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KAIJA KOMULAINEN

*Oral Health Promotion among
Community-Dwelling Older People*

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KAIJA KOMULAINEN

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ABSTRACT

Evidence showing that common oral diseases can be controlled by good oral and denture hygiene, diet control and fluorides relates mainly to younger age groups or to old age groups among those who live in nursing homes or are in institutional care. With the number of dentate old people on the rise, studies which focus on the effect and appropriate regimens for oral health promotion among older people living at home are warranted.

The aim in this thesis was to study the effect of preventive oral health care intervention among community-dwelling older people. In addition, determinants for the need for preventive oral health care were studied as well as factors which associated with oral-self care and oral hygiene and with the participants who preferred the dentist's home visit instead of paying a visit to a dental clinic.

This oral health study was part of an intervention study 'Geriatric Multidisciplinary Strategy for the Good Care of the Elderly' (GeMS). The oral health study is based on a random sample of persons aged 75 or older living in Kuopio who resided in community- dwelling and whose oral status was recorded (n=321). For the oral health study, the participants in the parent GeMS study intervention group were further randomized into an oral health intervention group (n=165) and control group (n=156). Data on oral health were obtained in face-to-face interviews and in clinical oral examinations.

The study showed that old people had much need for preventive oral health care. Fifty five per cent of the edentulous participants with full dentures and 82% of the dentate subjects required preventive oral health care. The most important non-oral determinants for the need for preventive oral health care were being frail or pre-frail and high morbidity. Oral health improved in both the intervention and the control group during the two-year study, and especially the positive changes in periodontal health can be considered to be clinically substantial. Nevertheless, the changes in health behaviour and oral health between the intervention and control group were quite small and statistically insignificant, and the positive changes in oral health were not possible to attribute solely to oral health intervention. The study also showed that impaired functional ability associated with poor oral hygiene, such as infrequent toothbrushing and toothpaste use and a higher amount of dental plaque teeth. In the case of dentist's home visits, more than every fourth participant preferred home visits by the dentist. This preference associated with impaired cognitive and functional ability and low use of health care services.

In conclusion, this study showed that the oral health of old people can be improved by preventive oral health care measures. But, despite preventive intervention, the need for preventive oral health care and the presence of oral diseases remained quite high. These study results emphasize that old people need regular dental care by professionals and possible aid in oral self-care, and that the oral health services need to be brought home.

National Library of Medicine Classification: WU 113, WU 490

Medical Subject Headings: Aged; Aged, 80 and over; Dental Care for Aged; Independent Living; Health Education, Dental; Preventive Dentistry; Oral Health; Oral Hygiene

Komulainen, Kaija

Suun terveyden edistäminen kotona asuvilla iäkkäillä

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TIIVISTELMÄ

Tutkimusnäyttö siitä, että useimpia suun sairauksia voidaan ennaltaehkäistä ja hallita hyvällä suu- ja proteesihygienialla, dieettineuvonnalla ja fluoriyhdisteillä, koostuu pääasiallisesti lapsilla ja nuorilla sekä ikääntyneillä laitospotilailla tehdyistä tutkimuksista. Tutkimustietoa ennalta ehkäisevän hoidon onnistumisesta tarvitaan myös kotona asuvien iäkkäiden osalta.

Tässä väitöskirjatyössä oli tavoitteena tutkia ennalta ehkäisevän hoidon ja terveysneuvonnan tehoa suun itsehoitotottumuksiin ja suun terveyteen kotona asuvilla yli 75-vuotiailla. Tutkimuksessa selvitettiin myös ennalta ehkäisevän hoidon tarpeeseen, suun itsehoitoon ja hyvään suuhygieniaan sekä hammaslääkärin kotikäynnin valintaan liittyviä tekijöitä.

Tutkimus oli osa laajempaa geriatrasta interventiotutkimusta "Ikääntyneiden Hyvän Hoidon Strategia" (HHS), johon oli satunnaisotannalla valittu 75 vuotta täyttäneitä kuopiolaisia. Suun tutkimusta varten HHS-tutkimuksen interventoryhmä satunnaistettiin suun tutkimuksen interventio- (n=165) ja verrokkiryhmään (n=156). Suun tutkimuksen aineisto kerättiin tutkimushenkilöitä haastattelemalla ja suun kliinisellä tutkimuksella. Interventiotutkimuksen kesto oli kaksi vuotta, ja aineisto kerättiin vuosien 2004–2007 aikana.

Tutkimus osoitti, että iäkkäillä on suuri tarve ennalta ehkäisevään hoitoon: 82 % hampaallisilla potilailla ja 55 % hampaattomilla kokoproteesipotilailla. Tärkeimmät ennalta ehkäisevän hoidon tarvetta selittävät yleisterveydelliset tekijät olivat hauraus-raihnaisuus-oireyhtymä ja sairauksien kasaantuminen. Kaksivuotisen tutkimusjakson aikana suunterveys parani sekä interventio- että verrokkiryhmään kuuluvilla ja esimerkiksi hampaiden tukikudosten paranemista voidaan pitää myös kliinisesti merkittävänä. Interventio- ja verrokkiryhmien välillä erot terveystäyttyymis- tai suunterveysmuutoksissa olivat kuitenkin pieniä eivätkä ne olleet tilastollisesti merkitseviä. Tutkimuksen tulokset osoittivat myös, että alentunut toimintakyky yhdistyi alentuneeseen frekvenssiin hampaiden harjauksessa ja hammastahnan käytössä sekä harjauksen jälkeiseen runsaaseen jäännösplakkiin. Joka neljäs tutkimukseen osallistunut halusi, että hammaslääkärin tutkimus tehdään kotona. Sitä halusivat erityisesti ne henkilöt, joiden toimintakyky ja muisti olivat heikentyneet ja joiden terveyspalveluiden käyttö oli vähäistä.

Tutkimuksen mukaan kotona asuvien yli 75-vuotiaiden suunterveyttä voidaan edistää ennalta ehkäisevillä hammashoidon toimenpiteillä. Ennalta ehkäisevistä toimenpiteistä ja terveysneuvonnasta huolimatta ennalta ehkäisevän hoidon tarve ja suun sairauksien esiintyvyys jäi kaksivuotistutkimuksen lopussa kuitenkin edelleen suureksi, erityisesti hampaallisilla henkilöillä. Tulosten mukaan iäkkäät tarvitsevat säännöllistä suun sairauksien ehkäisyä ja hoitoa sekä suun terveydenhuollon palvelujen viemistä kotiin.

Yleinen suomalainen asiasanasto: ikääntyneet, kotona asuminen, suun terveys, suuhygienia, itsehoito, hammashuolto, ehkäisevä hammaslääketiede, terveysneuvonta, kotikäynnit

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Kuopio, August 2013

Kaija Komulainen

List of the original publications

This thesis is based on the following original publications, referred to in the text by Roman numerals I - IV. Some unpublished data are also presented.

I Komulainen K, Ylöstalo P, Syrjälä A-M, Ruoppi P, Knuuttila M, Sulkava R, Hartikainen S. Determinants for preventive oral health care among community-dwelling older people – a population-based study *Special Care in Dentistry*, in press

II Komulainen K, Ylöstalo P, Syrjälä A-M, Ruoppi P, Knuuttila M, Sulkava R, Hartikainen S. Oral Health Intervention among Community-dwelling Older People: A Randomized Two-year Intervention Study *Gerodontology*, in press, published online 2013 Jul 10. doi: 10.1111/ger.12067

III Komulainen K, Ylöstalo P, Syrjälä A-M, Ruoppi P, Knuuttila M, Sulkava R, Hartikainen S. Associations of instrumental activities of daily living and handgrip strength with oral self-care among community-dwelling elderly 75+. *Gerodontology* 2012; 29: e135–e142.

IV Komulainen K, Ylöstalo P, Syrjälä A-M, Ruoppi P, Knuuttila M, Sulkava R, Hartikainen S. The preference for dentist's home visits. *Community Dent Oral Epidemiol* 2012; 40: 89–95.

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Abbreviations

CI	Confidence interval
CGA	Comprehensive Geriatric Assessment
DFS	Decayed and filled tooth surfaces
DMFT	Decayed, missed and filled teeth
FCI	Functional Co-morbidity Index
GeMS	Geriatric Multidisciplinary Strategy for Good Care of the Elderly
IADL	Instrumental Activities of Daily Living
MMSE	Mini-Mental State Examination
MNA	Mini Nutritional Assessment
SD	Standard Deviation
WHO	World Health Organisation

Definition of key terms

Community-dwelling/home-dwelling

The term is used when referring to older people who are living at home or in circumstances comparable to home, not in nursing homes, residential care home, hospitals and other types of institutional accommodation where they are assisted also at night time.

Co-morbidity

Co-morbidity is either the presence of one or more disorders or diseases in addition to a primary disease or disorder, or the effect of such additional disorders or diseases.

Health

Health is defined as a state of complete physical, social and mental wellbeing, and not merely the absence of disease or infirmity. Health is a resource for everyday life, not the object of living. It is a positive concept emphasizing social and personal resources as well as physical capabilities.

Old/older people

In this thesis, in the literature section, most of the publications concerning older people refer to people aged 65 or older. In the results of this thesis, the age of 75 or older is used as the age limit for old/older people.

Oral health

Oral health is defined as a standard of health of oral and related tissues which enables an individual to eat, speak and socialize without active disease, discomfort or embarrassment, and which contributes to general wellbeing.

Oral health intervention

A health intervention is an effort to promote good health behaviour, or prevent bad health behaviours or an activity or set of activities aimed at modifying a process, course of action or sequence of events, in order to change one or several of their characteristics.

Oral health promotion

Health promotion is a process of enabling people to increase control over and improve their health through education, prevention and health protection.

Preventive oral health care

Preventive dentistry or preventive oral health care refers to measures taken to prevent oral diseases, rather than curing them or treating their symptoms.

1 Introduction

The proportion of old people is growing fast, in Finland faster than in most other industrialized countries. At present, the number of people at age 75 years or older is about 430 000 and is expected to double by the year 2030, and at the same time the number of people 85 years or older has been predicted to increase from the current 100 000 up to 250 000 (Statistics Finland 2009).

Based on nation-wide data for 2000, 66% of all Finnish people aged 65 years or older had their own natural teeth in 2000 while among those aged 55–64 the proportion of people with their own natural teeth was somewhat higher, being 84% (Suominen-Taipale et al. 2004). This change in the proportion of dentate people together with demographic changes will alter the pattern and type of oral diseases (Dounis et al. 2010, Gallagher et al. 2010) and this will also present a challenge to health care systems in the form of a greater need for dental care (Kandelman et al. 2008, Petersen et al. 2010).

Oral diseases have been suggested to be risk factors for non-oral diseases such as cardiovascular (Tonetti 2009), cerebrovascular (Jimenez et al. 2009), metabolic diseases (Taylor and Borgnakke 2008), late-life physical (Yu et al. 2011) and cognitive disability (Yu and Kuo 2008), and infectious complications (Nibali et al. 2007). On the other hand, good oral health can in many ways contribute to a person's well-being and overall quality of life (Walls and Steele 2004, Ettinger 2007, Locker and Quinonez 2011).

The evidence that common oral diseases such as dental caries and periodontitis can be controlled by good oral hygiene measures, diet control and fluorides (Öhrn and Sanz 2009) has been manifest mainly in younger age groups (Vanobbergen et al. 2004, Hugoson et al. 2007), and the effect of preventive measures in older age groups have mainly been performed among those who live in nursing homes or in institutional care (Peltola et al. 2007, De Visschere et al. 2010). Evidence about the effect of preventive measures among the eldest people living at home is minimal and therefore studies that focus on the effects and regimens to be used in oral health promotion among community-dwelling older people are called for.

The purpose of this study was to investigate the effect of multi-component oral health promoting intervention on oral health behaviour and on oral health among community-dwelling people aged 75 years or older. This thesis also aimed to produce evidence on determinants of preventive oral health care need and on factors that associate with oral self-care and oral hygiene and with the use of dental health care services.

2 Review of literature

2.1 AGEING AND LIVING AT HOME

Ageing is usually regarded as a series of progressive and irreversible biological changes, which typically result in reduced physical and cognitive ability (Sander et al. 2008, Stanziano et al. 2010). The extent to which impairment is experienced is influenced by genetic, behavioural, psychological and socioeconomic factors (Kirkwood 1996).

There is no agreed consensus on what constitutes “old age”, and it can in fact mean anything from 60 to 100 years or more (Christensen et al. 2009). However, the most commonly used categorization of chronological age divides the geriatric population into three age groups as follows: the young-old (65–74 years), the old (75–84 years) and the oldest old or very elderly people (85 years or above) (Kilmartin 1994).

Age-related changes in oral cavity are based on the same pathological processes as those generally recognized in all tissues: from tissue desiccation to diminished reparative ability, and from reduced elasticity to altered cell permeability (Campisi et al. 2009, McKenna and Burke 2010). There is large variation in the oral health of old people, as in health generally (Lamster and Crawford 2008).

Despite possible health problems, most old people prefer to live at home in a familiar environment. For both humane and economic reasons, measures to achieve autonomous and independent life at home have been established as a goal (Fleischer et al. 2008). In Finland, currently about 90% of all old people live at home and about 7% in various forms of sheltered accommodation, and a small number in long-term institutional care (Sosiaali- ja terveystieteiden ministeriö 2001). The national recommendation in Finland is that more than 90% of people 75 years or older live at home independently (Sosiaali- ja terveystieteiden ministeriö 2001).

2.2 CHANGES IN ORAL STATUS AND IN ORAL HEALTH BEHAVIOUR AMONG OLDER PEOPLE

The oral health of Finnish people has improved during the last decades but oral health among older Finnish people is still fairly modest compared to the older population of other western societies. Changes over the last few decades in edentulism, use of dental prostheses, number of teeth, oral diseases and oral health behaviour in Finland and in some, mainly western societies, are presented below in Tables 1–3.

2.2.1 Changes in oral status

Edentulism, removable dentures and number of teeth

There are large differences in the proportion of edentulous persons between countries and between geographical regions and between socioeconomic strata (Holst 2008, Locker 2009). A general feature is that people belonging to a low social class and income and people with low education are more likely to be edentulous than people belonging to a higher social class and higher levels of income or education (Krustrup and Petersen 2007, Tsakos 2011a). The proportion of edentulous people in Finland is high compared to other Nordic countries, for example. Table 1 illustrates that the proportion of edentulous people aged 70 decreased for example in Sweden from 51% in 1975 to 7% in 2001 in the 65–74 age group and in Denmark from 72% in 1975 to 9% in 2005 while the proportion of edentulous people in Finland decreased from 58% in 1980 to 36% in 2000.

The widely used marker of acceptable functional dentition is 20 or more natural teeth (WHO 1982). Twenty or more teeth in most cases means acceptable biting ability, reduced need for prosthetic rehabilitation (Meeuwissen et al. 1995, Ikebe et al. 2002) and the ability to follow a healthy diet (Yamanaka et al. 2008, Yoshihara et al. 2009). However, the proportion of such people is fairly low, varying from 29% to 65% among people 60 years or over in developed countries (Mack et al. 2003, Muller 2007, Vysniauskaite 2009). In Finland, according to a National Health Survey carried out in 2000, the proportion of dentate people with 20 or more teeth is still quite low despite the improvement in oral health developments during the last few decades, as only 23% of people ≥ 65 years had 20 or more natural teeth (Suominen-Taipale et al. 2004). The mean number of teeth among dentate people 65 years or older used to be low, but increased in Finland since 1980 from 11.0 to 15.3 in 2000. This increase in the number of own natural teeth can be compared with the situation in Sweden, where the increase in the number of natural teeth among people aged 70 rose from 13 teeth in 1971 to 21 in 2003 (Hugoson et al. 2005) (Table 1).

