



*Impact of oral status on
general health of elderly*

Mieke Bakker

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rijksuniversiteit
 groningen

Impact of oral status on general health of elderly

Proefschrift

ter verkrijging van de graad van doctor aan de
 Rijksuniversiteit Groningen
 op gezag van de
 rector magnificus prof. dr. C. Wijmenga
 en volgens besluit van het College voor Promoties.

De openbare verdediging zal plaatsvinden op

woensdag 9 juni 2021 om 16.15 uur

door

Mieke Henriëtte Bakker

geboren op 14 september 1991
 te Coevorden

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Funding

The research presented in this thesis was performed at the Department of Oral and Maxillofacial Surgery, University Medical Center Groningen, the Netherlands.

This research was financially supported by grants of the 'Stichting Bevordering Tandheelkundige Kennis / Nederlands Tijdschrift voor Tandheelkunde', the Oral and Maxillofacial Surgery Research Fund 'Boeringstichting', and the 'Nederlandse Vereniging voor Orale Implantologie'.

Colofon

Cover illustration: Sander Steeman

Lay-out: Saar de Vries

Printing: Van der Eems

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Chapter 1

General introduction

General introduction

The population of elderly in the Netherlands is growing rapidly. According to estimates, the number of people aged 65 and over will increase by 55% in 2040, resulting in 4.8 million elderly in a total population of 18 million.¹ The ageing of the Dutch population will have a major impact on the healthcare system because most elderly eventually become frail and care-dependent. The number of elderly with a natural dentition or dental implants is also growing rapidly due to major improvements in dental awareness and dental care over the last 50 years. Until the 1960s, oral hygiene was not a daily activity for most people, and extracting teeth in case of tooth decay or pain complaints was commonplace. Nowadays, most people in the Netherlands retain their natural dentition due to technical improvements in dentistry and a positive change in attitudes towards oral health.² Brushing your teeth with fluoride toothpaste and visiting your dentist regularly have become normal practice and is essential to maintain good oral health (Figure 1). However, this does not apply to elderly aged ≥ 75 years, as a large proportion of this group, especially the frail elderly, are at risk of discontinuing their visits to the dentist.³



Figure 1: Good oral health in an 86-year-old patient

Several barriers have been identified that might prevent elderly from visiting the dentist. These barriers include mobility problems due to poor general health, poor accessibility of the dental office, health problems that are in need of more urgent care, financial stress, cognitive impairment and lack of awareness of the importance of oral health.^{3,4} When elderly retain their natural dentition until high age and oral care has been neglected, oral pathologies such as caries, periodontal decay, fractured teeth and dry mouth are frequently seen (Figure 2), and they often experience oral pain. However, it is unclear how many community-dwelling elderly experience oral pain and if they have easy access to dental care or the ability to deal with their dental care needs. In other words, are they able to visit a dental practice when they experience oral pain? Greater insight into how elderly deal with their dental care needs is important as many community-dwelling elderly experience oral health problems, including oral pain.⁵

As previously mentioned, improvements in dental care have resulted in a growing proportion of elderly who retain a natural dentition until high age. This shift in oral status is reflected by the decrease in the number of edentulous elderly with



Figure 2a and 2b: Poor oral health and oral function in an 82-year-old patient

conventional dentures in the last 20 years.⁶ In 2000, 51% of the Dutch elderly between 65 and 75 years of age and 70% of the elderly aged ≥ 75 years were edentulous. In 2018, these percentages have dropped to 15% and 39%, respectively.⁷ When elderly become edentulous and experience denture problems, dental implants are often placed to retain an overdenture (implant-retained overdenture: IOD). This treatment option can be considered as very favorable, because oral function (especially chewing ability) and quality of life are significantly better in elderly wearing IODs when compared to elderly wearing conventional dentures.^{2,8} Although placement of dental implants to support a mandibular overdenture is regarded a safe and predictable treatment, little is known about the long-term performance (≥ 10 years of follow-up) of IODs, especially in elderly who become frail over time. Frail elderly are at risk of developing cognitive and physical disabilities, and multimorbidity and polypharmacy are common in this population. It is unknown, however, whether age-related decline in general health, and the associated decline in oral self care and dental visits, have impact on peri-implant health in elderly patients.

