and coordination, all of which impinge on oral hygiene. On the whole, the participants apparently felt well taken care of during the assessment. Apelian et al. (2020) discuss the fact that dental care is far behind when it comes to person-centered care. Though their biomedical knowledge is extensive, many who work in dental care often avoid taking an interest in the patient's life history. In Apelian et al.'s (2020) study, the dentists' willingness to share decision-making with the patient was also perceived as low.

## PHASE 4: RELIABILITY AND VALIDITY

In Phase 4, the reliability of OHAI was assessed. First, test–retest reliability was examined in Part I of OHAI. The recommended time between interviews varies between surveys, but according to Polit (2014), it is important that the time is not too long for older adults. In older adults, a lot can happen in a short amount of time (Terwee 2007), so the time interval was set to two weeks. Of the 37 participants, three had had a fall accident between the two interview

occasions. This is not unusual for older adults, among whom falls and fall-related injuries are omnipresent, according to Montero-Odasso et al. (2021). Such incidents may influence responses in a retest interview, which was shown in this study as one participant had received home care services after the fall.

The test–retest reliability values were low for four items. What accounts for this shift in responses is unclear but can partly be explained. The item knowledge of oral hygiene is broad, potentially making it difficult to understand and respond quickly to. The poor test–retest values for the other two items, pain when brushing/picking and how important is dental care, could be because participation in the study provided some new knowledge, as noted in this quote from a retest interview: "I now brush twice a day and have made an appointment with the dentist". It was discovered that the initial survey had positively affected some participants. At the time of the retest, more people answered affirmatively to the question: "Does it happen that you are bothered by loneliness?" The reason for this shift is debatable; perhaps loneliness was more perceptible during a phone call than during the physical meeting (Ågren & Pavlidis 2023).

To determine intra- and interrater reliability, short videos and intraoral photos were used (Allison et al. 2004). Using videos in repeated assessments is not a new method, but it has not been used frequently in research including older adults. In a digitized world, it will probably become more common, especially in the case of behavioral observations (Haidet et al. 2009; Wang & Lien 2013). There are both pros and cons to using videos and photos in this way. For older adults, not having to come to the examination twice is a big advantage. For the rater, it is convenient to be able to stop the video, go back, and watch a sequence again. It turned out to be difficult to find participants willing to be video recorded during the OHAI assessment, as they felt uncertain about the distribution of the videos and who would see them. For this reason, surrogate participants (Peters et al. 1999) were used in 13 out of the 15 videos. These 13 videos were treated as small model situations of various conditions, such as stroke and cognitive disorders. Two videos contained authentic situations in which two study participants were assessed in Parts II and III of OHAI. All participants gave their consent to use the intraoral photographs showing their dental status, since it is close to impossible to recognize a particular person from these photos (Peters et al. 1999). The number of videos was only 15, a small sample size for a reliability study, in which 50 is a sample size often required. However, De Vet et al. (2011) argued for this sample size in the case of photos and slides that can easily be circulated among the raters. In our case,

the main problem was the time-consuming nature of rating the videos. The videos took a long time to watch and the raters were reluctant to spend a lot of time watching all the videos. Each video took about 10-15 minutes to rate, so intra-/interrater reliability testing took at least 2.5 hours × 2 per rater. It also proved difficult to find people willing to be "actors" for these videos.

The results of the criterion validity study of the OHAI items on balance, frailty, oral clearance, and fine motor skills showed good sensitivity to the gold-standard instruments used. For the remaining items, except the vision item, the criterion validity was acceptable. This indicates that to assess the factors/conditions that affect the oral hygiene ability of an older adult, OHAI can work well, and it is easier to administer the single OHAI assessment than several different instruments.

Vision displayed low criterion validity values in relation to the OHAI vision items with which they were compared. This may be because vision was measured using a KM board, which measures vision from a distance. To use interdental brushes or to unscrew a toothpaste tube cap, one needs to be able to see up close, a visual ability not examined with the chosen gold-standard instrument. Vision is an important factor, however, and asking patients in clinical practice to show how they use, for example, interdental aids, provides good knowledge of how the patients handle the activity and how well it is supported by vision.