The reduction in edentulism has had a strong effect on the demand and content of dental care, as the most common therapy for older people with remaining natural teeth requires restorative and prosthetic treatment of a different nature than before (Mojon et al. 2004, Muller 2007). The changes in content of treatment will continue to exist in the future, as it is expected that fixed restorations and partial removable dentures will become more widespread among older people (Petersen and Yamamoto 2005, Zitzmann et al. 2007). However, conventional full dentures are also expected to be common (Douglass and Watson 2002, Felton et al. 2011), although the proportion of full denture users in Europe will fall (Mojon et al. 2004). In Finland, the use of removable partial dentures has more or less doubled in twenty years among males aged 75 or older (Table 1). In 2000, the overall use of removable dentures including full and partial removable dentures was 71% among people 65 years or

older in Finland (Suominen-Taipale et al. 2004). This percentage, 71%, is high compared with other Nordic countries (Österberg et al. 2007, Li et al. 2011).

Table 1. *Changing oral status of older people, edentulism, dental prostheses and number of teeth*

Outcome	Change	Age group	Time period years	Sample	Reference and country
Edentulism	58% → 36% 68% → 59% female 54% → 47% male	65-74 ≥ 75	1980 → 2000	National	Health 2000 Survey Finland
Edentulism	51% → 7%	70	1971 → 2001	Göteborg H70 n=583 → n=386	Österberg et al. 2007 Sweden
Edentulism	53% → 16%	≥ 60	1975 → 2002	National	Holst 2008 Norway
Edentulism	72% → 9% 71% → 31%	65-74 ≥ 75	1975 → 2005	National	Li et al. 2011 Denmark
Edentulism	27% → 14%	65-74	1992 → 2002	National	Zitzmann et al. 2008 Switzerland
Edentulism	46% → 24% 60% → 29%	65-74 75-79	1974 → 2002	National	Brown 2008 USA
Presence of removable prosthetic	n.a. → 66% n.a. → 76%	65-74 ≥ 75	1980 → 2000	National	Health 2000 Survey Finland
Presence of removable prosthetic	76% → 17%	70	1971 → 2001	Göteborg H70 n=583 → n=386	Österberg et al. 2007 Sweden
Presence of removable prosthetic	15% → 10%	65-74	1992 → 2002	National	Zitzman et al. 2008 Switzerland
Presence of removable partial denture	19% → 39% men 29% → 39% women	≥ 75	1980 → 2000	National	Health 2000 Survey Finland
Fixed partial dentures	26% → 58%	70	1971 → 2001	Göteborg H70 n=583 → n=386	Österberg et al. 2007 Sweden

Table 1. *Continues*

Table 1. Continued

Outcome	Change	Age group	Time period years	Sample	Reference and country
Teeth ≥ 20	11% \rightarrow 23% 7% \rightarrow 16%	65-74 ≥ 75	1980 \rightarrow 2000	National	Health 2000 Survey Finland
Teeth ≥ 20	14% \rightarrow 38%	70	1971 \rightarrow 2001	Göteborg H70 n=583 \rightarrow n=386	Österberg et al. 2007 Sweden
Teeth ≥ 20	29% \rightarrow 52%	≥ 60	1985 \rightarrow 2002	National	Holst 2008 Norway
Teeth ≥ 20	16% \rightarrow 40% 7% \rightarrow 20%	65-74 ≥ 75	1987 \rightarrow 2000	National	Petersen et al. 2004 Denmark
Teeth ≥ 20	11% \rightarrow 24%	≥ 80	1993 \rightarrow 2005	National	Yamanaka et al. 2008 Japan
Mean number of teeth	11.0 \rightarrow 15.3	≥ 65	1980 \rightarrow 2000	National	Health 2000 Survey Finland
Mean number of teeth	13.3 \rightarrow 20.7	70	1973 \rightarrow 2003	Jönköping study n=100 \rightarrow n=88	Hugoson et al. 2005 Sweden
Mean number of missing teeth	15.4 \rightarrow 10.4	65-74	1992 \rightarrow 2002	National	Zitzman et al. 2008 Switzerland
Mean number of missing teeth	17.6 \rightarrow 14.2	65-74	1997 \rightarrow 2005	National	Schiffner et al. 2009 Germany

Dental caries and periodontal diseases

Dental caries or its sequelae is one of the main causes of oral pain, suffering, disability and tooth loss in western societies (Baelum et al. 2007). In industrialized countries, dental caries is declining (Murray 2011) but the reduction, if any, is lowest among elderly subjects (Krustrup and Petersen 2007, Micheelis 2011) (Table 2), and there are in fact also reports showing that dental caries is actually increasing among older people (Selwitz et al. 2007).

In Finland, among people 65 years or older, the prevalence of dental caries has declined both among men and women (Suominen-Taipale et al. 2004) (Table 2). On the other hand, a number of studies have shown that dental caries is a problem among very old people (Fure 2004, Griffin et al. 2004) and it has been suggested that the risk for dental caries is even 8 times higher among those 75 years or older compared to those aged 18–24 (6%) (Petersson et al. 2004). Consequently, as caries had decreased in younger adults and increased among the oldest age groups over the past three decades, the burden of caries can be considered to have been re-distributed, moving from simpler problems among the younger population to more complicated ones among older people (Baelum et al. 2007, Selwitz et al. 2007, Skaar and O'Connor 2012).

In Finland, the prevalence of periodontitis in both men and women decreased from 1980 to 2000, but the change was not as pronounced as in the case of other indicators of oral health (Suominen-Taipale et al. 2004), and it is noteworthy that the positive changes were the smallest among older people, as was the case with dental caries. Among men, the proportion of persons 65 or older with at least one deepened periodontal pocket decreased from 81% in 1980 to 75% in 2000 and among women from 71% to 65% (Table 2).

Periodontal health has improved in many countries over the past decades, for example in Sweden, where the proportion of people without periodontal disease increased between 1973 and 2003 among all ages from 8% to 44% (Hugoson et al. 2008). However, as in Finland, the improvement was less pronounced in older age groups. The proportion of people aged 70 or older with moderate periodontal diseases decreased from 83% to 63% whereas the proportion with severe periodontal experience remained the same, i.e. 6% (Hugoson et al. 2008). The infection of periodontium among old people has been reported to be common also elsewhere; for instance in the United Kingdom, where 60% among people 65 years or older showed infection of periodontium, and in Germany, where the respective figure was 88% (Adult Dental Health Survey 2011, Micheelis 2011) (Table2).

Table 2. *Changing oral status of older people, their dental caries and periodontal conditions oral hygiene and oral diseases*

Outcome	Change	Age group	Time period years	Sample	Reference and country
Presence of dental caries in participants Mean number of carious teeth	64% → 30% female 68% → 50% male 2.5 → 1.1	≥ 65	1980 → 2000	National	Health 2000 Survey Finland
Dental caries, surfaces, mean	1.9 → 1.8	65-81	1982 → 2000	National	Krustrup et al. 2004 Denmark
Decayed or unsound teeth, mean	2.2 → 0.9	65-74	1968 → 2009	National	Murray 2011 United Kingdom
Decayed teeth, mean DMFT	0.3 → 0.3 23.6 → 22.0	65-74	1997 → 2005	National	Micheelis 2011 Germany
Presence of dental caries DMFT	30% → 20% 19.9 → 18.3	≥ 75	1988-1994 → 1999-2004	National	Dye 2007 USA
Decayed teeth, mean	0.6 → 0.5				
Deepened periodontal pockets ≥ 4 mm	71% → 65% female 81% → 75% male	≥ 65	1980 → 2000	National	Health 2000 Survey Finland
Deepened periodontal pockets ≥ 4 mm	67% → 60%	≥ 65	1998 → 2009	National	Adult Dental Health Survey United Kingdom
Deepened periodontal pockets ≥ 4 mm	71% → 88%	65-74	1997 → 2005	National	Micheelis 2011 Germany
Plaque score, change %	62% → 31%	80	1983 → 2003	Jönköping study n=80 → n=61	Hugoson et al. 2008 Sweden
Gingivitis score, change %	34% → 18%				
Pockets 4-5 mm, mean number of sites	21% → 12%				

Other oral diseases

Xerostomia and hyposalivation

The state of oral mucosa and teeth largely rely on salivary secretion. A subjective feeling of dry mouth (xerostomia) and decreased salivary secretion (salivary hypofunction) are common in older people as a result of qualitative or quantitative salivary gland disorders, medications and medical disorders (Turner and Ship 2007). Dry mouth problems can have a clinically significant deleterious impact on oropharyngeal health (Visvanathan and Nix 2010), and among old people both an objective and a subjective experience of a dry mouth can hamper the oral health-related quality of life in several ways (Gerdin et al. 2005, Locker and Quinonez 2011).

The underlying causes behind dry mouth problems may be general dehydration, chronic nasal obstruction leading to breathing through the mouth, diseases of the autoimmune system, diabetes, sequelae of radiotherapy of the head and neck or systemic chemotherapy, depression, anxiety, stress or Alzheimer disease (Bergdahl and Bergdahl 2000). Hyposalivation and xerostomia are also among the adverse (anticholinergic) effects of several commonly prescribed drugs (Scully and Ettinger 2007). Over 500 medications have been associated with dry mouth, and the risk increases with the number of medicines taken (Murray Thomson et al 2006, Ichikawa et al. 2011).

Despite extensive research in the field of hyposalivation and xerostomia, knowledge about the prevalence of hyposalivation is scarce (von Bultzingslowen et al. 2007, Flink et al. 2008). Moreover, salivary secretion varies widely from one individual to another, and the prevalence of hyposalivation is difficult to estimate because the definition of the condition varies and is confusing and terminology is not harmonised (Nederfors 2000). It has, however, been estimated that about 30% of older people, those aged 65 or older, suffer from xerostomia (Guggenheimer and Moore 2003, Murray Thomson et al. 2006, Gueiros et al. 2009). According to a Swedish study, it was found that 61% of the participants had very low or low unstimulated salivary secretion and 10% low stimulated saliva secretion in the age group 60–69 years (Flink et al. 2008).

Mucosal lesions

Although ageing *per se* does not appear to increase the risk of mucosal lesions, the decline in salivary secretion, immunological responsiveness, increased systemic diseases and medications can lead to higher susceptibility to infections and trauma of oral mucosa in older people (Campisi et al. 2009, McKenna 2010). One of the most common oral mucosal lesions in the old-age population is denture stomatitis, which is characterized by inflammation and erythema of oral mucosal areas covered by a removable denture (Gendreau and Loewy 2011). The prevalence of denture stomatitis has been reported to vary between 15% and 70% among those who have

full dentures (Geerts et al. 2008, Kossioni 2011, Salerno et al. 2011). Stomatitis was high among people in institutional care, among the very old and among women, as well as among those who had old dentures (de Souza et al. 2009). Etiological factors for denture stomatitis include inadequate denture hygiene, nocturnal denture use, poor denture quality, diabetes mellitus, immune deficiencies, impaired salivary function and salivary secretion, antibiotic therapy and possible deficiencies in vitamin A, folate or iron supplies, and smoking (Shulman et al. 2005). Other denture-related lesions, such as traumatic ulcers with prevalence of 20%, denture hyperplasia and angular cheilitis, both with prevalence of 5% are found especially among persons with dentures that are ill-fitting or un-retentive (Jainkittivong et al. 2010).

The prevalence of leukoplakia and lichen planus in older people has been reported to range from 1% to 5 % and 1% to 7%, respectively (Zegarelli et al. 2008).

2.2.2 Changes in oral health care behaviour

Dental and denture hygiene

Knowledge on oral self-care, especially among independently living older people, for example those aged 75 or older, is scarce. This is because most studies on old people have focused on those aged 65 or less, or then the studies have treated all subjects aged 65 or older as one group (Saunders and Friedman 2007, Strömberg et al. 2012). In addition, the results regarding oral health behaviour are most likely biased, giving too positive a view, as the frailest old people do not participate in the studies (Robare et al. 2011).

Tooth and denture cleaning with toothpaste or a denture cleaning agent twice a day are the basic elements in biofilm/plaque removal (Claydon 2008). It has been reported that toothbrushing frequencies at least twice a day have generally been rising to varying degrees, ranging between 40% and 97%, among old people in western countries (Claydon 2008). In twenty years (1980 *vs.* 2000), the change in the proportion of people aged 65 years or older who brushed their teeth twice a day had increased among women from 45% to 69% and among men from 34% to 46% in Finland (Suominen-Taipale et al. 2004). These figures are lower than those recorded in Sweden, (80%) (Hugoson et al. 2005) and in the United Kingdom, (70%) (Adult Dental Health Survey 2011) but at about the same level as those for old people aged 65–74 in Germany (61%) (Schiffner et al. 2009) and in Denmark (54%) (Christensen et al. 2003) (Table 3).

Information about changes in the cleaning habits of removable dentures is likewise scarce. According to the Health 2000 Survey in Finland, the proportion of people who brushed their denture at least twice a day was 71% among women and 47% among men. In the same study, about one half of the participants with a removable denture had clean dentures in the clinical examination. The daily cleaning

of removable dentures has been common, as 80% users of dentures in 1980s and 1990s cleaned their dentures daily (Mikkonen et al. 1984, Murtomaa et al. 1992). Information on denture cleaning agents is scant; in a Japanese study 44% of old people were reported to use denture cleansers daily (Nishi et al. 2011).

Use of dental health care services

Although regular use of dental health care services has been regarded as a cornerstone in maintaining good oral health, it is worth noting that earlier studies have shown that both the frequency of oral examinations and the number of dental care visits are lower among older people than middle-aged people, even though older people tend to have on average a higher burden of oral diseases (Holm-Pedersen et al. 2005).

The use of health care services is influenced by several factors, including facilitators and barriers to care (Dolan 2010). Structural barriers include the lack of primary care providers or other health care professionals to meet special needs, or the lack of health care facilities (Kiyak and Reichmuth 2005). At an individual level, the main factors that have been reported to predict dental attendance among older people are the presence of natural teeth, the perceived need for treatment and household income levels (Suominen-Taipale 2001, Holm-Pedersen et al. 2005, Kiyak and Reichmuth 2005).

The proportion of dentate people aged 65 or older who have regularly used dental health care services has increased during the last decades in industrialized countries. For example, the increase in Finland was from less than 20% in 1980 to 50% in 2000 (Suominen-Taipale et al. 2004), in Sweden from 20% to 80% over the same period (Österberg et al. 2007), in Denmark from 14% in 1975 to 90% in 2005 (Li et al. 2011) and in Australia from 54% (1987–1988) to 68% (2004–2006) (Australian Research Centre for Population Oral Health 2007) (Table 3).

Domiciliary care includes oral health care and dental treatment carried out in an environment where the patient is resident either permanently or temporarily as opposed to dental care which is delivered in dental clinics or mobile units (Domiciliary Guidelines 2009). To date, the possibility to receive domiciliary dental oral health care is available in Japan, Belgium and the United Kingdom, for example (Shinsho 2001, De Visschere et al. 2006, Sweeney et al. 2007). The realized proportion of domiciliary visits of all dental services is quite low and is reported to be decreasing although the demand and need for this kind service is increasing (Kleinman et al. 2009). It has been shown in earlier studies that some frail, disabled, functionally or cognitively dependent older people can be best served by bringing dental services to them (Simons 2003, Shahidi et al. 2008). Also people at age 90 or over have shown a preference for home visits, as it enables them to use their limited energy in receiving care rather than travelling to care locations (Lester et al. 1998).