As the population ages, the risk of becoming malnourished increases as well. Poor oral health, especially when teeth are fractured or lost, and pain and chewing complaints have been shown to be a risk factor for malnutrition in institutionalized elderly.⁹ It is unclear whether oral health problems, edentulousness and health-related quality of life also pose a risk for malnutrition in community-dwelling elderly. It is possible that nutritional status is also affected by the oral status of elderly. For example, edentulous elderly with conventional dentures often tend to choose foods that are easy to chew, such as refined carbohydrates and fats, instead of harder, more fibrous foods.¹⁰⁻¹² This might result in malnutrition, but neither the potential association between oral status and malnutrition nor the potentially positive effect of wearing an IOD have been confirmed in published studies.

Furthermore, very little information is available on the general health of elderly who are provided with an IOD. Consequently, there is a need to determine whether general health status of elderly (aged ≥ 75 years) with an IOD differs from that of elderly with a natural dentition or from those wearing a conventional denture. A cross-sectional study involving community-dwelling elderly showed that elderly with IODs have better general health outcomes and are less frail than elderly with conventional dentures.⁵ It has not been confirmed, however, whether these favorable associations are already present when elderly receive their IODs. Therefore,

there is need to determine the general health status of elderly receiving IODs compared with the general health status of large, non-selected Dutch cohorts of elderly with either a natural dentition or conventional denture.

If the general health status of elderly IOD wearers is shown to be similar to that of elderly with a natural dentition and better than the general health of elderly wearing a conventional denture, it will be interesting to follow these groups of elderly with differing oral status as part of a longitudinal study. Although cross-sectional studies have shown that elderly with a natural dentition or an IOD have better general health outcomes and quality of life,^{2,5} no longitudinal studies have compared the general health status of a large (big data), unbiased cohort of Dutch elderly with differing oral status over a longer period of time. Such cohort studies with large groups can provide insight into whether retaining a natural dentition or receiving an IOD remain beneficial for elderly over a longer period in terms of general health outcomes.

Aim of this study

The general aim of the research described in the PhD thesis was to assess the association between oral status and general health, frailty and quality of life, nutritional status, oral pain complaints and dental care utilization in elderly (aged ≥ 75 years). The specific aims were to assess the following:

- The general health status, healthcare costs and dental care use between elderly with a natural dentition and edentulous elderly wearing an implant-retained or conventional denture over a period of eight years (2009–2016) (**Chapter 2**).
- The general health status of elderly edentulous patients at the time they receive an implant-retained overdenture compared with elderly with a natural dentition or conventional denture (**Chapter 3**).
- The long-term (>20 year) clinical, radiographic and patient-reported outcomes, such as frailty and quality of life, of an elderly population with mandibular implant-supported overdentures (**Chapter 4**).
- The ability of community-dwelling elderly to deal with their dental care needs, in particular when reporting oral pain (**Chapter 5**).
- Whether oral status, oral health problems and health-related quality of life are associated with malnutrition in community-dwelling elderly (**Chapter 6**).

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Chapter 2

General health, healthcare costs and dental care use of elderly with a natural dentition, implant-retained overdenture or conventional denture

Mieke H Bakker

Arjan Vissink

Gerry M Raghoobar

Lilian L Peters

Anita Visser

This chapter is an edited version of the submitted manuscript

Abstract

Background Cross-sectional studies have shown that elderly with a natural dentition have better general health than edentulous elderly, but this has not been confirmed in studies with longitudinal design.

Materials and methods This longitudinal study with a follow-up of eight years aimed to assess differences in general health, healthcare costs and dental care use between elderly with a natural dentition and edentulous elderly wearing an implant-retained or conventional denture. Based on data of all national insurance claims for dental and medical care from Dutch elderly (aged ≥ 75 years) general health outcomes (chronic conditions, medication use), healthcare costs and dental care use could be assessed of three groups of elderly, viz. elderly with a natural dentition, elderly with a conventional denture and elderly with an implant-retained overdenture.

Results At baseline (2009), a total of 168 122 elderly could be included (143 199 with a natural dentition, 18 420 with a conventional denture, 6 503 with an implant-retained overdentures). Here we showed that after eight years follow-up elderly with a natural dentition had more favorable general health outcomes (fewer chronic conditions, less medication use), lower healthcare costs and lower dental costs – but higher dental care use – than edentulous elderly. At baseline the general health of elderly with an implant-retained overdentures resembled the profile of elderly with a natural dentition, but over time their general health problems became comparable to elderly with conventional dentures.