A large percentage of the participants in the study stated that they had problems with balance. Osoba et al. (2019) noted that balance and the risk of falling are strongly linked to age. When OHAI was used during home visits, it became clear how important it was that the bathroom should be adapted to the older adult. Poor balance can make it difficult to carry out oral hygiene activities, because one must work on keeping balance and having support to avoid falling. To be able to sit down when brushing one's teeth, the sink and mirror must be adapted so that the activity is both safe and effective, which also applies if one has come to use a wheelchair.

The OHAI items selected to capture frailty and the gold-standard instruments with the same purpose (i.e., FRESH and TUG) all showed that the proportion of older adults with frailty was high in the sample. These findings suggest that it is important for dental carers to listen to the older adult, ask questions about housing and determine whether help with ADL such as oral hygiene is needed.

One factor found to have a large impact on the participants was oral clearance, which is known to affect oral hygiene (Grönbeck-Lindén et al. 2017). The OHAI items selected to capture oral clearance and the gold-standard instruments with the same purpose (i.e., MST and Hue) all displayed relatively high or high percentages. Several factors such as saliva flow, oral motor skills, and dental status interact here, and are also strong risk factors for caries and periodontal diseases. These factors are also strongly affected by age and therefore need attention (Holmén et al. 2012; Schimmel & Abou-Ayash 2020; Strömberg et al. 2012). The acceptable to good criterion validity in comparison with the gold-standard instruments shows that these OHAI items are relevant to maintaining good oral hygiene in older adults.

Construct validity was assessed in terms of known-group differences, which were largely as expected. The stroke group had more problems with balance than the other two groups, and the cognitive disorder group, unsurprisingly, had more problems with cognitive function and spatial ability. Spatial ability has been shown to be linked to cognitive ability, especially in vascular cognitive disorder (Jongsiriyanyong & Limpawattana 2018). The cognitive disorder group also had more problems with frailty, probably because the mean age in this group was higher than in the other two groups and frailty increases with age (Collard et al. 2012). The group chosen as the reference group (the general dental patient group) comprised older adults who live independently. They commented that research for older adults was important, and were happy to contribute. They had no major problems with any of the factors/conditions found to influence oral hygiene ability, and they generally had good oral and physical health. This made them a good reference group.

There were no major differences between the groups concerning the emotion items, nor was this expected. Emotions have nothing to do with age, but with one's personality and cumulative life experience (Chambers 2007). The items about emotions, such as fear of pain, choking, and bleeding, were important to include, although few participants in this study responded that they had problems with them. These emotions can lead to avoidance of oral hygiene activities and to avoidance of dental care. The emotion items form a new influencing factor and will be added to the raters' assessment.

The raters' summary assessment is an important part of OHAI that provides an overview of what the raters assess to have an impact on the participant's oral hygiene ability. All factors in this section were assessed to have some impact on oral hygiene ability, but different factors applied to varying extents to the

different groups. The correlation between raters' assessments and OHAI items was found to be moderate to good. Really strong associations would have been dubious, as the OHAI items are intended to capture whether the older adult is afflicted by specific factors/conditions, whereas the raters' assessment determines whether this factor/condition has an impact on the person's oral hygiene ability.

Of all influencing factors, balance was found to have the greatest impact on oral hygiene, and this was true in all three groups. In the stroke and cognitive disorder groups, the percentages were remarkably high. This could be because some of the raters did not assess whether the balance affected oral hygiene ability, but rather whether the participant had balance problems. Therefore, it was decided that the raters' summary assessment should be clarified and have new response options.

It is obvious that the stroke group was the most influenced by factors related to motor skills, and the cognitive disorder group by factors related to memory, such as frailty, knowledge, and spatial ability. For the general dental patient group, the influencing factors were assessed to have very little impact on oral hygiene. This was not entirely surprising. The general dental group had good health compared to the two other groups, but on the other hand, most of the participants had good oral hygiene. The latter is a weakness in this validation of OHAI, as OHAI is intended to be used only in cases of poor oral hygiene. There was a preponderance of participants who had an interest in oral health, as well as an interest in not deprioritizing dental care. The study plan was to examine 150 people. If only those who did not have acceptable or good oral hygiene during the screening had been allowed to participate, the evaluation would have taken an unreasonably long time, requiring many more resources and thus more funding. This limitation probably did not have a major impact because the results are still very clear, not least in the stroke and cognitive disorder groups.