Table 3. *Changing oral health behaviour among older people*

Outcome	Change	Age group	Time period years	Sample	Reference and country
Toothbrushing ≥ 2 a day	45% \rightarrow 69% female 34% \rightarrow 39% male	≥ 65	1980 \rightarrow 2000	National	Health 2000 Survey Finland
Toothbrushing ≥ 2 a day	67% \rightarrow 70% 78% (female) 51% (male)	≥ 65	1998 \rightarrow 2009	National	Adult Dental Survey 2000 and 2011 United Kingdom
Toothbrushing ≥ 2 a day	n.a. \rightarrow 61%	65-74	1997 \rightarrow 2005	National	Schiffner et al. 2009 Germany
Seeking care on a regular basis, dentate	$< 20\%$ \rightarrow 50% \rightarrow 6%	65-74	1980 \rightarrow 2000	National	Health 2000 Finland
Edentulous Dentate	n.a. \rightarrow 44%	≥ 75			
Seeking care on a regular basis, dentate	20% \rightarrow 80%	70	1971 \rightarrow 2001	Göteborg H70 n=583 \rightarrow n=386	Österberg et al. 2007 Sweden
Seeking care on a regular basis, dentate	32% \rightarrow 91% 19% \rightarrow 88%	65-74 ≥ 75	1985 \rightarrow 2005	National	Li et al. 2011 Denmark
Seeking care on a regular basis, dentate	54% \rightarrow 68%	≥ 65	1987 \rightarrow 2006	National	Data Watch 2007 Australia
Seeking care on a regular basis, dentate	n.a. \rightarrow 72%	65-74	1997 \rightarrow 2005	National	Schiffner et al. 2009 Germany

2.3 ORAL HEALTH PROMOTION AND PREVENTIVE ORAL HEALTH CARE AMONG OLDER PEOPLE

2.3.1 Terms used in and aspects of oral health promotion

Health is defined by WHO as “a state of complete physical, mental and social wellbeing, and not merely the absence of diseases and infirmity” (World Health Organization 1986 and 1998) while oral health is defined a standard of health of oral and related tissues, which enables an individual to eat, speak and socialize without active disease, discomfort or embarrassment, and which contributes to general wellbeing (Ettinger 2006, Baelum et al. 2007).

It has been suggested, in a wide sense, that a person’s health is determined by five determinants, namely genetics and gestation, social circumstances (level of education, employment, poverty, housing, social cohesion in the community), environmental conditions (e.g. place where to live and work), behavioural choices and quality and use of health care (McGinnis et al. 2002). Understanding the effects of the above-mentioned determinants helps in planning and implementation of oral health promotion in geriatric dentistry (Choo et al. 2001, Gooch et al. 2005, MacEntee 2010).

In addition, oral diseases are among the most prevalent chronic problems that adult people have to deal with (Ettinger 2007, Baelum et al 2007, Maltz 2010). They have the same risk factors, such as unhealthy diet, poor hygiene, smoking, and excessive use of alcohol that also cause the most serious chronic diseases, such as heart disease, stroke, cancer, chronic respiratory diseases and diabetes, for example. From the point of view of prevention, policies to reduce sugar, fat, salt and smoking and to increase the consumption of healthy diets would have a positive effect on overall health by reducing oral diseases as well as non-oral diseases, such as cancers and cardiovascular diseases (Baelum et al. 2007).

2.3.2 Special features in oral health promotion among an older population

Older adults have in the past been a relatively small proportion of the population, of whom the majority were edentulous (Ettinger 2010). At present, older people have on average better oral health than previous generations at least in terms of the number of teeth, and there is also an ambition to retain natural teeth for as long as possible (Choo et al. 2001, Fure 2004, Petersen and Ogawa 2005). However, in general, this is challenging due to age-related changes and the effect of exposure to different health risks (Tsakos 2011b). Studies have in fact shown that the complexity of dental care increases as people live longer and retain their natural teeth (Skaar and O’Connor 2012).

Oral health care of functionally independent older adults is directly or indirectly affected by a number of common conditions and diseases such as arthritis, cancer, chronic obstructive pulmonary disease, diabetes, heart disease, hypertension, mental and cognitive health (dementia and depression), Parkinson disease, stroke and

osteoporosis (Scully and Ettinger 2007). These diseases, together with the medication for these diseases, can decrease immune response, cause symptoms of dry mouth and lead to special oral hygiene needs (Scully and Ettinger 2007, Syrjälä et al. 2012) as well as pose difficulties in access to dental treatment (Avlund et al. 2001). In addition, special hygiene needs among older people are often related to age-associated changes such as a decrease in saliva secretion, loss of elasticity of the oral epithelium, loss of periodontal attachment, increased periodontal pocket depth, complex prosthetics or other restorations, for example (Ettinger 2006). This means that the said aspects indicate that oral health promotion should be tailored according to each individual's functional and cognitive ability and level of dependency and should include manipulation of the environment to favour health and provide appropriate aid (Choo et al. 2001).

The assessment of risks of oral diseases is both demanding and complicated due to the diversity and heterogeneity of older people when they are very old (Chalmers 2003, Watt 2005, Austin et al. 2011). Another component, besides individual risk assessment, is the motivation of the patients and their communities to maintain good oral health (Sgan-Cohen 2008). Moreover, negative stereotypes, such as "ageism", may exist, nurturing negative attitudes to old age (by society, by professionals, by the old people themselves), or a presumption of low adaptability or compliance to changes (social, environmental, biological, attitudinal) may exist (Ettinger 2006, Cruz-Jentoft et al. 2009).

2.3.3 Benefits of oral health promotion and good oral health

The terms "health-related quality of life" and "quality of life" reflect the fact that life is no longer aimed at just prolonging it or at staying free of disease. Based on this aim, it is also designed to make the quality life better (Locker and Quinonez 2011). Oral diseases and tooth loss have been shown to impact functionally, psychologically and socially on the quality of life and on the wellbeing of older people (Sanders et al. 2009, Gerritsen et al. 2010). The number of teeth is especially important and it has been reported that individuals with few teeth had a lower Oral Health Related Quality of Life (OHRQoL) than people with a higher number of teeth (Dahl et al. 2011).

There is a substantial number of older people whose ability to chew food is compromised by their poor oral health; either they have few or no natural teeth at all (Walls and Steele 2004). This may lead to reduced overall food intake and low intake of fruits and vegetables, leading to a reduction in both non-starch polysaccharide and micronutrient intakes (Walls and Steele 2004, Yoshida et al. 2011), which are protective items against chronic diseases, for example (McKevith 2005, Meisel et al. 2010, Sumi et al. 2010). Other problems such as malnutrition also increases consistently as the number of oral health problems increases, such as chewing problems, swallowing difficulties, pain in the mouth and xerostomia (Soini et al.

2006). The exact role of poor oral health (edentulism, difficulties in chewing different foods, social avoidance) in later life disability is not known (Holm-Pedersen et al. 2008, Yu and Kuo 2008, Avlund et al. 2011, Yu and Lai 2011). But it seems that oral impairments and general functional or cognitive limitations (e.g. mobility and memory problems) can show a bidirectional causal relation, and prevention should be aimed at both of them if the intention is to optimally promote good oral health (Yu and Lai 2011, Aida et al. 2012).

Edentulous oral cavities and also removable dentures can be a source of several pathogenic microbes, which, especially in older people, have serious infectious or inflammatory effects on general health (Coulthwaite and Verran 2007, Sachdeo et al. 2008). This emphasizes the importance of oral and denture hygiene. Poor oral hygiene has been shown to be related to mortality and morbidity from pneumonia Yoneyama et al. 2002, Sjögren et al. 2008).

Periodontal diseases have been suggested to be independent risk factors for cardiovascular (Dave and Van Dyke 2008, Persson and Persson 2008) cerebrovascular (Jimenez et al. 2009) and some metabolic diseases such as diabetes (Iacopino 2001, Lalla and Papapanou 2011) and possibly for metabolic syndrome (Kushiyama et al. 2009). In addition, disability has been linked to chronic inflammation (Kuo et al. 2006), which means that the treatment of systemic conditions in combination with comprehensive periodontal treatment, for instance, is important in the management of patients with a multiple risk factor syndrome (Shimoe et al. 2011).

Fast developing techniques and materials in restorative dentistry require more dental care personnel and are also more expensive compared to both older and preventive treatment methods. As shown consistently in studies, higher income groups have better oral health and higher levels of access to dental care (Listl 2011). Older people in lower socio-economic groups face a double disadvantage: poor oral health and more limited access to services that could potentially improve their oral health and quality of life (Tsakos 2011a).

2.3.4 Preventive oral health care and regimens in oral health intervention

Preventive oral health care among older people

Whereas oral health promotion optimally involves a combination of educational, organizational, economic and environmental supports for healthy behaviour, preventive care works mostly at an individual level (Choo et al. 2001, Watt 2007). Preventive care measures that are offered to old people include a variety of commonly used measures, such as removal of bacterial biofilm, fluoride treatment and counselling in oral hygiene practices, for instance. In Finland, it has been reported, for example, that about half of the dentate population aged 65 or older had

regular dental check-ups, and of those, 68% had received scaling or polishing and 23% fluoride therapy (Suominen-Taipale et al. 2004). In USA, 52% of the dental services that were given to people aged 65 or older were examinations and prophylaxes (Brown 2008). Other preventive care, such as counselling in toothbrushing, is seldom given in Finland, as only 6% of the patients were given counselling in toothbrushing (Suominen-Taipale et al. 2004) compared to the situation in the United Kingdom (Adult Dental Health Survey 2011), where 78% of the patients reported having been provided with toothbrushing instructions during the last dental treatment period. Other studies have shown that among people aged 50 or older, the percentage of people who had received preventive care during dental treatment varied widely, from 3% in Poland to 47% in Denmark (Listl 2011).

Although data on preventive care are scarce, studies have shown that preventive care services have been associated with socioeconomic status; the higher the income and educational level, the more preventive care was received (Watt 2007, Listl 2011) and the higher the patient's educational level, the more participation there was in oral health promotion programmes (Hosseinpoor et al. 2012, Passalacqua et al. 2012, Van den Branden et al. 2012).

Regimens in preventive oral health care

Selected oral health intervention studies conducted among older people living in the community are presented in Table 4 and Table 5. According to these studies and based on available literature, it seems that preventive regimens among older people living at home are the same as those used in general dental practice.

Successful mechanical removal of dental biofilm is deemed to be the key regimen in the prevention of most common oral diseases. The recommendation to brush teeth twice a day with fluoride toothpaste is supported mainly by studies conducted on children and young people but appears to be valid for adults too (Fure et al. 2009). Besides brushing with fluoride toothpaste, fluoride rinses, varnishes and gels have been shown to be effective in reducing dental caries in people at risk of dental caries (Marinho 2008).

The general recommendations to restrict the frequency of consumption of foods and beverages containing free sugar to a minimum are also valid in caries prevention among healthy old adults (Moynihan and Petersen 2004, Austin et al. 2011). An additional method to reduce dental caries is the use of xylitol products. The effects of xylitol have mainly been investigated with young people, but the use of products containing xylitol has also been highly recommended for adults who have increased risk of caries, especially instead of sucrose products (Featherstone 2006, Rethman et al. 2011).

Scaling and cleaning of teeth by a dentist or dental hygienist are common and often regularly used measures and effective in reducing inflammation, especially in patients with periodontitis (Needleman et al. 2005, Öhrn and Sanz 2009). In the

treatment of periodontal diseases, it has been observed that, besides effective mechanical plaque removal, there exists a need for an additional regimen, such as antimicrobial mouth rinses or gels containing chlorhexidine digluconate, for example (Davies 2004, Claydon 2008). Also the effect of mouth rinses containing other substrates such as essential oils and toothpastes containing triclosan/copolymer, for example, have been shown to have antiplaque and antigingivitis effects (Teles et al. 2008). The effectiveness of these additional regimens in reducing dental plaque and gingivitis has been extensively documented (Jones 1997, Gunsolley 2006). Although a toothbrush is not effective in the interproximal region of the teeth, at present no systematic review data to provide best practice recommendations for interproximal cleaning exist (Claydon 2008). Dental floss, interdental brushes or toothpicks are usually recommended, based on individual choice, for daily use in interdental oral hygiene (Hoenderdos et al. 2008, Slot et al. 2008).

Mechanical denture cleaning every day with a nonabrasive denture cleaning agent is recommended (Felton et al. 2011). A variety in denture cleaning methods exist but no single denture cleaning method has been shown to be superior to others (de Souza et al. 2009). There are also other recommendations for improving denture and oral hygiene; it is advisable that dentures not be used continuously (24 hours a day) (Kanli et al. 2005, Felton et al. 2011) and it is recommended that clean dentures be stored in a dry container (Paavola and Ainamo 2003).

Evidence is not strong enough to support any specific recommendations for the treatment dry mouth (von Bultzingslowen et al. 2007, Furness et al. 2011). However, professional judgment and experience as well as patients preferences may support recommendations in the treatment of dry mouth, such as low-sugar diet, daily use of topical fluoride, antimicrobial mouth rinses, oral moisturizers, lubricants, artificial saliva and night-time use of bedside humidifiers. Drinking fluids while eating and frequent water moistening between meals appear to be helpful (Ship 2002, Turner and Ship 2007). For patients with viable salivary gland tissue, different stimulation techniques by xylitol pastilles or chewing gum, for example, can be useful (Ship 2002).

Table 4. Randomized clinical trials with oral health promotion activities among community-dwelling older people

Target of intervention	Setting	Study period	Age group	Intervention	Results given	Reference
Periodontal health	N=297 Comparison of five groups	3 years	Mean 72.8	1. None 2. Behavioural training 3. +weekly chlorhexidine rinse 4. + semi-annual fluoride varnish 5. + semi-annual prophylaxis	Group differences did not persist for three years	Persson et al. 1998 USA
Dental caries increment (DFS)	N=164 Caries risk patients, Comparison of four groups	2 years	Mean 71.5	All brushed teeth twice a day with fluoride toothpaste + 1. Rinsing with 0.02 NaF solution twice a day 2. Sucking 1.7 mg NaF tablet twice a day 3. Brushing with slurry toothpaste three times a day 4. Control, fluoride toothpaste twice a day	Lowest increment of dental caries in the rinsing group the highest in group four	Fure et al. 1998 Sweden
Dental caries	N=201 Comparison of five groups	3 years	Range 60-99	1. Usual oral care 2. Educational seminar or 3. Educational seminar + chlorhexidine rinses+ 4. With fluoride varnish+ 5. Scaling and root planing	No significant reduction of coronal or crown caries was observed between the groups	Powell et al. 1999 USA
To increase seeking dental treatment	N=183 experiment N=180 control Two groups	6 months	≥ 75	1. Experimental group: oral health visit once, performed by general medical practice staff 2. Control group: no oral health visit	Dental attendance increased significantly among the experimental group	Lowe et al. 2007 United Kingdom
Sound tooth structure	N=1 101 Double-blind clinical trial	5 years	60-75	1. 0.12% chlorhexidine rinsing 2. Placebo rinsing	No substantial effect of chlorhexidine rinsing on preservation of sound tooth structure	Wyatt et al. 2007 Canada

Table 4. Continues

Table 4. Continued

Target of intervention	Setting	Study period	Age group	Intervention	Results given	Reference
Tooth loss Periodontitis	N=1020	Cross-sectional	60-96	Regular dental treatment	More retention of teeth, no impact on plaque, gingival inflammation or alveolar bone levels	Renvert et al. 2011 Sweden
Nutritional intake	N=44	Pre-post	≥65	Prosthetic rehabilitation using two different methods	MNA score improved with both methods	McKenna et al. 2011 Ireland

Table 5. *Non-randomized studies with oral health promotion activities among community-dwelling older people*