Conclusions It was concluded that elderly with a natural dentition had significant better health and lower healthcare costs compared to edentulous elderly (with or without dental implants).

Introduction

For decades, the prevalence of edentulism has declined: more and more elderly retain their natural dentition until advanced age. Among elderly aged ≥ 75 years, the prevalence of edentulism in the United States decreased from 67.3% in 1957–1958 to 24.1% in 2009–2012.¹ European countries showed a similar decrease.^{2,3} There are, however, large differences between countries, as well as differences between rural areas and cities.² In Europe, the prevalence of edentulism among adults ≥ 65 years old ranges from 69% in Albania to 15% in Austria.^{4,5} This decline of edentulism is primarily the result of improved dental care and the changing attitudes towards oral health and dental care over the last four decades.² Previous studies have suggested that maintaining a natural dentition is beneficial. Cross-sectional studies have shown that elderly with a natural dentition have better general health.^{6,7} Elderly who retain their natural dentition until late in life have a higher quality of life and better oral function than edentulous elderly.⁷⁻⁹

When elderly become edentulous and their masticatory function decreases, this often affects their diet.^{10,11} Hard, fibrous food that is difficult to masticate is replaced by softer food,^{12,13} often with higher levels of cholesterol and saturated fats. As a consequence, their nutritional status and subsequently their general health are at risk, leading to a higher prevalence of obesity and an increased risk for cardiovascular disease.^{14,15} Furthermore, elderly with good masticatory performance have higher scores on general cognition and verbal fluency than elderly with limited masticatory ability.¹⁶ Next, edentulousness can limit social interaction and lead to avoidance of social activities.¹⁴ Considering the above aspects, several researchers have suggested that edentulousness should be viewed as a disability and that it may even be a predictor of various health issues and shortened longevity.^{17,18} Oral function in edentulous patients suffering from ill-fitting dentures and poor oral function can be regained by placing dental implants that retain an overdenture. Elderly with implant-retained overdentures (IODs) show significantly better scores on oral function, denture satisfaction and oral health-related quality of life than elderly with conventional dentures.⁹⁻²² This is the major reason that IODs are now considered as the first choice for treatment of edentulous patients with poor oral function.^{23,24}

Nearly all research on oral function in edentulous elderly has been performed in cross-sectional setting. Few studies with a long-term follow-up have been published on edentulousness and general health or on comparisons between

edentulous elderly and those with a natural dentition. As a result, little is known whether elderly with a natural dentition have better general health over the long term than edentulous elderly wearing an implant-retained or conventional denture. The aim of this study was to assess differences in general health, healthcare costs and dental care use between elderly with a natural dentition and edentulous elderly wearing an implant-retained or conventional denture over a period of eight years. Differences in general health (presence of chronic conditions, medication use and prescribed medication, healthcare use), healthcare costs and dental care use between those with a natural dentition and edentulous elderly wearing an implant-retained or conventional denture were monitored during this period.

Materials and methods

This study was performed in collaboration with Vektis, an organization that warehouses the data on all health care declarations in the Netherlands. The cohort of elderly aged ≥ 75 years was formed in 2009 and subsequently followed for 7 years (2010–2016). Formation of the cohort in 2009 was done according to the dental indicators shown in Table 1. This way the elderly could be grouped in one of three categories: natural dentition, conventional denture or IOD. Fixed implant-retained dentures are rarely seen in the Netherlands, due to the high reimbursements on removable implant-retained overdentures and are therefore not taken into account.

During this period each year the following data were collected:

- Visits to medical professionals, defined as dentists, general practitioners (GP), medical specialists (hospital), physiotherapists, mental health practitioners or allied health professional other than a physiotherapist (i.e. dietician).
- Admission to a nursing home. Data from 2012–2016 (data from previous years were not available).
- Healthcare costs according to provider: dentist, GP, hospital, pharmacology, physiotherapy, mental health, paramedical care, nursing home.
- Type of medication received: antithrombotics, bisphosphonates, inhalation corticosteroids, antihypertensives, antidepressants.
- Total number of medication received: no drugs used, 1–4 drugs or ≥ 5 drugs (polypharmacy).²⁵ Only antithrombotics, bisphosphonates, inhalation cortico-

Table 1: Indicators used by Vektis for the cohort of elderly (≥ 75 years) in 2009.