The thesis states that OHAI is appropriate to use to find out the cause when a person has poor oral hygiene. Poor oral hygiene is then equated with the presence of plaque and food residues. However, it is important to highlight that gingivitis, which is an effect of poor oral hygiene, also is important in this context. Most people are extra careful with their oral hygiene before a dental care visit. It may therefore be appropriate to use OHAI also in cases of gingivitis, even if the teeth are clean at the time of the visit. In periodontitis,

OHAI can also be an important tool to investigate why a person cannot optimize their oral hygiene.

Validation of OHAI entailed some minor changes to the instrument. This probably did not affect reliability and validity to any great extent, and any changes were likely in a positive direction. As always when it comes to instrument development and evaluation, continuous validation should be carried out when conditions change. As far as OHAI is concerned, this may be when there are changes regarding the items, the population to be assessed, and the type of rater.

# CONCLUSION

Oral hygiene was found to be a multifactorial and complex activity that requires consideration of many aspects when assessing an older adult's ability to self-care in terms of oral hygiene.

A multifactorial instrument to assess the cause of any inability for older adults to manage daily oral care has been developed. The reliability and validity of this instrument, OHAI, proved to be valid for the group for which it is intended, with only minor revisions needed.

The development of OHAI means that a person-centered tool for use in prophylactic work to analyse impaired oral hygiene in older adults now is available both for clinical use and for research.

This thesis highlights that older adults are a special and large group in society where some may need a distinct personal treatment.

# FUTURE PERSPECTIVES

- Implementing OHAI in dental care, as an extended anamnesis for older adults who exhibit poor oral hygiene and manage their oral hygiene independently, can be an important prophylactic measure that ought to be studied on a larger scale in the future.

- An assessment with the OHAI could also be valuable for other persons than older adults when a poor oral hygiene is found.

- The multifactorial nature of oral hygiene should be further explored, for example regarding different cultures, other ages, or the influence of various socioeconomic factors.

- Other professional groups, such as occupational therapists, or assistant nurses in home care and nursing homes, may also benefit from an instrument like the OHAI.

- Observation of the toothbrushing activity (OHAI, Part III) has the potential to be developed into a scale, with a point total. It is also possible that the observation part in some situations/surveys can be used alone to capture the impact of, for example, cognitive function, fine motor skills, balance, or spatial ability on a person's oral hygiene ability.

- The dependence on a subjective evaluation by the rater of the OHAI information may be reduced (eliminated) using modern digital techniques such as artificial intelligence.

- Validation of an instrument is an ongoing process that requires cooperation between test developers and test users in order for the test to provide valid interpretations of the results over time.

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# APPENDIX 1

## Oral Hygiene Ability Index

Kod ☐☐☐ Undersökare initialer _ _ _

Intervjudatum _ _ _ _ _ _ _ _
År Mån Dag

Födelseår _ _ _ _

Kön

☐ Man

☐ Kvinna

**Screeningfrågor:**

**Får du hjälp med din tandborstning?**

❒ Nej, inte alls

❒ Ja, av: ……

**Munhygien (tänder, implantat, proteser)**

❒ Rena, ingen synlig beläggning eller matrester

❒ Beläggning och/eller matrester lokalt

❒ Beläggning och/eller matrester generellt

**Formuläret innehåller frågor om livssituation, hälsa, mun och tandhälsa.**
**Jag läser upp frågorna för dig. Svara med det alternativ som passar bäst in på ditt liv.**
**Det är helt frivilligt att svara på frågorna, och du kan närsomhelst avbryta din medverkan.**

❒ **Patienten kan inte svara på intervjudelens frågor.**
**Fyll i de frågor som du kan besvara med hjälp av ev. journal, information från boende.**
**→ Gå därefter vidare till del B klinisk undersökning.**

## *Del A. Intervju*

Allmän anamnes

**1. Mediciner?** ❒ Nej ❒ Ja; nämligen _____

_____

**2. Har du några sjukdomar?** ❒ Nej ❒ Ja; nämligen _____

_____

Ev. kommentar.....