Target of intervention	Setting	Study period	Age group	Intervention	Results given	Reference
Periodontal health	N=54 vs. N=53 Two groups	4 months	Range 50-70	Group-based behaviour modification intervention including 1. Self-care training and self-monitoring 2. No such intervention	Significantly greater net decrease in intervention group for plaque and gingivitis	Little et al. 1997 USA
Plaque removal from natural teeth and denture	N=30 Pre-post, single group	2 years	Mean 59.7	Oral hygiene education, teeth and RPD, professional cleaning, recall intervention	Low level of hygiene remained, no effect with recall intervals	Vanzeveren et al. 2002 Belgium
Dental plaque removal	N=14 Single group	6 months	Range 68-85	Powered toothbrush 3 months and manual toothbrush 3 months	Plaque and gingivitis decreased significantly by powered toothbrush compared to manual	Verma et al. 2004 India
Denture biofilm decrease	N=32	3 months	Mean 62.3	Six different methods to remove denture biofilm	Brushing alone or in combination with soaking is more effective compared to chemical method	Paranthos et al. 2007 Brazil
Plaque and gingivitis	N=101 Four groups	6 months	Mean 62.6	1. Improved mechanical cleaning 2. Usual mechanical + chemical amine/stannous rinse 3. Usual mechanical + antibacterial rinse 4. Control group, no specific measures	Gingivitis reduction in all groups, less plaque reduction in rinse group	Schiffner et al. 2007 Germany

Table 5. *Continues*

Table 5. Continued

Target of intervention	Setting	Study period	Age group	Intervention	Results given	Reference
Dental root caries	Frail elderly with root caries N=189 Three different groups	8 months	Mean 73.8	1. Dental hygienist brushed the teeth and applied once a month fluoride varnish + usual toothpaste+information 2. Use of fluoride tooth paste with 5000 ppm fluoride twice a day + information 3. Usual toothpaste (1450 ppm fluoride) + information Oral hygiene education	1. Group: in eight of ten 2. Group: in seven of ten 3. Group: in five of ten caries development can be controlled	Ekstrand et al. 2008 Denmark
Plaque removal	N=53 Pre- post	1 year	Mean 55 years	Oral hygiene education	Better oral hygiene despite the different education method	Ribeiro et al. 2009 Brazil
Dietary and nutrient adequacy	N=30 Pre-post	n.a.	Mean 74	Prosthodontic rehabilitation, new complete dentures	No difference in nutritional adequacy with new dentures	Little et al. 1997 USA
Dietary advice	N=28 (IOD) N=26 (CD)	6 months	Mean 65 71	Implant-supported mandibular denture (IOD) Conventional full dentures (CD)	Healthier diet in IOD group	Vanzeveren et al. 2002 Belgium
Eating pattern	N=35 Pre-post	1 month	Mean 68	Prosthodontic rehabilitation, new complete dentures	Intake of fruits, vegetables and milk products increased	Verma et al. 2004 India

2.3.5 Ethical aspects of health promotion among old people

Health promotion invariably involves ethical aspects, whether deliberated consciously or not (Etene 2008). In the ethics of medical professionals, the term beneficence, which refers to actions that serve the best interests of patients and promote their wellbeing, is central. While there is sometimes uncertainty about which practices actually help patients (Sokol 2008), it is worth remembering that the best interest of the patient is always in relation to their whole life and the current conditions.

In the care of the older people, other principles, such as human dignity, autonomy and informed consent are of special importance. Informed consent means agreement which is based on good information of the facts in a way that old people (or/and family members of old people) can understand and make their own decisions in an autonomous way (Sreenivasan 2003).

The obligation to promote health and prevent diseases is important and should be the main principle in all actions of health care professionals based on the civil rights of all people (Suomen perustuslaki 1999, Terveystieteiden tutkimuskeskus 2010) and also on professional ethical guidelines (Saarni 2005). Moreover, from the broader point of view, a system that focuses mainly on the treatment of diseases alone and not on preventive measures cannot be deemed economically, socially and ethically responsible (Tomar and Cohen 2010).

The role of both the society (enabling) and the individual him/herself (to increase control and improve) to bear the responsibility of health-promoting actions has been emphasized in the WHO definition (World Health Organization 1986). This means that also a wide range of social, economic, political and organizational forces that are outside the control of the individual should be changed in a way that can facilitate health promotion (Braunack-Mayer 2008).

2.4 SUMMARY OF THE LITERATURE REVIEW

During the last decades, the oral health of older people has improved: the mean number of teeth has increased and edentulism has at the same time decreased. However, these improvements require more effective oral self-care and regular preventive oral health care in securing good oral health compared to the situation decades ago when old people had few or no natural teeth left and most old people had full dentures. Despite the improvements that have taken place over the past decades, there is still much to be done in improving oral self-care, as oral hygiene is often modest, oral diseases are highly prevalent and dental health care services are used mostly on an irregular basis.

The importance and benefits of good oral health have also been shown. Good oral health can contribute to the quality of life, ensure balanced diet and reduce risks for many non-oral diseases. Also the ethical aspects related to lower cost of preventive oral health care are important; with the disposable resources, preventive care enables access to more people than does more expensive restorative care. Different angles to oral health promotion and special features of health promotion among old people have been presented. Various preventive oral health care measures have also been presented to better understand and meet the challenge of preventive oral health care among community-dwelling old people.

To date, it seems that among very old people, evidence on the effectiveness of improving oral hygiene and prevention of oral diseases is lacking. Notably, sufficient evidence from wide, multi-component, longitudinal population-based studies does not exist. Older adults would most likely benefit from preventive programs and regimens in oral health care and due to the lack of evidence for best practices, further studies are still warranted.

3 Aims of this study

The purpose was to study the effect of oral health-promoting intervention among community-dwelling older Finnish people, those aged 75 or more: can their oral health behaviour and oral health be improved by preventive oral health measures. Factors associated with preventive oral health care need, oral self-care, oral hygiene and dental attendance patterns were also studied.

More specifically, the aims were to study:

1. the determinants for preventive oral health care need,
2. the effect of oral health promoting intervention on oral health behaviour and on oral health,
3. the role of functional ability and handgrip strength in oral self-care and oral hygiene,
4. the use of dental health care services and description of the characteristics of the study participants who preferred the dentist's home visit instead of visiting a dental clinic.

4 Subjects and methods

This thesis was based on the Geriatric Multidisciplinary Strategy for Good Care of the Elderly (GeMS) study, which was a longitudinal, population-based intervention study conducted in Kuopio, in Eastern Finland, between 2004 and 2007. The purpose of the GeMS study was to optimize medical treatment and medication and improve and prevent a decline in function and nutrition among community-dwelling older people. The participants in the intervention group of the parent GeMS study underwent a Comprehensive Geriatric Assessment (CGA) at the baseline and annually from 2005 to 2007. The CGA was performed by a team of two medical doctors, three study nurses and two physiotherapists. The control group of the parent GeMS study was interviewed and examined annually and they received ordinary medical care. The parent GeMS study is described in more detail in articles by Lampela and Rikala (Lampela 2007, Rikala 2011).

4.1 STUDY POPULATION

The GeMS study was a random sample ($n = 1,000$) selected among all people aged ≥ 75 years living in the city of Kuopio, Finland, on the first of November 2003 (88253 inhabitants, 5615 of whom were aged ≥ 75). Five hundred people of the sample were randomized with the aid of computer-generated random numbers into an intervention group and 500 into a control group.

For this study – the Oral Health GeMS – the intervention group of the parent GeMS study was in turn randomized into an oral health intervention group ($n = 250$) and a control ($n = 250$) group. Study subjects living in institutional care at the baseline were excluded from the study.

At the baseline, there were 165 community-dwelling persons in the oral health intervention group and 156 subjects in the control group. Reasons for non-participation included refusal, death before being contacted, and moving (Figure 1). The intervention group was examined and interviewed by a dentist yearly and the control group two years after the baseline examination. Altogether 145 persons in the intervention group and 134 in the control group completed the oral health study (Figure 1). The dropout rate after two years was 13.1%, ($n = 25$ died, $n = 15$ refused, $n = 2$ moved) (Figure 1).

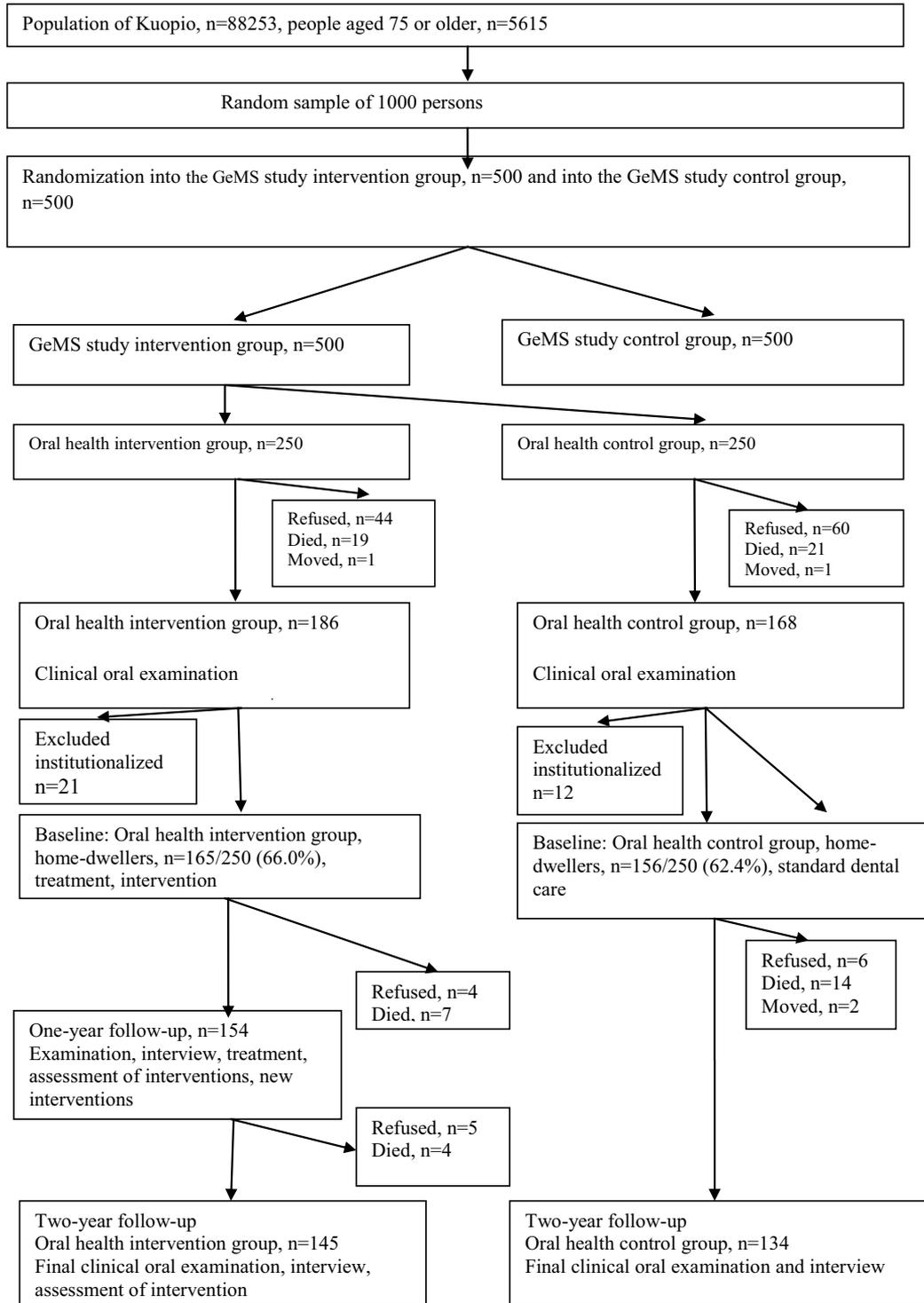


Figure 1. Flow chart of the study setting

4.2 DATA COLLECTION

4.2.1 Data collected in the parent GeMS study

Two study nurses performed a structured interview on health status, use of social and health care services as well as socio-demographic factors.

Socio-demographic factors

The educational level of the subjects was classified on the basis of the number of years of formal education: lower level education being either comprehensive school or less, and upper level of education being secondary school or occupational education. The subjects' residential status was defined as community-dwelling if the participants lived, alone or with somebody else, in their own home or sheltered accommodation in circumstances comparable to home-living.

Health factors

Non-oral health was measured by means of self-reported health, cognitive capacity, functional ability, malnutrition risk and frailty status in addition to illnesses. Self-reported health was measured as part of an interview on a five-point scale, and was categorized into two categories: good or excellent vs. moderate, poor or very poor.

Cognitive capacity was assessed by a study nurse using a Mini-Mental State Examination (MMSE) (Folstein et al 1975) screening test to assess various cognitive functions (arithmetic, memory, orientation) involving a 30-point questionnaire. The maximum score was 30, meaning good cognitive capacity, the cut-off point was 24 points or less, indicating impaired cognitive capacity (Russell and Burns 1998).

Functional ability was measured using an 8-point Instrumental Activities of Daily Living (IADL) screening instrument introduced by Lawton and Broody (Lawton and Broody 1969). A full 8 points meant independence in the following tasks: using the telephone, grocery shopping, preparation of meals, housekeeping, doing the laundry, mode of transport, taking care of medication and managing money, while lower scores indicated partial dependency.

Malnutrition or the risk of malnutrition was screened using the Mini Nutritional Assessment (MNA) test (Kaiser et al 2009). The screening was performed at the baseline using the short MNA test (score ≤ 11 at risk vs. score 12–14 normal status).

Co-morbidities were assessed using a Functional Comorbidity Index (FCI, modified for the GeMS study) (Groll et al. 2005), with a higher score indicating higher co-morbidity. The original FCI is a validated scale that predicts physical function of older people. The modified version, used in this study, suitable in an old population, comprised data on 13 conditions: rheumatoid arthritis and other connective tissue disorders, osteoporosis, chronic asthma/chronic obstructive pulmonary disease (COPD), coronary artery disease, heart failure, myocardial infarction, Parkinson's disease/multiple sclerosis, stroke, diabetes mellitus, depression, visual impairment, hearing impairment, and obesity (body mass index

>30) (Lönnroos et al. 2012). Information on the presence of a specific disease/symptom was ascertained by self-reporting by the participants, by a doctor's assessment or from medical reports.

Frailty status, as used in the study, consisted of five frailty criteria used in the Cardiovascular Health Study (CHS) (Fried et al. 2001): shrinking/sarcopenia, weakness, low energy, slowness and low physical activity level. As a component of frailty, shrinking/sarcopenia was defined as a weight loss of $\geq 5\%$ of body weight in the previous year. Weakness was defined as the lowest quintile for handgrip strength adjusted for gender. The third component of frailty status, low energy, was defined based on an answer to a question in the self-reported Geriatric Depression Scale (GDS). Slowness was defined as the slowest quintile of the subjects based on the time to walk 10 metres, adjusted for gender. The fifth criterion, low physical activity level, was defined using a modified version of the six-graded Grimby scale (Grimby 1986) used for classifying physical activity. The participants were considered frail if at least 3 out of the 5 criteria were met, pre-frail if 1–2 out of the 5 criteria were fulfilled and robust if none of the criteria were met.

Handgrip strength

Handgrip strength was measured using a Saehan dynamometer. It was measured in a seated position with the subject's elbow flexed at 90 degrees, and was measured twice for each hand. The result (the higher value of the two measurements) of the stronger hand was used in this study. The classification of handgrip strength was made by the lowest tertile vs. the upper two tertiles and by gender and age group. For females aged 75–79, the mean grip strength was 22.6 kg (SD 5.6) and the limit for the lowest tertile was 20.0 kg or less. For females aged 80 or older, the mean grip strength was 17.9 kg and the limit for the lowest tertile was 17 kg or less. For males aged 75–79, the mean grip strength was 35.9 kg (SD 10.4) and the limit for the lowest tertile was 32.0 kg or less. For males aged 80 or older, the mean grip strength was 31.9 kg and the limit for the lowest tertile was 29.0 kg or less.

Use of services

The use of home-care services organized by the municipality was classified into two categories according to whether or not the participant received home-care services. These services included assistance with medication or basic nursing activities but did not include assistance in cleaning, cooking or shopping.