	Elderly with a natural dentition	Elderly with a conventional denture	Elderly with an implant-retained overdenture
Dental care	Received dental care in 2009	Received a removable upper and lower denture in 2009	Received dental implants and an implant-retained removable overdenture in upper and/or lower jaw in 2009
Dental treatment	Received one of following treatments: <ul style="list-style-type: none"> - Endodontic treatment - Tooth extraction/surgery - Fixed dental prosthesis (without implants) - Periodontal surgery - Direct dental restoration 	Received one of following treatments: <ul style="list-style-type: none"> - New complete denture - Relining or rebasing of upper <u>and</u> lower denture 	Received the following treatments: <ul style="list-style-type: none"> - Placement of dental implants - Implant-retained overdenture

steroids, antihypertensives and antidepressants were used to determine the number of medication received.

- Medical conditions: asthma, chronic obstructive pulmonary disease (COPD), cancer, high cholesterol, diabetes, cardiac disease, hypertension, kidney disease, Parkinson's disease, rheumatoid arthritis. The diagnosis was based on prescribed medication according to a pharmacy-based cost group model,²⁶ which means that specific types of medication prescribed in a base year is used as a marker for chronic conditions.

Furthermore, information regarding elderly who died, elderly who changed oral status (for instance: from conventional denture to IOD) was included and socio-economic status (SES) was indexed based on data provided by the Netherlands Institute for Social Research.²⁷ The following variables were used to determine SES: average income, percentage of citizens with low income, percentage of citizens with low education level and the percentage of unemployed citizens. SES scores were categorized at municipal level into low, middle and high SES. Elderly participants who changed oral status during this study and elderly who died were then excluded for further research.

This study was performed in collaboration with Vektis, an organization that collects data on health insurance claims in the Netherlands. The year 2009 was selected as baseline because this was the first year the coverage of the Vektis database for health insurance claims at health insurance companies was >90% for medical specialties, which provided acceptable insight into healthcare use in the Netherlands. The year 2016 was selected as the final year in this study because Vektis made these data available in June 2018.

Statistics

Descriptive statistics were used to report demographic characteristics, chronic conditions, medication use, prescribed medication and healthcare use. At baseline (2009) dental care use was 100% for all groups, as this was an inclusion criterion. Therefore, the year 2009 was excluded from the analyses for dental care use. For each year, Chi² tests and Fisher's exact tests were used to analyze differences between elderly with a natural dentition, conventional denture and IOD. The Vektis dataset specified the total amount of healthcare costs per profession for the total group. To determine average healthcare costs on the individual level, healthcare costs were divided by the number of individuals who had accessed this type of medical specialty in each year. Statistical differences between groups were determined using Kruskal-Wallis test. SPSS IBM Statistics version 23.0 (SPSS, Chicago, IL, USA) was used for statistical analysis of the results.

Due to the large number of included elderly, almost all differences between groups are statistically significant ($p < 0.001$). This phenomenon is commonly seen in big data studies; even the smallest differences are statistically significant.²⁸ However, not every significant difference is relevant to daily practice. Therefore, this study did not focus on statistically significant differences at one point, but rather on the (visible) trends throughout the period 2009–2016. There was a special interest in figures that varied or increased by $\geq 5\%$.

Results

Population

At baseline (2009), a total of 168 122 elderly were included. In this population, 82% ($n=143 199$) elderly had a natural dentition, 14% ($n=24 923$) a conventional

denture, and 4% ($n=6 503$) an IOD. The majority of the elderly (85%, $n=147 931$) were aged between 75 and 85 years. Edentulous elderly with a conventional denture were on average older than those with a natural dentition and IOD. At baseline, 19% of elderly ≥ 85 years were edentulous with a conventional denture, 11% had a natural dentition and 6% had an IOD. Elderly with a natural dentition had a higher SES on average than edentulous elderly. Age and SES were significantly different between the three subgroups. Characteristics of the study population are presented in Table 2. A more detailed version of this table is included in Supplementary Data Table 1.

General health

An overview of general health and chronic conditions is presented in Table 3. Almost all variables were significantly different between the three groups, except for variables with low prevalence (<5%), which were cancer, Parkinson's disease and rheumatoid arthritis. Clinically relevant differences (i.e. difference in prevalence $\geq 5\%$) were found for cardiac diseases and diabetes (Figures 1a and 1b). Edentulous elderly with a conventional denture were more often diagnosed with these chronic conditions than those with a natural dentition. At baseline, the general health of elderly with an IOD was similar to those with a natural dentition (Figures 1a and 1b). During the seven-year follow-up period, the prevalence of cardiac disease and diabetes showed an increase for elderly with an IOD, while this figure remained stable for the other groups. At the end of follow-up, the general health of elderly with an IOD was similar to the profile of elderly with a conventional denture.