**3. Har du någon funktionsnedsättning och/eller problem med balansen?**

❒ Nej
❒ Ja funktionsnedsättning; nämligen _____
❒ Ja balansproblem; nämligen _____

Ev. kommentar.....

***Då kommer några frågor om din livssituation***

**4. Hur bor du idag?**

❒ Eget boende (villa, bostadsrätt, hyresrätt)
❒ Korttidsboende
❒ Växelboende (växelvis, särskilt boende/hemma)
❒ Särskilt boende (äldre boende)

Ev. kommentar.....

**5. Bor du ensam eller tillsammans med någon?**

❒ Bor ensam
❒ Bor med partner (make, maka, sambo)
❒ Bor med barn eller andra släktingar
❒ Särbo

Ev. kommentar.....

**6. Får du hjälp med att:**

| **JA** | **Nej** | |
|---|---|---|
| ❒ | ❒ | Handla |
| ❒ | ❒ | Personlig vård/hygien |

**7. Händer det att du besväras av ensamhet?**

- ❒ Ja, ofta
- ❒ Ja, då och då
- ❒ Nej

**8. Hur upplever du din livssituation som den är nu?**

- ❒ Mycket nöjd
- ❒ Ganska nöjd
- ❒ Ganska missnöjd
- ❒ Mycket missnöjd

Ev. kommentar.....

***Då kommer några frågor om din munhälsa och besök hos tandvården.***

**9. Hur ofta brukar du gå till tandläkare eller tandhygienist om du tänker på hur det har varit de senaste 10 åren?**

- ❒ Regelbundet - minst 1 gång per år
- ❒ Regelbundet - mer sällan än 1 gång per år
- ❒ Oregelbundet
- ❒ Endast akutbesök
- ❒ Inte alls

**10. Vem skötte kontakten med tandvården vid det senaste besöket?**

- ❒ Jag själv
- ❒ Anhörig/vän
- ❒ Omsorgspersonal
- ❒ Inte relevant, har ingen tandvårdskontakt

**11. Hur viktig är din munhälsa för dig?**

- ❒ Mycket viktigt
- ❒ Ganska viktigt
- ❒ Inte speciellt viktigt
- ❒ Inte alls viktigt

**12. Hur ofta brukar du borsta tänderna (protesen)?**

- ❒ Mer än 2 ggr/dag
- ❒ 2 ggr/dag
- ❒ 1 ggr/dag
- ❒ Mer sällan än 1 gång/dag

**13. Hur säker känner du dig på hur du bör sköta dina tänder (protester)?**

- ❒ Mycket säker
- ❒ Ganska säker
- ❒ Ganska osäker
- ❒ Mycket osäker

**14.** Händer det att det blöder när du borstar eller gör rent mellan tänderna?

❒ Ja — Om ja: vad gör du då?
- ❒ Fortsätter som tidigare
- ❒ Fortsätter mer försiktigt
- ❒ Slutar

❒ Nej

**15. Händer det att det gör ont när du borstar eller gör rent mellan tänderna?**

- ❒ Aldrig
- ❒ Sällan
- ❒ Ofta
- ❒ Alltid

**16. Händer det att du kväljer eller upplever äckel när du borstar eller gör rent mellan tänderna?**

- ❒ Aldrig
- ❒ Sällan
- ❒ Ofta
- ❒ Alltid

**17. Händer det att du har problem med att svälja torr mat som t.ex. kex?**

- ❒ Aldrig
- ❒ Sällan
- ❒ Ofta
- ❒ Alltid

**18. Händer det att du har problem med muntorrhet?**

❒ Aldrig
❒ Sällan
❒ Ofta
❒ Alltid

**19. Kan du tugga hårda saker som hårt bröd eller äpplen?**

❒ Ja, helt utan svårighet
❒ Ja, med viss svårighet
❒ Ja, med stor svårighet
❒ Nej, inte alls