The study participants were also asked about visits to primary health care. Visits to a primary care doctor consisted of visits to a medical doctor in public and/or private health care and home visits by a medical doctor (classified as yes *vs.* no) during the past year. Also the frequency of visits to a doctor during the past year was recorded.

Drug use

Information on drug use was obtained by interview and verified from prescriptions and the drug containers. The status of the polypharmacy was based on a classification used by Jyrkkä et al. (2011).

Tobacco smoking

The tobacco-smoking status of the subjects was asked by a study nurse, and classified as follows: never smoked; smoked earlier but quit; or current smoker (daily or occasional).

A general description of the study population at the beginning of the study is presented in Table 6.

Table 6. *Socio-demographic and health-related characteristics of participants by study group*

	Intervention group n=165	Control group n=156	All n=321
Socio-demographic factors			
Age, mean \pm SD*	81.3 \pm 4.4	81.9 \pm 4.8	81.6 \pm 4.6
Gender, females, n/all (%)	125 (75.8)	104 (66.7)	229/321 (71.3)
Education \geq 7 years, n/all (%)	66 (40.0)	71 (45.5)	137/310 (43.1)
Living alone, n/all (%)	89 (53.9)	83 (53.2)	172/321 (54.3)
General health-related factors			
Good self-reported health, n/all (%)	65 (39.5)	73 (46.8)	138/320 (43.1)
MMSE [†] , mean \pm SD	26.6 \pm 4.1	26.1 \pm 5.0	26.3 \pm 4.6
MMSE, impaired \leq 24, n/all (%)	34 (20.6)	36 (23.1)	70/321 (23.1)
IADL [‡] score, mean \pm SD	6.7 \pm 1.9	6.6 \pm 1.9	6.7 \pm 1.9
IADL, impaired \leq 6, n/all (%)	42/162 (25.9)	51/156 (32.7)	93/318 (29.2)
Handgrip strength, kg, mean \pm SD			
female	18.4 \pm 6.9	18.1 \pm 7.0	18.3 \pm 7.0
male	33.3 \pm 8.9	31.5 \pm 10.3	32.3 \pm 9.6
MNA [§] score, (score \leq 11) n/all (%)	35/156 (21.2)	31/156 (19.9)	66/321 (20.6)
FCI mean \pm SD	2.5 \pm 1.7	2.3 \pm 1.6	2.4 \pm 1.6
Frailty			
pre-frail or frail n/all (%)	89/156 (57.1)	79/152 (52.0)	168/308 (54.5)
Smoking			
never, n/all (%)	117 (70.9)	117 (75.0)	234/321 (72.9)
former, n/all (%)	42 (25.5)	32 (20.5)	74/321 (23.1)
current, n/all (%)	3 (1.8)	5 (3.2)	8/321 (2.5)
Regular drugs, mean \pm SD			
polypharmacy, \geq 6 drugs, n/all (%)	65 (39.4)	46 (29.5)	111/321 (34.6)
Use of home-care services, n/all (%)			
Previous visit to medical doctor			
in the past year, mean \pm SD	3.7 \pm 3.6	3.5 \pm 3.7	3.6 \pm 3.9
during past year visited, n/all (%)	144 (87.8)	133 (86.4)	285/317 (89.6)

*SD = standard deviation.

†Mini-Mental State Examination.

‡Instrumental Activities of Daily Living.

§Mini Nutritional Assessment (short form).

||Functional Co-morbidity Index.

4.2.2 Data collected in the Oral Health GeMS

The interviews and clinical oral examinations were carried out in the primary care settings of the social welfare and health centre of Kuopio or alternatively in the person's home. The clinical oral examinations (extra-oral and intra-oral) were performed in a standard dental unit based on written instructions. The dentists' home visits were carried out in a similar manner, with the exception that since the dental unit was not available in these cases, the source of light was a headlamp for the dentist and a flashlight for the dental nurse when extra light was needed, and moisture was controlled using cotton rolls and gauzes instead of ordinary dental devices.

The clinical examinations were performed by two experienced dentists. The examiners were standardized by having them examine and assess the need for preventive oral health care measures on seven study participants together before the survey. Because of the high age of the participants and the length of the examination (one hour), no repeat or parallel examinations were performed. The oral examinations were carried out in adjacent rooms, allowing the examiners to consult each other when needed. Workshops for the dental team were also held before the study and in the course of the study to resolve any problems that arose.

Oral health assessment

The interview, saliva flow rate measurement and the clinical oral examination were identical in the intervention and control groups. The intervention and treatment for the subjects in the intervention group, if indicated, were planned on basis of all the information received from the oral health assessment. The participants belonging to the control group received written information about the findings of the clinical oral examination. The choice of seeking dental care in the control group was based on the participants' own decision.

Oral health behaviour interview

Questions on oral health behaviour were asked by the dentist in the context of the clinical oral examination. Before the clinical oral examination, the dentist asked about the use and presence of removable dentures, the frequency of tooth and denture brushing, use of toothpaste and a denture cleaning agent, interdental cleaning, use of sugar products, and utilization of oral health care services.

The subjects' use of dental health care services was asked during the interview. The use of dental health care included visits to a dental technician, a dental hygienist, and/or a dentist in public and/or private dental care. The time lapse since the last dental visit was also asked and the variable was classified into three categories: less than one year, one to three years, and over three years. In addition, the reasons for the dental visit were asked. This variable was used as a dichotomous variable: a visit to dental care at regular, scheduled intervals (varying between 4

months and 2 years) or being in a dental recall system *vs.* irregular use of dental health care services.

Among the dentate participants, the variables were toothbrushing at least twice a day, use of toothpaste at least twice a day, and use of toothpicks and interdental floss or a brush at least once a day. In denture cleaning, the variables were cleaning the denture at least twice a day and using a denture cleaning agent daily. The frequency of consumption of sugar products, sweet rolls, juice or other soft drinks, and sweets was also asked. Daily use of sweets was used as an outcome and categorized into: at least daily use *vs.* no daily use of sweets.

Saliva flow rate measurement and subjective feeling of dry mouth

Before the clinical oral examination, unstimulated and stimulated saliva secretion was measured using a draining method. The subjects were asked to abstain from eating and drinking for one hour before the measurement. Among persons with dentures, collection of unstimulated saliva was performed without dentures. During this measurement the participant sat in a relaxed position, leaning slightly forward. After swallowing, saliva was passively drained into a cup for 5 minutes (Navazesh 1993) graded in 1.0 ml increments to 30 ml. Before the measurement of the stimulated saliva flow rate, the participants were first advised to chew a piece of paraffin wax for 30 seconds and then to spit or swallow the saliva. After clearing the mouth of saliva, the paraffin wax was chewed and the saliva stimulated through mastication was drained into a cup for 5 minutes. Unstimulated salivary secretion was classified as normal salivary flow rate (≥ 0.1 ml/min) *vs.* reduced salivary flow rate (< 0.1 ml/min) and the stimulated salivary flow ≥ 1.0 ml/min and < 1.0 ml/min respectively (Flink et al. 2008).

Besides the salivary measurement, the dentist asked about the subjective feeling of dry mouth in connection with the clinical oral examination. The classification was: often, occasionally, or not at all. The need to treat xerostomia (i.e. subjective feeling of dry mouth) and hyposalivation (reduced salivary flow rate) was based on both subjective symptoms and objective saliva secretion measurement.

Clinical oral measurements

The clinical oral examination was based on visual and tactile inspection, and no radiographs were taken unless indicated for dental treatment. At the beginning of the examination, the participants were asked whether they had current pain or discomfort in their mouth.

The condition of the teeth and periodontium was registered for dentate subjects. Subjects were defined as dentate if they had at least one clinically visible tooth or dental radix. Oral hygiene among dentate subjects was measured by means of the presence of dental plaque, which was visually examined on the buccal and/or

palatal/lingual surfaces of each tooth. The classification of oral hygiene was dental plaque on 0–20% *vs.* more than 20% of all teeth (Axelsson et al. 2004).

The presence of gingivitis was based solely on visual examination and recorded as presence of redness and/or oedema on the buccal and/or lingual/palatal side of the gingiva of each tooth (yes *vs.* no). Periodontal pocket depth was measured by probing (WHO periodontal probe) at two sites, namely the mesiobuccal and distopalatal/distolingual surfaces of each tooth. The extent of periodontal infection was measured by the number of teeth with a deepened periodontal pocket, ≥ 4 mm. The presence of supra- and subgingival calculus was recorded during the probing of periodontal pockets.

Dental caries was examined on each surface of every tooth and recorded as crown caries (caries had reached the dentin layer of the clinical crown), root caries (softened root surface), crown and root caries, or carious dental radix. Dental caries was recorded at tooth level; a tooth was defined as carious if any of the above-mentioned criteria was met on any surface of the tooth.

Plaque on dentures was defined based on a modified version of a method adopted by Ambjørnsen et al (1982). Denture hygiene was categorized as no or minimal denture plaque *vs.* denture plaque detected by scraping with a blunt instrument or visible denture plaque. The presence, type, and condition of the denture were recorded.

Mucosal lesions were examined on the mucosal membranes, palate, tongue, tissues under the tongue, gingiva, and alveolar ridges. The findings were classified by their location, colour, and surface structure. The presence of mucosal findings was recorded according to whether they needed follow-up. If there was smooth or nodular redness in the oral mucosa in the context of the removable denture, it was categorized as denture stomatitis.

Summary of the use of variables as outcomes

The outcome variables and the study subjects that were used in each article are presented in Table 7. In the first article, the outcome was the need for preventive oral health care. In the second article, there were seven outcome variables related to oral health behaviour and nine related to oral health. In the third article, the outcome variables were toothbrushing frequency, toothpaste use and oral hygiene. In the fourth article, the preference for a dentist's home visit was used as the outcome. In addition, the use of dental health care services at baseline and during the study is also reported.

Table 7. Study subjects and outcome variables according to original articles

Article	Study subjects	Outcome variable
I	Subjects in intervention group at baseline (all, n=165, dentate, n=77, edentulous, n=88)	Subjects with preventive oral health care need
II	Dentate subjects who completed the two-year study (n=68 in the intervention, n=80 in the control group)	Toothbrushing ≥ 2 times a day (yes vs. no) Use of toothpaste ≥ 2 times a day (yes vs. no) Use of toothpicks daily (yes vs. no) Use of interdental floss or brush daily (yes vs. no) Good oral hygiene (plaque teeth $< 20\%$) Absence of gingivitis Absence of calculus Absence of deepened periodontal pockets Absence of dental caries
	Subjects with removable denture who completed the study (n=113 in the intervention group, n=93 in the control group)	Denture cleaning ≥ 2 times a day (yes vs. no) Use of denture cleaning agent daily (yes vs. no) Good denture hygiene (yes vs. no) Absence of denture stomatitis
	All study subjects who completed the study (n=145 in the intervention group, n=134 in the control group)	Use of sweets daily (yes vs. no) Absence of oral pain or discomfort Absence of mucosal lesions
III	Dentate study subjects at baseline (n=168)	Toothbrushing at least ≥ 2 times a day (yes vs. no) Use of toothpaste at least ≥ 2 times a day (yes vs. no) Good oral hygiene (plaque teeth $< 20\%$)
IV	All study subjects at baseline (n=321)	Study subjects who preferred dentist's home visit instead of paying visit to dental clinic Visits to dental health care professionals by study group and by dentate and edentulous subjects

Table 8. *Intervention program*

Target of intervention / Outcome	Intervention:	Tool /product*
Dental plaque/ Outcome: Proportion of participants with good oral hygiene (plaque teeth 0 – 20% of all teeth) Calculus / Outcome: Proportion of participants without calculus teeth Gingival or periodontal infection / Outcomes: Proportion of participants without gingivitis or deepened periodontal pockets Dental caries / Outcome: Proportion of participants without dental caries	<ul style="list-style-type: none"> - Intensifying mechanical plaque removal, oral self-care instruction counselling and motivating - Decrease of sugar use frequency, counselling - Professional cleaning - Control/re-instruction, follow-up, range 3–12 months 	<ul style="list-style-type: none"> - Suitable toothbrush and fluoride toothpaste at least twice a day - Interdental cleaning (brushes if possible) daily - Compensating sugar-containing products with xylitol or sugar-free products and sweet drinks with water - Mouth rinses or gel for a given period (mainly chlorhexidine 0.2% or 0.12% rinses, gel 1%) - Dental treatment if indicated - Fluoride and/or xylitol sucking tablets or fluoride rinses daily, fluoride or fluoride–chlorhexidine varnishes in practice
Removable denture plaque/ Outcome: Proportion of participants with good denture hygiene (no plaque on marker points) Infection under the denture / Outcome: Proportion of participants with no stomatitis	<ul style="list-style-type: none"> - Intensifying mechanical denture plaque removal, self-care instruction, counselling and motivating - Decrease of sugar use frequency, counselling - No denture use at night, keeping denture dry if not in use, medication - Checking health background factors (e.g. sugar balance, immunosuppression) - Control/re-instruction, follow-up, range 3–12 months 	<ul style="list-style-type: none"> - Suitable denture brush (undercuts observed) and denture cleaning agent (soap or dentifrice) at least twice a day, - In special cases soaking once a week in alkaline peroxides - Mild salt water rinses - Denture brushing with chlorhexidine gel (1%), mouth rinses with chlorhexidine (0.2% or 0.12%) denture overnight in chlorhexidine solution - Antifungal medication, if indicated - Possibly new denture
Xerostomia and/or hyposalivation / Outcomes: Proportion of participants with feeling of dry mouth often and decreased flow rate of unstimulated/stimulated saliva	<ul style="list-style-type: none"> - If troublesome or oral health problems - Avoiding irritating agents (e.g. food, spices, too hard toothbrush, toothpaste with sodium lauryl sulfate) - Stimulating the salivary flow rate - Palliative treatment 	<ul style="list-style-type: none"> - Good water/fluid intake, mouth moistening with water - Sucking tablets (containing e.g. xylitol, betaine, citric or apple acid, fluoride) - Mouth-wetting agents (food oil, gel, spray)

*Besides normal toothpastes (fluoride content 1000–1500 ppm) we mainly recommended different forms of following products: Biotène®, BioXtra®, Corega®, Corsodyl®, Fludent®, DentifPlus®, Meridol®, Paroex®, Xerodent® and Xerostom.

4.3 ORAL HEALTH INTERVENTION

The oral health intervention included individually tailored personal guidance in dental and denture hygiene, relief of symptoms of dry mouth, use of fluoride, xylitol, or chlorhexidine products, and scaling and cleaning tooth and root surfaces (Table 8). Standard dental care was performed when indicated. Study subjects who had no need for preventive care were encouraged to pursue their good oral health habits.

The need for oral health intervention was based on the interview and assessment of health status and on a comprehensive assessment of each subject's oral status. This criterion was met if the participants had any of the following: poor oral or denture hygiene, signs of mucosal or gingival inflammation (presence of mucosal lesions, gingivitis, calculus and deepened periodontal pockets), caries activity (cariological status in relation to treatment history), subjective symptoms of dry mouth (xerostomia) or objective low saliva secretion.

Based on individual need, short interventions, such as counselling to improve oral hygiene, were performed by the dentist in the context of the examination or treatment visit. More comprehensive oral health counselling and intervention regimens were performed mainly by a dental hygienist during a separate visit at the dental clinic or in the subject's home. The dental hygienist interventions varied according to need, from one to three visits in the course of a year.

In the intervention group, the interview and the clinical measurements were performed at the baseline, after one year and after a two-year study period while in the control group they were carried out at the baseline and after a two-year study period.

4.4 STATISTICAL ANALYSES

Odds ratios (OR) with 95% confidence intervals (CI) are presented in articles I, III and IV, and they were estimated using logistic regression models. The selection of the confounding factors was based on current knowledge about factors that are known to relate to the outcome variables.