Medication use was highest for elderly with a conventional dentures and IOD at baseline (Figure 1c) and the use of antithrombotics was substantially different between the three groups. The elderly with an IOD showed a rapid increase in medication use (especially polypharmacy) and use of antithrombotics; after eight years, this resulted in a level of medication use comparable to elderly with a conventional denture. Medication used of elderly with a natural dentition and conventional denture increased slowly during this period.

Dental care and healthcare use

Dental care use differed between all oral status groups. At the end of the follow-up, edentulous elderly had significantly lower dental care use (11% for conventional denture and 26% for IOD) than elderly with a natural dentition

Table 2: Changes in the characteristics of Dutch elderly stratified on oral health status in 2009 (baseline) as a function of time.

	2009 (baseline)			2012		
	ND ¹	CD ²	IOD ³	ND	CD	IOD
	143 199	18 420	6 503	128 100	14 918	5 994
Demographic characteristics	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Age						
75–85 years	127 017 (89%)	14 824 (81%)	6 090 (94%)	99 627 (78%)	10 130 (68%)	5 057 (84%)
≥85 years	16 182 (11%)	3 596 (19%)	413 (6%)	28 473 (22%)	4 788 (32%)	937 (16%)
Socioeconomic status⁴						
Low	34 846 (24%)	5 413 (29%)	1 784 (28%)	29 291 (23%)	4 063 (27%)	1 576 (26%)
Middle	56 101 (39%)	7 658 (42%)	2 806 (43%)	50 546 (39%)	6 247 (42%)	2 649 (44%)
High	52 252 (37%)	5 349 (29%)	1 913 (29%)	48 263 (38%)	4 608 (31%)	1 769 (30%)
Chronic conditions						
Asthma	5 152 (4%)	815 (4%)	308 (5%)	4 715 (4%)	634 (4%)	293 (5%)
Cancer	95 (<1%)	18 (<1%)	9 (<1%)	543 (<1%)	62 (<1%)	32 (1%)
Cardiac disease	18 914 (13%)	4 019 (22%)	882 (14%)	19 557 (15%)	3 334 (22%)	1 002 (17%)
COPD ⁵	5 357 (4%)	1 373 (8%)	423 (7%)	5 254 (4%)	1 122 (8%)	450 (8%)
Diabetes	12 665 (9%)	2 581 (14%)	723 (11%)	11 646 (9%)	2 003 (13%)	731 (12%)
High cholesterol	21 294 (15%)	2 425 (13%)	1 137 (18%)	20 930 (16%)	2 126 (14%)	1 124 (19%)
Hypertension	74 063 (52%)	10 296 (56%)	3 339 (51%)	68 236 (53%)	8 355 (56%)	3 295 (55%)
Kidney disease	571 (<1%)	127 (<1%)	31 (1%)	572 (<1%)	108 (<1%)	34 (<1%)
Parkinson's disease	1 398 (1%)	230 (1%)	83 (1%)	1 353 (1%)	170 (1%)	68 (1%)
Rheumatoid arthritis	948 (<1%)	143 (1%)	49 (1%)	1 016 (1%)	133 (<1%)	70 (1%)