---

## *Del B. Klinisk undersökning*

**Kräver handspegel, sond, ficklampa samt egen utrustning som t.ex. handskar**
**Säg t.ex.:** ***”Då vill jag titta lite i din mun för att bedöma muskler, bett och slemhinnor.”***

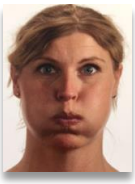
**20. Först vill jag att du biter ihop käkarna så hårt du kan.**

❒ Tydlig aktivitet registreras när två fingrar hålls på käkmusklerna (masseter) på båda sidor.
❒ Viss aktivitet
❒ Ingen aktivitet
❒ Patienten koopererar inte

**21. Kan du slicka med tungan runt munnen?**

❒ Kan föra tungspetsen längs läpparna och når mungiporna.
❒ Klarar delvis
❒ Kan inte
❒ Patienten koopererar inte

**22. Nu vill jag att du provar att blåsa upp kinderna så här [VISA SJÄLV] och håller kvar tills jag räknat till tre.**



❒ Kan blåsa upp kinderna utan läckage av luft eller att ljud uppstår.
❒ Klarar delvis (mindre än 3 sek.)
❒ Kan inte
❒ Patienten koopererar inte

**23. Muntorrhet (spegel mot kindslemhinna)**

❒ Glider lätt
❒ Glider trögt
❒ Glider inte alls

**24. Bettförhållanden**

❒ Goda bettförhållanden
❒ Enstaka tandluckor och/eller trasiga tänder och/eller trångställningar
❒ Dåliga bettförhållanden, många saknade och/eller trasiga

**25. Tandstatus** (flera svar möjliga)

❒ Egna tänder i god kondition (även kron/bro försedda)
❒ Egna tänder i dålig kondition
❒ Delproteser eller implantat
❒ Helprotes i en eller båda käkar

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## Del C: Observation

1. **Ge patienten testboxen och tandborstglas med vatten.**
2. **Tandstickor/picks/borstar läggs fram separat utifrån vad patienten säger sig använda.**

Om de inte säger sig använda något sådant, ber man istället att de skall ”göra rent” med tandsticka”. Lägg fram hjälpmedlet på en tork så att patienten själv kan ta det från brickbord eller tvättställ.

Boxens innehåll:
-Tandborste
-Kam
-Hårborste
-Tandkräm
-Handkräm

***Nu ska du få visa hur du gör hemma när du borstar tänderna. Tänk på att göra precis som du skulle göra hemma, som om inte jag var här."*** **Vid behov uppmanas eller hjälps försökspersonen. Säg då ungefär:** ***"Nu kan du prova att …"*** **(vad som är nästa steg)**

| **Aktivitet** | **Förmåga** |
|---|---|
| 26. Tar fram tandborste?<br>*Identifiera tandborsten*<br>*Greppa den* | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |
| 27. Tar fram tandkrämstuben?<br>*Identifiera tandkrämstub*<br>*Greppa den* | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |
| 28. Skruvar av korken på tuben? | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |
| 29. Applicerar tandkräm på tandborsten? | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |
| 30. Borstar systematiskt och riktigt? | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |
| 31. Plocka upp tandsticka/<br>mellanrumsborste från tvättställ. | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |
| 32. Använda mellanrumsborste/<br>tandsticka | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |
| 33. Skölj munnen med vatten. | □ Klarar lätt<br>□ Klarar med viss svårighet<br>□ Klarar med hjälp<br>□ Klarar inte alls |

**Bedömning:**

**Hur bedömer du att var och en av faktorerna nedan påverkar patientens munhygien?** Markera med kryss.

| | Inga problem | Vissa problem | Stora problem |
|---|---|---|---|
| **Kognitiv förmåga** (förstår) | | | |
| **Ork** (trötthet/koncentration) | | | |
| **Motivation** (försöker/vill klara uppgiften, förstår vikten av munhygien) | | | |
| **Syn** (klarar munhygien - med eller utan synhjälpmedel) | | | |
| **Finmotorik** (grepp/kraft i fingrar) | | | |
| **Koordination** (styrning av tandborste/hjälpmedel) | | | |
| **Kunskap** (vet försökspersonen hur och med vad man skall sköta tänderna) | | | |
| **Spatial förmåga** (rumslig orientering i munnen) | | | |
| **Självrengöring** (saliv, oral motorik) | | | |
| **Balansproblematik** (upplevd av behandlare) | | | |

# APPENDIX 2

**Gold-standard instruments used in the validation of the OHAI**

1. Cognitive impairment was defined as ≤ 25 points on the Mini Mental Test (MMSE-SR) scale. MMSE-SR was used as an adjunct to an existing medical diagnosis (Folstein et al. 1975).