The effect of the intervention was analysed using a generalized linear model with binomial distribution and the identity link function (article II). The baseline value of each outcome variable was included in the model in order to control for baseline differences. In the models, a positive effectiveness value indicates an advantage for the intervention group and a negative value represents an advantage for the control group in all cases except the daily use of sweets, teeth with a deepened periodontal pockets, and mucosal lesions, where a negative value denotes an advantage for the intervention group. The analyses were based on those subjects who participated in both the baseline and two-year follow-up measurements. The power calculation

(article II) using a statistical power of 0.80 with an alpha of 0.05 showed a need that about 80 subjects were required in both groups in order to detect a difference of 20–25% in proportions. The data were processed and analysed using SPSS statistical software 14.0 for Windows (SPSS, Chicago Ill. USA). In article II the analyses were performed using SAS version 9.2, procedures GENMOD and GLM (SAS Institute, Cary, NC, USA).

4.5 ETHICS

Participation in this study was entirely voluntary. Written informed consent was obtained from the study participants or their relatives. The study protocol was approved by the Research Ethics Committee of the Hospital District of Northern Savo, as required by Finnish legislation.

Where there were problems with communication or with the memory of the participant, the appointment for the examination visit was made with a family member. The family member or the person responsible for providing home-care services was present during the dentist's home visit in these cases. Written information about the key findings of the clinical oral examination was given to each study participant. All the participants were offered standard dental care, including relief for oral pain and restorative, prosthetic, and surgical treatment, when indicated.

5 Results

In this study population of older people (mean age 81.6 years), 71% were women and 29% men. In terms of general health, 57% of the participants had modest or poor self-reported health, 23% had impaired cognition and 29% had three or more impairments to everyday functional activity (Table 6).

The oral health of the participants was poor; of the participants, 70% had gingivitis, 59% had deepened periodontal pockets of 4 mm or more and 46% had carious teeth, 26% reported oral pain or discomfort, and 13% mucosal lesions which needed follow-up. A dry mouth was also often reported; 45% of the participants reported having the feeling of a dry mouth, of which 18% reported having the feeling of a dry mouth often. The clinical oral examinations revealed that 36% of the participants had decreased unstimulated saliva secretion and 31% had decreased stimulated saliva secretion.

Fifty-two per cent of the participants had their own natural teeth, the mean number of teeth among the dentate subjects being 14.4. Among the whole study population, 77% had a removable denture and 39% of the dentate participants had a removable partial denture. Dentures were often old and in poor condition; half of the dentures were more than ten years old and 23% of the denture users reported that the dentures needed repairing or renewal. Denture stomatitis was found in 20% of those who used removable dentures.

Regarding oral health behaviour, 69% of the participants brushed their teeth at least twice a day and 8% used a powered toothbrush daily, 48% used toothpaste at least twice a day and 13% used a mouth care product other than toothpaste daily. Dental health care services were regularly used by 58% of the dentate and 3% of the edentulous participants. Altogether 65% of the dentate and 12% of edentulous participants paid dental health care service visits during the past year (Table 9).

Table 9. Oral health-related factors of study participants by study group at the baseline examination

	Intervention group n=165	Control group n=156	All n=321
Dentate persons, n/all (%)	77 (46.7)	91 (58.3)	168/321 (52.3)
Number of teeth, mean \pm SD*	13.4 \pm 8.1	15.3 \pm 8.1	14.4 \pm 8.1
Removable denture, n/all (%)	136 (82.4)	111 (71.2)	247/321 (76.9)
Partial removable denture, n/all (%)	29 (37.7)	36 (39.6)	65/168 (38.7)
Toothbrushing at least \geq 2 a day, n/all (%)	48 (62.3)	68 (74.7)	116/168 (69.0)
Toothpaste use at least \geq 2 a day, n/all (%)	33 (42.9)	48 (52.7)	81/168 (48.2)
Good oral hygiene, n/all (%)	18 (23.4)	38 (42.5)	56/168 (33.3)
No gingivitis, n/all (%)	21 (27.3)	30 (33.0)	51/168 (30.4)
No calculus, n/all (%)	13 (16.9)	26 (28.5)	39/168 (23.2)
No deepened periodontal pockets n/all (%)	31 (41.3)	37 (41.1)	68/165 (41.2)
No dental caries, n/all (%)	42 (54.5)	48 (52.7)	90/168 (53.6)
Caries teeth, mean \pm SD	1.1 \pm 1.7	1.2 \pm 2.3	1.2 \pm 2.1
Denture cleaning at least \geq 2 a day, n/all (%)	96 (70.6)	77 (69.4)	173/247 (70.0)
Denture cleaning agent daily, n/all (%)	61 (45.5)	59 (54.1)	120/243 (49.4)
Good denture hygiene, n/all (%)	73 (54.1)	60 (54.7)	133/245 (54.3)
No denture stomatitis, n/all (%)	110 (80.9)	87 (78.4)	197/247 (79.4)
No oral pain or discomfort, n/all (%)	113 (68.5)	125 (80.1)	238/321 (74.1)
No mucosal lesions, n/all (%)	132 (80.0)	148 (94.9)	280/321 (87.2)
Unstim.saliva flow < 0.1 ml/min n/all (%)	61 (38.4)	45 (30.6)	106/306 (34.6)
Stimulated saliva flow < 1.0 ml/min, n/all (%)	51 (33.0)	44 (30.1)	95/300 (31.6)
Feeling of dry mouth n/all (%)	78 (47.3)	66 (42.9)	144/319 (45.1)
Regular dental check-up n/all (%)	44 (27.2)	57 (37.0)	101/316 (31.9)
Dentate	40 (51.9)	56 (62.9)	96/166 (57.8)
Edentulous	4 (4.7)	1 (1.5)	5/150 (3.3)
Previous visit to dental care			
< one year n/all (%)	58 (35.2)	66 (42.3)	124/312 (39.7)
Dentate	47 (61.8)	60 (67.4)	107/165 (64.8)
Edentulous	11 (13.1)	6 (9.5)	17/147 (11.6)

*SD = standard deviation.

5.1 DETERMINANTS FOR PREVENTIVE ORAL HEALTH CARE NEED (Article I and unpublished data)

In this study, the need and the determinants for preventive oral health were studied among subjects who were in the oral health intervention group. It was found that 82% of the dentate and 55% of the edentulous participants with full dentures and almost all (97%) of those who wore a partial removable denture presented a need for preventive care. The preventive oral health care need at the baseline examination and the changes in preventive care needs during the study are presented in Figure 2. At the end of the study, half of all (n=73) and three out of four of the dentate (n=53) study subjects still required preventive oral health care. Of the study subjects who required no oral health promotion, the majority (86%) were edentulous.

In the total study population, the main determinants for the preventive care need were age OR 1.1 (CI 1.0–1.2), co-morbidity (measured by means of the Modified Functional Co-morbidity Index) OR 1.2 (CI 1.0–1.5), being pre-frail or frail, OR 2.5 (CI 1.2–5.1) and presence of natural teeth, OR 4.8 (CI 2.2–10.4).

Among the edentulous participants, frailty status, co-morbidity and impaired cognition were associated with a need for preventive oral health care whereas among the dentate participants, poor general health, co-morbidity and frailty status were more weakly associated with the need for preventive oral health care than among the edentulous participants. Among the dentate participants, the use of a removable partial denture was found to be strongly associated with the need for preventive oral health care, OR 12.8 (CI 1.4–114.4).

Baseline **Baseline, n=165** **1. Follow-up, n=154** **2. Follow-up, n=145**

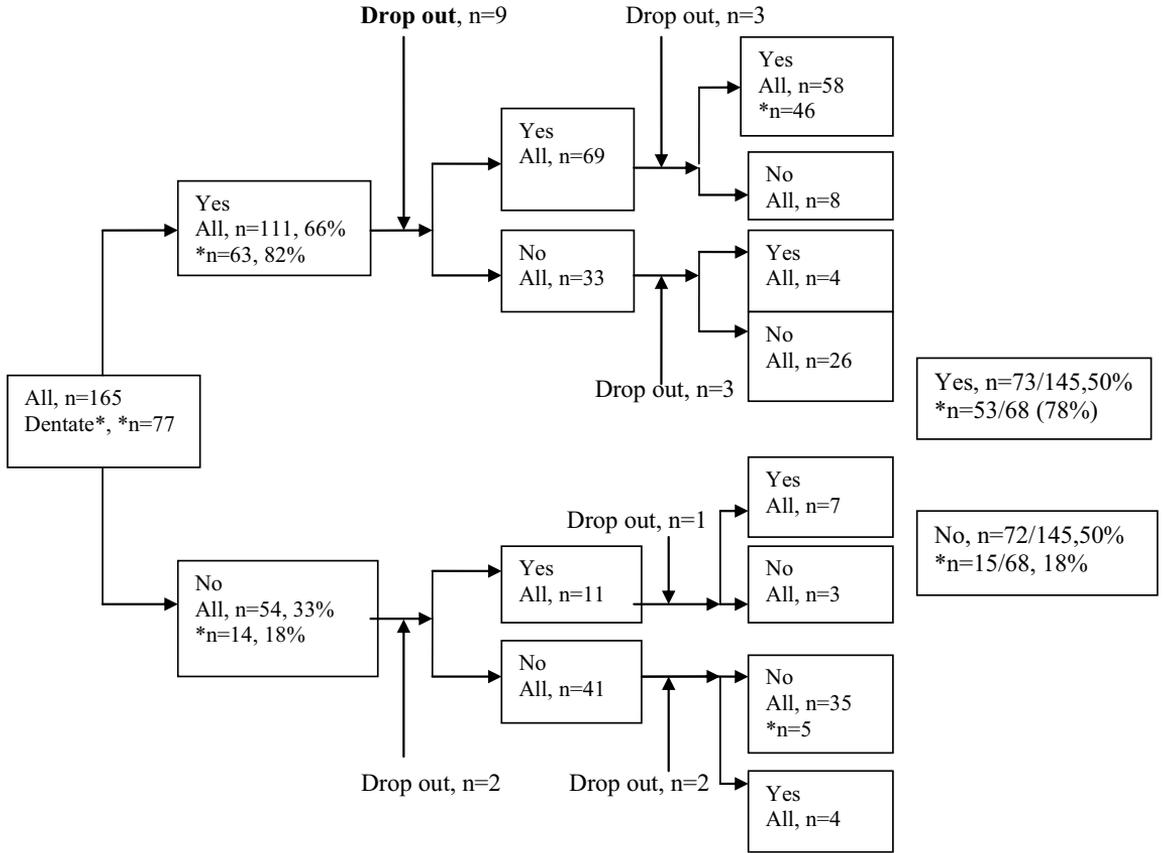


Figure 2. *The need for preventive oral health care*

5.2 EFFECT OF THE ORAL HEALTH INTERVENTION (Article II)

In terms of socio-demographic background and non-oral health-related factors, the allocation proved to be fairly successful and the participants between the intervention and control group were quite similar. The only exception was that in the intervention group there were more subjects who used drugs regularly. In terms of oral health, the groups differed, as the participants in the intervention group showed poorer oral health on average; there were more edentulous participants and ones with removable dentures in this group, and they manifested poorer oral hygiene and showed more oral pain and mucosal lesions more often than the subjects in the control group, for instance (Table 10).

During the two-year follow-up, participants in the intervention group improved their oral health behaviour. Participants in the control group also improved their oral health behaviour but to a lesser degree (Table 10).

In terms of oral health outcomes, the participants in both the intervention and control group showed less gingivitis, calculus, deepened periodontal pockets, dental caries, denture stomatitis and oral pain or discomfort in the follow-up examination than in the baseline examination (Table 10). The percentage point differences in changes between the intervention and the control groups (effect of the intervention), when taking into account the baseline differences, were not statistically significant at p-value level 0.05 in any of the oral health behaviour or oral diseases/conditions except the daily use of sweets (Table 11).

Table 10. Proportions of participants by outcomes, at baseline and after two-year follow-up

	Intervention group			Control group		Change %
	Baseline	Final	Change	Baseline	Final	
	%	%	%	%	%	
Oral health behaviour						
<i>Dentate subjects*</i>						
Toothbrushing ≥ 2 times a day	63.6	72.7	9.1	76.3	76.3	0
Toothpaste ≥ 2 times a day	43.9	50.0	6.1	53.3	57.3	4.0
Toothpick daily	40.6	46.9	6.3	39.5	43.4	3.9
Interdental floss or brush daily	25.8	31.8	6.0	14.5	19.7	5.2
<i>Subjects with removable denture[†]</i>						
Denture cleaning ≥ 2 times a day	72.2	72.2	0	72.7	72.7	0
Denture cleaning agent daily	59.3	71.3	12.0	75.3	65.2	-10.1
<i>All subjects[‡]</i>						
Use of sweets daily	20.9	14.9	-6.0	17.3	29.3	12.0
Oral health						
<i>Dentate subjects*</i>						
Good oral hygiene	22.1	41.2	19.1	42.5	50.0	7.5
No gingivitis	23.5	60.3	36.8	32.5	51.3	18.8
No calculus	16.7	31.8	15.1	29.5	37.2	7.7
No deepened periodontal pockets	37.9	57.6	19.7	41.0	60.3	19.3
No dental caries	52.9	73.5	20.6	51.3	65.0	14.7
<i>Subjects with removable denture[†]</i>						
Good denture hygiene	54.9	65.5	10.8	59.3	74.7	15.4
No denture stomatitis	77.0	90.3	13.3	77.4	87.1	9.7
<i>All subjects[‡]</i>						
No oral pain or discomfort	69.4	79.2	9.8	78.8	81.8	3.0
No mucosal lesions	20.0	7.6	-12.4	5.2	7.5	-2.3

*Intervention group, n=68; control group n=80.

[†] Intervention group, n=113; control group n=93.

[‡] All subjects who completed the study; intervention group n=145, control group n=134.

Table 11. The effects of the preventive oral health intervention on oral health behaviour and on oral health, multivariate models with 95% confidence intervals (95% CI). Adjusted for baseline values

	Between groups	
	Effect*	
	%	95% CI to %
Oral health behaviour		
<i>Dentate subjects[†]</i>		
Toothbrushing ≥ 2 times a day	4.1	-6.6–14.8
Toothpaste ≥ 2 times a day	- 4.0	-17.9–9.9
Toothpick daily	3.3	-10.2–16.7
Interdental floss or brush daily	8.0	-3.9–19.8
<i>Subjects with removable denture[‡]</i>		
Denture cleaning ≥ 2 times a day	-0.7	-11.3–10.0
Denture cleaning agent daily	6.7	-6.5–19.8
<i>All subjects[§]</i>		
Use of sweets daily	-13.2	-26.2–(-0.2)
Oral health		
<i>Dentate subjects[†]</i>		
Good oral hygiene	-0.4	-15.7–14.8
No gingivitis	7.6	-6.1– 21.2
No calculus	-1.1	-16.2–13.9
No deepened periodontal pockets	-1.9	-15.6–11.8
No dental caries	4.8	-8.6–18.3
<i>Subjects with removable denture[‡]</i>		
Good denture hygiene	-10.3	-22.4–1.7
No denture stomatitis	2.6	-4.5–9.8
<i>All subjects[§]</i>		
No oral pain or discomfort	2.5	- 5.6–10.6
Mucosal lesions	-1.0	-6.6–4.6

* Percentage point change (%) between the intervention and control group. Positive values indicate an advantage for the intervention group in all cases except the daily use of sweets and presence of mucosal lesions, when a negative value denotes an advantage for the intervention group.

[†] Intervention group, n=68; control group n=80.

[‡] Intervention group, n=113; control group n=93.

[§] All subjects who completed the study; intervention group n=145, control group n=134.

5.3 ASSOCIATION OF FUNCTIONAL ABILITY AND HANDGRIP STRENGTH WITH ORAL SELF-CARE (Article III)

In this study, oral self-care was measured by means of toothbrushing twice a day, the use of toothpaste and oral hygiene level. It was found that 67% of the participants with a high functional ability, measured by the score of Instrumental Activity of Daily Living (IADL score 7–8), and 45% of those with a low functional ability (IADL score ≤ 6) brushed their teeth at least twice a day. There was also a difference in the use of toothpaste. Among participants who had good functional ability, 55% of the subjects used toothpaste twice a day whereas among participants with low functional ability they amounted to 26%. In the case of oral hygiene, 33% of the participants had good oral hygiene (0–20% teeth with dental plaque); 38.8 % among those with good functional ability and 15.8% among those with low functional ability.

The results of the multivariate analyses showed that, after controlling for confounding factors such as gender, age, education, number of teeth, cognitive status (MMSE), experiencing the feeling of a dry mouth and having their own dentist, functional ability associated with all measures of oral self-care, i.e. toothbrushing frequency, toothpaste use and dental plaque. In this study, there was practically no association between handgrip strength and oral self-care after adjusting for the above-mentioned confounding factors.

5.4 USE OF DENTAL HEALTH CARE SERVICES (unpublished data and article IV)

Use of dental health care services

The participants differed in their use of dental health care services according to whether they had their own natural teeth or not. Altogether 58% of the dentate and 3% of the edentulous subjects had regularly used dental health care services at the baseline (Table 9). The participants also differed in terms of the number of dental visit within the last year, with about two thirds of the dentate and 12% of the edentulous study subjects having visited a dental care unit over the past year (Table 9). Of all the visits, 40% were made due to pain or discomfort.

During the two-year study period, the mean number of visits to dental health care services was 5.4 (range 0–23) among the dentate and 1.3 (range 0–13) among the edentulous participants in the intervention group, and 3.2 (range 0–22) among the dentate subjects and 0.3 (range 0–5) in the control group, respectively (Table 11). The mean number of visits to the dentist (public and/or private care) among the dentate subjects was 3.9 in the intervention group and 3.1 in the control group during the two-year study period (Table 12).

Preference for dentist home visit

According the study protocol, home visits by the dentist were offered to the participants, of whom 26% (n = 83) opted for it. The strongest determinants for a home visit by the dentist were impaired cognition, MMSE score ≤ 24 , OR 6.1 (CI 2.9 – 13.6) and low functional ability, IADL score (< 8), OR 8.0 (CI 3.6 – 18.6). In addition, the preference for a home visit by the dentist associated with high use of home-care services and less use of primary health care, such as visits to a medical doctor and dental health care services.

Those participants who preferred the dentist's home visit had on average poor oral health habits; they brushed their teeth only once a day or less, had reduced unstimulated salivary secretion and had fewer teeth than those who preferred to come to the dental clinic. There were no essential differences in oral diseases, such as dental caries, denture stomatitis or periodontal condition between participants who came to the dental clinic and those who preferred the dentist's home visit.

Table 12. *Visits to dental health care services, two-year period by study subjects*

	Intervention group			Control group		
	All	Dentate	Edentulous	All	Dentate	Edentulous
Visits, mean (SD*)	3.3 (4.0)	5.4 (4.4)	1.4 (2.3)	2.1 (3.7)	3.2 (4.3)	0.3 (1.0)
Dentist, public care, mean, (SD)	1.6 (3.3)	2.6 (4.3)	0.7 (2.0)	1.3 (3.3)	2.2 (4.0)	0.04 (0.2)
Dentist, private care, mean, (SD)	0.7 (1.8)	1.3 (2.4)	0.04 (0.3)	0.5 (1.4)	0.9 (1.7)	0
Dental technician, mean, (SD)	0.1 (0.6)	0.1 (0.3)	0.2 (0.7)	0.1 (0.5)	0.06 (0.3)	0.2 (0.7)
Dental hygienist, mean, (SD)	1.0 (1.3)	1.5 (1.4)	0.4 (0.9)	0.1 (0.5)	0.2 (0.5)	0.1 (0.6)

*SD=standard deviation

6 Discussion

This thesis was based on data from the intervention study of the Geriatric Multidisciplinary Strategy for Good Care for Elderly People (GeMS). In the following chapters, the effect of the oral health intervention, preventive oral health care need and its determinants, the role of functional ability in oral self-care, the use of oral health care services and the characteristics of study participants who preferred a home visit by the dentist will be discussed. Aspects related to methodology, study design, measurements, and strengths and limitations of the study will also be discussed.

6.1 DISCUSSION OF THE RESULTS

6.1.1 Effect of intervention on oral health

One interesting finding of this study was that the improvement in oral health and health behaviour was detected both in the intervention and control groups, and while this improvement was clinically substantial in most cases, the differences in changes between the intervention and control group were quite small and statistically insignificant.

Periodontal health

The condition of periodontium improved during the two-year study period in both the intervention and the control group. The improvements were pronounced and can be considered clinically noteworthy whereas respective improvements in oral health behaviours, including oral hygiene practices, were fairly small. The explanation for the improvement in the control group cannot be established with certainty, but it is possible that better periodontal health in both the intervention and control group was at least in part explained by the information that was given in the context of the clinical oral examination and interview. Other studies have also reported improvement in oral health behaviour in periodontal health among participants in the control group (Karikoski et al. 2003, Schiffner et al. 2007, Bakhshandeh et al. 2010).

The proportion of participants with deepened periodontal pockets, about 40%, in the two-year follow-up, was fairly low compared to previously existing data among older people (Dye 2012), 66% in Denmark (Krustrup and Petersen 2006), and 88% in Germany (Holtfreter et al. 2010) and 70% in a previous study in Finland (Suominen-Taipale et al. 2004). Apart from the effect of preventive care and the information provided, one obvious reason for a fairly good periodontal condition in this population could also be the fairly low number of own natural teeth, 14.4 teeth on average.

Dental caries

The increment in dental caries and the effect of preventive measures on dental caries were difficult to study for a number of reasons. The main reason was that, in addition to the preventive regimen, restorative treatment was also offered to the intervention group (owing to the long study period it was not possible deny it from the control group either). It is possible, therefore, that the reduction in the number of carious teeth was caused by restorative treatment rather than by a fall in the incidence of dental caries. The same dilemma has been encountered in other studies (Schuller and Holst 2001, Holst and Schuller 2011). Needless to say, it is (also) possible that the use of topical fluorides (used mainly by dental hygienists), counselling to reduce frequent use of sugar products and intensified oral hygiene together decreased the increment of dental caries.

Roughly half of the participants were caries-free at the baseline, which is at about the same level as that reported in Sweden among people 80 years old or older (Avlund et al. 2004), and somewhat higher than reported in the Health 2000 Survey in Finland (Suominen-Taipale et al. 2004) and in Japan (Imazato et al. 2006) among people 65 years old or older. In this context, it should be remembered that precise comparisons between epidemiological dental caries studies across countries is problematic because of the use of different measurements of caries and differences in study populations. One of the most important differences is the variation in the number of own natural teeth among dentate persons.

Denture stomatitis and mucosal lesions

Even though the participants' dentures were old on average and were often in need of repair or renewal, denture stomatitis was quite uncommon (23% at the baseline, 10% in the follow-up) compared to previously reported epidemiological studies. For example, in the Finnish Health 2000 Survey, the prevalence of denture stomatitis was 31% among people aged 75 but figures as high as 70% or higher have been reported among community-dwelling older people with removable dentures (Kulak-Ozkan et al. 2002, de Souza et al. 2009). The decrease that was observed in this study during the intervention in denture stomatitis can most likely be attributed to improved denture plaque removal and denture hygiene, because other methods such as fungal medications were not used.

The prevalence of denture-related lesions, in presence of ill-fitting or unretentive dentures, has in other studies been reported to range from 4% to 26% (Petersen and Yamamoto 2005, Jankittivong et al. 2010), which is in line with what was observed in this study. Mucosal lesions requiring follow-up mainly associated with poor removable denture retention and mechanical trauma. The improved fitting of removable dentures by repairing or renewing the dentures was possibly one reason for the reduction from 20% to 7% in mucosal lesions among the participants in the

intervention group. As in the case of denture stomatitis, improved oral and denture hygiene may have played role, too.

6.1.2 Effect of intervention on dental and denture hygiene

Dental cleanliness

Dental hygiene improved more in the intervention group than in the control group, which concurs with earlier studies (Axelsson et al. 2004, Ribeiro et al. 2009). Relative to other studies on older people, dental plaque removal was at about same level (Morris et al. 2001, an der Weijden et al. 2005, Micheelis 2011) or even better (Mack et al. 2003, Holtfreter et al. 2010). However, reports showing a better oral hygiene level among older people also exist (Hugoson et al. 2005). The improvement in dental hygiene observed in the present study was somewhat surprising, because changes in toothbrushing habits, although in favour to the intervention group, were quite small. On the other hand, it is worth noting that toothbrushing frequency has been shown to be related to the cleanliness of teeth among adults even where overall mechanical dental plaque removal is insufficient (L e 2000, Liu et al. 2012).

The proportion of subjects who brush their teeth twice a day corresponded quite well with data reported in the Nordic countries (Christensen et al. 2003, Hugoson et al. 2005). Besides frequency, also the design of the brush, the skill of the individual in using a brush and the duration of the brushing all impact dental and denture plaque removal (van der Weijden et al. 2005). The skill of using a toothbrush or denture brush depends on the strength of the subject's hand and on manual dexterity (Choo et al. 2001). It has been shown in earlier studies among older frail people that the dexterity of the hand is associated with good plaque removal and effective toothbrushing (van der Weijden et al. 2005, Padilha et al. 2007). Contrary to these earlier observations, the handgrip strength, as an indicator of total body muscle strength, did not seem to affect the removal of dental plaque in this study, which may be due to the fact that participants in this study had a fairly good handgrip strength on average.

One way to improve oral hygiene is to use toothpaste at least twice a day and daily interdental cleaning. Despite attempts to motivate the participants of this study to use toothpaste twice daily, its use seemed to remain quite low and only half of the subjects used toothpaste twice a day, as is currently recommended. Overall, the daily use of toothpaste in our study was at the same level as reported in earlier studies on adults (Christensen et al. 2003; Tseveenjav et al. 2010), with 78% among the males and 90% among the females doing so. In the case of interdental cleaning, the first choice recommended in this study was an interdental brush. However, among the participants, the most popular way to clean interdental spaces was toothpicks. Other studies have also shown that old people use toothpicks more often than interdental floss or interdental brushes (Christensen et al. 2003).

Another way to improve oral hygiene is to use a powered toothbrush. Powered toothbrushes were not used by many subjects at the start of this study, a mere 8%, and at the end of the study the use of powered toothbrushes had slightly decreased. This low percentage is due to two reasons: firstly, during the study years of 2004–2006, powered toothbrushes were not as popular in Finland as they are nowadays, and secondly, at that time of the study powered toothbrushes were not an active target in the oral health promoting intervention.

Cleanliness of removable dentures

The use of removable dentures was common in this study population—about three out of four of the participants had some kind of removable denture. One important finding was that the dentures were old; half of the dentures were more than ten years old and almost every one in four participants had dentures needing repair or renewal. Earlier studies have also shown that older people tend to have old dentures and also that old dentures tend to be more difficult to clean than new ones (Kanli et al. 2005, Shulman et al. 2005).

Inadequate denture hygiene that leaves a high quantity of micro-organisms on denture surfaces and on the surfaces of the underneath tissues of dentures has been reported to be common, especially among old people in nursing homes and among those who are in institutional care (de Souza et al. 2009). In denture cleaning, a combination of mechanical and chemical methods is routinely recommended for patients with removable partial dentures (Blankenstein and Peroz 2011, Nishi et al. 2011). The evidence-based guidelines for care and maintenance of complete dentures in the USA (Felton et al. 2011) recommend denture cleaning daily by soaking and brushing with an effective nonabrasive denture cleaner, but also brushing with toothpaste, one of the most common methods for cleaning dentures, is considered to be simple, inexpensive and effective (Jagger 2009, Paranhos et al. 2007). The daily use of denture cleaning agents increased during the study period from 59% to 71% among the participants with a removable denture. Besides the use of cleaning agents, another way to improve denture hygiene is to avoid constant wearing of dentures (Felton et al. 2011). In this study, about half of the subjects who use removable dentures said they use the dentures continuously and, despite the recommendations, no changes in denture use were observed. The good denture hygiene among the participants of this study—three out of four participants had clean dentures—can at least partly be attributed to an increased use in denture cleaning agents. At the end of study, denture hygiene was clearly better than that reported in earlier studies (Gendreau and Loewy 2011).

6.1.3 Other clinical observations

Although the participants had, for example, less dental caries, less mucosal lesions, and less denture stomatitis in the follow-up than in the baseline study, every fifth

subject still had oral pain or discomfort at the end of the study. One reason may be the subjective feeling of a dry mouth, which actually slightly increased during the study. This means that the efforts to relieve dry mouth symptoms were not successful. Despite the symptoms, the study participants were not motivated to use mouth moisturizing agents as recommended, possibly because they felt they were not benefitting from its use. It is also worth noting that the optimization of medication by a medical doctor as part of the GeMS study (Lampela et al. 2010) did not seem to affect the subjects' dry mouth experience or saliva secretion.

Dietary advice to restrict the use of sugar most likely played only a minor role compared to the overall dietary advice given by the study nutritionist. The purpose of the nutrition intervention performed by the study nutritionist was to reduce the risk of malnutrition and to treat participants at risk of malnutrition by increasing the frequency of meals and/or by adding energy and proteins to the meals. In terms of the use of sugar products, the only change was a decrease in the daily use of sweets in the intervention group and an increase in the use of these products in the control group over the two-year study period.

6.1.4 Preventive oral health care need

The need for preventive oral health care was high among the dentate participants and it also remained high (four out of five) during the two-year period in spite of intense oral hygiene instruction, motivation and professional dental cleaning among the dentate participants. The strongest determinant for the need for preventive care among the dentate participants was the use of a removable partial denture, which is in line with previous findings (Vanzeveren et al. 2002). The high need for preventive care can be contrasted with the regular use of dental care services, which in this population was quite low—52% among the dentate subjects and 5% among the edentulous ones in the intervention group. This discrepancy between need and use suggests that there is a gap between the use of dental health care services and the need for dental care, both among dentate subjects and edentulous subjects.

It was also somewhat surprising that more than half of the edentulous participants with full dentures required preventive oral health care, as it is generally believed that edentulous people do not need preventive oral health care. The most important determinants and possible underlying reasons for the need for preventive oral health care among the edentulous participants were the following: frailty, having other illnesses, and impaired cognition. The findings suggest that problems with full dentures might be an indicator of underlying health problems, as observed earlier (Weyant et al. 2004).

Among the dentate participants, the most important determinants for the need for preventive oral health care were the presence of partial dentures and irregular dental visits, but surprisingly, not the number of natural teeth. The role of non-oral

conditions was less important among the dentate study population than among the edentulous participants. The finding, for example, that impaired cognition or functional ability were not essentially associated with the need for preventive oral health care among the dentate subjects contradicts earlier studies, which have shown that old people with functional and cognitive disabilities have poorer oral hygiene and more oral diseases than old people equipped with normal function and cognition (Avlund et al. 2001, Chalmers and Pearson 2005). One explanation for the finding in our study could be that dentate and edentate participants in this population were essentially different in terms of their non-oral health.

6.1.5 Use of dental health care services

Regular dental care visits are essential for dentate people in general, but also for those who have dentures, so as to prevent denture-induced complications such as oral mucosal lesions and infections (Nevalainen et al. 1997, Colussi et al. 2009, Jaiakittivong et al. 2010). In the whole study population, the use of dental health care services among edentulous older people was very low; only 3% of the participants used dental health care services regularly whereas 58% of dentate used them regularly. The regular use of dental health care services has been observed to be low among edentulous people in other countries too and at about the same level among dentate older people as in the present study (Ikebe et al. 2002, Australian Research Centre 2010, Ohi et al. 2009, Li et al. 2011).