2. The Modified Schirmer test (MST) was used as a measure of unstimulated salivary flow (Schoppmeier et al. 2022).

   The standardized special filter paper strip (35 mm long and 5 mm wide) impregnated with dye was placed in the floor of the mouth next to the submandibular gland duct. When the wick end contacts moisture, blue dye travels up the strip and can be read at designated intervals. The cut off for this measurement was 25 mm unstimulated salivary flow during 3 minutes.

   The method was originally used to measure tear fluid, but has recently been used to measure saliva flow for screening purposes. The participant was sitting upright in a chair, and was asked to swallow the saliva in the mouth before the test.

   1= ≥ 25 mm = not dry mouth, 2= < 25 mm = dry mouth.

3. Hue-Check Gum was used to measure chewing function. This test includes evaluation of the chewing efficiency by judging the color mixture and bolus formation of two different colored gums, Orophys Hue-Check Gum, using the Subjective Assessment Scale (SA) (Schimmel et al. 2007 to assess the ability to chew.
   SA1: chewing gum not mixed, impressions of cusps or folded once
   SA2: large parts of chewing gum unmixed
   SA3: bolus slightly mixed, but bits of unmixed original color
   SA4: bolus well mixed, but color not uniform
   SA5: bolus perfectly mixed with uniform color
   In this study, SA4 and SA5 were regarded as having no problem with chewing function.

4. The Nine Hole Peg Test (NHPT) was used to measure dexterity for the dominant hand. Cut-off values according to gender and age and time for completing the measurement were used (Oxford Grice et al. 2003).

   Normative values, men: age 61-65, dominant hand: cut-off 21 seconds
   age 66-70, dominant hand: cut-off 21s.
   age 71+, dominant hand: cut-off 26s.

   Normative values, women: age 61-65, dominant hand: cut-off 19 seconds
   age 66-70, dominant hand: cut-off 20s.
   age 71+, dominant hand: cut-off 22s.

5. Hand strength measured with a North Coast hand dynamometer (NC) was used as a measure of weakness. Grip strength (only for the dominant hand) was measured and cut-off values according to gender and age were used for this measurement (Bohannon et al. 2006).

   Normative values, men: age 65-69, dominant hand: cut-off 42 (kg)
   age 70-74, dominant hand: cut-off 38
   age 75-79, dominant hand: cut-off 28
   age 80-84+, dominant hand: cut-off 28

   Normative values, women: age 65-69, dominant hand: cut-off 26 (kg)
   age 70-74, dominant hand: cut-off 24
   age 75-79, dominant hand: cut-off 18
   age 80-84+, dominant hand: cut-off 18

6. The Timed Up and Go (TUG) instrument was used for balance (Podsiadlo & Richardson 1991). The participant was placed in an armchair, told to rise and walk 3 meters, turn, walk back and then sit down again. The procedure was clocked, and cut-off values according to time (seconds) for locomotion were applied.

7. For frailty the FRESH instrument was used, and participants were considered to be at risk of frailty by answering "yes" to two or more of the four questions included in the instrument (Eklund et al. 2016). The questions were:
   1) Do you get tired when taking a short (15–20 min) walk outside?
   2) Have you suffered general tiredness or fatigue in the last 3 months?
   3) Do you often fall or are you afraid of falling?
   4) Do you need help with shopping?

8. Visual acuity was measured using the KM chart at a distance of 1.5 meters (Hedin & Olsson 1984). Visual impairment was defined as a visual acuity of ≤ 0.5 using both eyes and the commonly used visual aids and > 0.5 meant acceptable to good vision.