Every two out of three dentate subjects in this study had attended dental care in the past year. This is about the same as for dentate older people as reported in nationwide study in Finland (60%) (Suominen-Taipale et al. 2004), in Australia (62%) (Australian Research Centre 2007) and in Japan (65%) (Sugihara et al. 2010) but less than in the Nordic countries: Sweden (80%) (Österberg and Carlsson 2007) and Denmark (88%) (Li et al. 2011).

Older people experience a number of obstacles in accessing the dental care they require (Dolan et al. 2005, Kiyak 2005; Borreani 2010). In this study, access was made easier by paying study-related transportation and offering home visits by the dentist. In spite of free transportation, the number of people who preferred home visits by the dentist was unexpectedly high. More than one in four participants preferred to have the dentist pay a home visit. Particularly the participants who used dental health care services irregularly preferred home visits. This suggests that different kinds of dental care service delivery are needed in order to ensure that older people use dental health care services more regularly.

In this study, the greatest difference between the participants in the intervention and in the control group was in the use of services offered by the dental hygienist, which was by no means surprising. During the two-year study period, of the dentate participants, nine out of ten subjects in the intervention group and one out of three in the control visited a dental hygienist. The explanation for the difference in visits to

dental hygienists was the attempt to respond to their real preventive care oral health needs. Over the two-year study period, the differences between the groups in terms of the mean number of visits to the dentist (public and private care) were not noteworthy: 3.9 in the intervention group and 3.1 in the control group. One possible explanation for the fairly high use of dental health care services also among those in the control group could be the thorough information about treatment needs given in the clinical oral examination.

In this study, the participants in the intervention group paid more visits to dental health care than did the participants in the control group, which, of course, was not unexpected. But what is significant is that the participants in the control group used more dental health care services than people in these age groups in general in Finland (Suominen-Taipale et al. 2004). This high use of dental care services may have diluted the effect of the intervention.

6.2 DISCUSSION ON METHODOLOGY

6.2.1 Study population and recruitment

The study population of this oral health study, the intervention group of the parent GeMS study, originally 500 persons, was randomly drawn from people aged 75 or older living in Kuopio, representing 9% of the total population of these age cohorts living in Kuopio. The participation rate for those who completed the oral health study was 56%, which was fairly low, but nonetheless at about same level as in longitudinal studies in these age groups (Heegaard et al. 2010, Newman 2010). In this study, frail general health and the absence of own natural teeth were found to be reasons for non-participation. The biasing effect of the non-participation was difficult to assess because only limited information about non-participants was available owing to privacy protection stipulated by Finnish legislation.

Despite best efforts of the dental team, it was difficult to motivate subjects to agree to participate if they had decided not to do so. The only measure available to persuade potential participants was to justify the benefits of the study, which would provide information about the study subjects' oral health, but the subjects were reluctant to change their mind if they had decided to refuse. The main reasons for refusal were being too tired to participate or having no natural teeth – both common conditions among older people. Difficulties related to the recruitment of older people have been observed in earlier studies (Stange 2010, Robare et al. 2011).

The way recruitment was executed may have had an effect on the results. The recruitment of the participants of the parent study commenced first, and the recruitment of the participants in the intervention group for the oral health study was carried out 6–8 months later. The recruitment of the participants for the control group of the oral health study started 3–4 months later, when the examination of the oral health intervention was in progress. This multiphase recruitment process could

have been more vulnerable to crossover of information between the study groups and could therefore have caused a dilution of the effect of the intervention.

6.2.2 Reliability and validity of the measurements

The data collection were performed by a team of professionals that included two dentists, two dental nurses, one dental hygienist, two medical doctors specializing in geriatrics, two physiotherapists, three nurses and one nutritionist. This team remained unchanged throughout the study barring one medical doctor leaving the team after a few months from the start of the study. The stability of the dental team over the study period most likely increased the reliability of the clinical oral measurements and implementation of the intervention. The two clinical examiner dentists, besides their training, received written instructions for the study.

The advantage of providing oral health intervention in a primary care setting with a permanent team made it possible to take advantage of a "clinician-patient" relationship, which has earlier been linked with health behaviour change as well as other positive aspects of care (Wissow et al. 2002, Goldstein et al. 2004). The preference for a permanent clinician-patient relationship has been observed especially in patients with chronic conditions (Pandhi and Saultz 2006). This rationale for better interpersonal relationships in health services is supported by benefits that stem from better communication and information transfer (Starfield and Holder 2007, Gervas and Starfield 2008). The question of continuity of care has not been studied in dentistry as profoundly as in general medicine (Slack-Smith et al. 2010) but evidence suggests that the above-mentioned benefits also apply in the treatment of chronic oral diseases (Borreani et al. 2008, Slack-Smith et al. 2010).

The questionnaire and the protocol of the clinical oral examination were based on an earlier population-based study in Finland (Suominen-Taipale et al. 2004). The questionnaire and clinical study was revised to better relate to the situation of older people. The parameters used to measure the effect of the oral health intervention were ones that are commonly used to measure oral health behaviour and oral diseases/conditions. The recording of dental plaque, gingivitis, calculus, deepened periodontal pockets and dental caries was done at tooth level. This resulted in a fairly reliable comparison between the baseline and follow-up examinations, compared with the use of index teeth or other partial clinical oral examinations, for example. On the other hand, the fact that the oral health outcomes were registered at tooth level, not on surface level, may have caused a slight underestimation. In addition, the fact that caries examination was based only on visual-tactile caries examination without bitewing radiographs may also have led to underdetection of caries lesions (Bader et al. 2001, Ewoldsen and Koka 2010).

Admittedly, the fact that one fourth of the participants preferred a home visit by the dentist, and their clinical oral examination was performed at home, may have resulted in less oral diseases being detected due to the more demanding

circumstances. Although not examined in this study, this kind of bias has been observed previously (Fairhall et al. 2009). However, in this study, 61% of the participants examined at home were edentulous. The low proportion of dentate subjects in the home-based examinations meant that overall underestimation of dental diseases was most likely small and therefore without any essential effect on the results.

6.2.3 Sample size

The size of the study groups of the oral health study was determined by the protocol of the parent GeMS study. To avoid any contamination between the intervention and control groups of the parent study, only the intervention group of the parent GeMS study was used for the oral health intervention study (Figure 1), and the control group of parent study was left intact, as based on study protocol.

Another factor that had an effect on the study size was the high rate of refusal and mortality during the study. These decreased the group size from 321 to 279 over the study period. In order to avoid further loss, those who were moved to institutional care during the study period were included in the study; eight of the study participants (5.5%) in the intervention group and five (3.7%) in the control group moved to institutional care.

When the study population involves old people, it is important to take into account the loss in participation when selecting the sample size (Newman 2010, Wilhelmson et al. 2011). In this study, the power calculations that were made afterwards revealed the need for about 80 subjects in both groups to detect a difference of 20–25% in proportions in order to achieve a statistical power of 0.80 with an alpha of 0.05. This means that the study was sufficiently powered. The stratified analyses were also sufficiently powered because the number of participants was over 80 in all subgroups, with the only exception that there were 68 dentate participants the intervention group.

When interpreting the results, it must be noted that it is possible that an effect smaller than 20–25% can also be clinically relevant. In this study, only one difference in change exceeded 10%, namely denture hygiene, where the change was -10.8 in favour of the control group. Bearing this in mind, a larger sample size would not have changed the situation essentially. However, admittedly, a large sample size could have reduced the role of chance.

6.2.4 Oral health intervention in real-life dental practice

The strength of the current study was that it was conducted in authentic circumstances, in the primary dental care of the social welfare and health care centre of Kuopio and mainly in a way that is standard dental care practice in Finland, taking into account the study protocol. In addition, most of the outcomes were the same as those generally used in daily dental practice, and the questionnaire and the

protocol of the clinical oral examination were based on two earlier population-based studies in Finland (Suominen-Taipale et al. 2004).

The clinical oral examinations were a part of a comprehensive geriatric assessment, and the oral health interventions were carried out with several other health interventions. This addresses the criticism that has been presented that clinical dental preventive care tends to use an isolated approach in which the mouth is studied separate from the rest of the body (Watt 2005, Martino 2010).

6.2.5 Effect of the intervention

The main reason why we did not find any essential improvement attributed to the intervention in oral health habits or oral health is that the participants belonging to the control group also improved their health habits and especially their oral health. This improvement in the control group was clear and in most cases beyond what can be expected to be caused by chance. This is most likely explained by the subjects being participants in the study (McCarney et al. 2007) and being followed up (Braunholtz et al. 2001, Krogsboll et al. 2009).

The randomization of the oral health study groups was done based on demographic data (age and gender) before the baseline measurement. This resulted in the participants in the intervention and control group being fairly similar in relation to socio-demographic and non-oral related factors, but not in terms of oral health-related factors. There were differences between the intervention and control groups. For example, the participants in the control group had on average more often natural teeth, better oral health habits and better oral health than the participants in the intervention group. This difference in oral health and health habits is problematic because in this age group the presence of natural teeth has been linked to a positive attitude towards oral health and dental care (Thorstensson and Johansson 2010, Guiney et al. 2011) as well as to social status (Holst 2008, Krustrup et al. 2008). Therefore, it is possible that the underlying attitudinal factors, such as adherence to dental treatment related to socioeconomic status, for instance, may explain the overall better oral health habits in the control group and also why the control group was able to improve oral health in many respects. Conversely, possible poor adherence or lack of a positive attitude toward dental health may explain why the improvement in oral health behaviour in the intervention group was quite modest. The said differences between the groups were partly eliminated by statistical methods, but one must take into account the possibility that statistical methods cannot fully eliminate the differences between the two groups.

In addition, it is possible that there was a contamination effect (Stuck et al. 2007), which means that the study participants in the control group received information on oral health promotion from the study people in the oral health intervention group and this generated an improvement in oral health and health habits among the

participants in the control group. In this study, contamination was possible because the participants in the oral health intervention study were recruited from the intervention group of the parent GeMS study, meaning that the participants belonging to the oral health control group had several opportunities to get information on the content of the oral health study. The fact that the control group of this study was examined a few months later than the intervention group increased the possibility of contamination.

Perhaps the most important aspect in interpretation of the results is that the intervention was based on an individual need and therefore not all the subjects were involved in any specific intervention (oral and/or denture hygiene, relief of dry mouth symptoms, use of fluoride, xylitol, or antimicrobial products, and professional tooth cleaning). For them, no benefit from the intervention can reasonably be expected. In this respect, the present study is exceptional compared to other intervention studies, in which researchers have investigated for example the effect of preventive measures on dental caries (Pettersson et al. 2007, Hietasalo et al. 2009, Gibson et al. 2011) or on periodontal health (Schiffner et al. 2009) among high-risk study populations or among subjects with an active disease.

There are also other factors that can limit the effectiveness of health promotion and preventive interventions, such as the acceptability, fidelity and sustainability of the target population to the preventive regimens offered (Ayala and Elder 2011, Neff 2011). No pre-testing or pilot testing was made to evaluate the acceptability of the intervention regimen in this study, but the regimens that were offered were generally accepted standard dental care procedures. In the case of fidelity, it was not possible to control the level of fidelity among the participants in the intervention group to the interventions recommended. This problem has also been observed in a current five-year oral health intervention study in a nursing home setting (De Visschere et al. 2011).

6.2.6 Study design

More attention has been placed on oral health-promoting activities among older people, and high-quality studies of adequate duration are required to determine the effect of these activities (McGrath et al. 2009).

The parent GeMS study included other components, such as medical treatment and medication (by a medical doctor), health counselling and managing care services (by a study nurse), nutrition counselling (by a nutritionist), physical and mobility improvement (by a physiotherapist) intervention. It is difficult to assess the effect these might have had on the oral intervention study, but in general they all probably had an activating impact on the life of the participants. It can be speculated that improved nutrition, for instance, may have had a positive effect on the empowerment of the participants to better handle oral self-care.

In an independent oral health intervention study, without other concomitant interventions (targeted for example at nutrition, mobility and functioning), the possibility of biases due to other interventions can be avoided, so that they do not interfere with the results of the oral health intervention. The possible contamination between the groups could have been eliminated better if the examinations of the intervention and control groups had been started at the same time. Contamination could also have been better avoided had the participants of the control been from a different locality.

Ideally, the participants would have been allocated according to whether they had their own natural teeth or not. Among the very old, many socioeconomic, attitudinal or behavioural background factors related to being dentate can interfere with the study results. Finally, the maximum effects of intervention would probably become better manifest among participants who all suffer from poor oral health and have a strong need for preventive oral health care.

7 Summary

The results of this study showed that dental diseases and oral health problems are common among older people and that four out of five of the dentate subjects and more than half of the edentulous subjects with full dentures required preventive oral health care. Besides being dentate or having a removable partial denture, the need for preventive oral health care associated with non-oral conditions, such as high comorbidity and being frail or pre-frail.

The study also showed that oral health and health behaviour could be improved, although the need for preventive care remained high and oral diseases were still common at the end of the study. Observed changes between the intervention and control group were quite small, however, indicating that the improvements cannot be attributed solely to the preventive oral health care measures that were offered to the participants of the intervention group.

This study also suggested that community-dwelling older people with poor functional ability are at risk of inadequate oral self-care; toothbrushing and toothpaste use twice a day was less common and the amount of residual dental plaque was high among these subjects. Poor functional ability, but not handgrip strength, appeared to be an important determinant of oral self-care.

The results also showed that the use of regular dental health care services was fairly low; 58% of the dentate and 3% of the edentulous subjects used dental health care services regularly, indicating a gap between the need for preventive oral care and the use of preventive oral care services.

Among the study population, more than one in four participants preferred a home visit by the dentist. Those who preferred home visits were more likely to have impaired cognition and poorer functional ability and were more often low users of health care services than those who preferred to pay a visit to the dental clinic, indicating that those who are low users of primary health care and oral health care services could be reached by delivering dental health care services at home.

8 Clinical implications

A comprehensive approach to older people's circumstances and health is needed for successful preventive oral health care. At present, dental professionals do not have easy access to relevant information on the cognitive, functional or physical status of old people, even though such information is important for understanding, implementing and managing preventive oral health care. From a comprehensive point of view, oral health should also be assessed as part of geriatric assessments. Otherwise important aspects of health are missed. Health care personnel and dental care staff should co-operate more closely to guarantee good care for old people.

The results of this study showed that the overall oral health behaviour and oral health among old people living at home can be improved by preventive oral health care. The key elements in improving oral health appear to be a profound clinical oral examination including obtaining information on non-oral health, and providing information and counselling to the patients.

Only one third of the study participants had used regular dental health care services before the study. The findings suggest that there is an urgent need to address the inequalities in oral health care and to get older people into regular dental health services. Based on the results of this study, appropriate assistance in oral self-care should be organized for old people who are in need of help. The delivery of dental health care services to the homes of old people also seems to be important.

Despite all efforts targeted especially at the participants in the intervention group, in the final examination, less than half of the participants had good dental hygiene and two thirds good denture hygiene. Since the removal of dental and denture plaque is known to be the most important preventive measure to reduce oral diseases, older people should be regularly followed up and the quality of oral-self-care should be regularly checked and appropriate aid given. Also the changes in health in terms of frailty status, such as weight loss or low physical activity, which can be inquired or observed by dental professionals, should be taken as indicators of possible oral health risks.

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KAIJA KOMULAINEN
*Oral Health Promotion among
Community-Dwelling
Older People*

The proportion of old people is growing fast. This is a challenge to health care systems in the form of a greater need for dental care and emphasizes the implementation of preventive care. This study produced evidence on the effect of preventive oral health care among old people living at home. Although the oral health of old people can be improved, the need for preventive care and the presence of oral diseases remained quite high. The old people need possible aid in oral self-care and regular dental care by professionals and to the part of the old people the oral health services need to be brought home.



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