	2014			2016		
	ND	CD	IOD	ND	CD	IOD
	113 420	12 241	5 438	97 196	9 830	4 763
Demographic characteristics	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Age						
75–85 years	76 791 (68%)	7 084 (58%)	4 042 (74%)	51 795 (53%)	4 363 (44%)	2 828 (59%)
≥85 years	36 629 (32%)	5 157 (42%)	1 396 (26%)	45 401 (47%)	5 466 (56%)	1 935 (41%)
Socioeconomic status⁴						
Low	36 091 (32%)	4 479 (37%)	1 977 (26%)	29 447 (30%)	3 463 (35%)	1 668 (35%)
Middle	45 941 (40%)	5 182 (42%)	2 378 (44%)	38 196 (39%)	4 102 (42%)	2 080 (44%)
High	31 388 (28%)	2 580 (21%)	1 083 (20%)	29 553 (31%)	2 265 (23%)	1 015 (21%)
Chronic conditions						
Asthma	4 104 (4%)	485 (4%)	258 (5%)	3 290 (3%)	368 (4%)	236 (5%)
Cancer	40 (<1%)	18 (<1%)	18 (<1%)	47 (<1%)	18 (<1%)	18 (<1%)
Cardiac disease	18 036 (16%)	2 790 (23%)	992 (18%)	15 866 (16%)	2 257 (23%)	916 (19%)
COPD ⁵	4 636 (4%)	906 (7%)	390 (7%)	3 805 (4%)	679 (7%)	341 (7%)
Diabetes	9 696 (9%)	1 546 (13%)	647 (12%)	7 703 (8%)	1 135 (12%)	558 (12%)
High cholesterol	19 242 (17%)	1 798 (15%)	1 074 (20%)	16 125 (17%)	1 439 (15%)	923 (19%)
Hypertension	59 236 (52%)	6 720 (55%)	2 973 (55%)	48 879 (50%)	5 138 (52%)	2 575 (54%)
Kidney disease	506 (<1%)	79 (1%)	41 (1%)	390 (<1%)	52 (<1%)	21 (<1%)
Parkinson's disease	1 156 (1%)	123 (1%)	51 (1%)	946 (1%)	75 (<1%)	31 (<1%)
Rheumatoid arthritis	797 (1%)	82 (1%)	52 (1%)	652 (1%)	59 (<1%)	44 (<1%)

Table 2: Continued

	2009 (baseline)			2012		
	ND ¹	CD ²	IOD ³	ND	CD	IOD
	143 199	18 420	6 503	128 100	14 918	5 994
Demographic characteristics	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Medication use						
0 drugs	35 588 (25%)	3 436 (19%)	1 570 (24%)	29 103 (23%)	2 847 (19%)	1 177 (20%)
1-4 drugs	95 713 (67%)	12 594 (68%)	4 391 (68%)	85 895 (67%)	9 997 (67%)	4 065 (68%)
5 or more drugs (polypharmacy)	11 898 (8%)	2 390 (13%)	542 (8%)	13 102 (10%)	2 074 (14%)	752 (12%)
Prescribed medication						
Antithrombotics	62 236 (44%)	9 498 (52%)	2 900 (45%)	61 734 (48%)	8 017 (54%)	3 037 (51%)
Antihypertensives	85 518 (60%)	12 303 (67%)	3 794 (58%)	80 343 (63%)	10 149 (68%)	3 861 (64%)
Antidepressants	12 528 (9%)	2 054 (11%)	690 (11%)	12 298 (10%)	1 663 (11%)	721 (12%)
Bisphosphonates	14 135 (10%)	1 866 (10%)	656 (10%)	12 960 (10%)	1 533 (10%)	661 (11%)
Corticosteroids	14 782 (10%)	2 713 (15%)	885 (14%)	13 193 (10%)	2 049 (14%)	865 (14%)
Healthcare consumption						
Dental care	143 199 (100%)	18 420 (100%)	6 503 (100%)	100 207 (78%)	1 429 (10%)	1 698 (28%)
General practitioner	141 371 (99%)	18 145 (99%)	6 442 (99%)	125 705 (98%)	14 394 (97%)	5 929 (99%)
Specialist care	128 444 (90%)	16 622 (90%)	6 008 (92%)	116 277 (91%)	13 331 (89%)	5 586 (93%)
Nursing home	-	-	-	15 110 (12%)	2 907 (20%)	546 (9%)
Mental health	5 989 (4%)	959 (5%)	246 (4%)	4 847 (4%)	583 (4%)	234 (4%)
Physiotherapy	12 426 (9%)	1 822 (10%)	526 (8%)	9 266 (7%)	1 084 (7%)	453 (8%)
Allied healthcare	6 774 (5%)	1 149 (6%)	352 (5%)	4 361 (3%)	611 (4%)	221 (4%)
Mortality	1 864 (1%)	1 864 (1%)	540 (3%)	6 360 (5%)	1 269 (9%)	262 (4%)

¹ND: Natural dentition²CD.: Conventional denture³IOD: Implant-retained overdenture

	2014			2016		
	ND	CD	IOD	ND	CD	IOD
	113 420	12 241	5 438	97 196	9 830	4 763
Demographic characteristics	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Medication use						
0 drugs	25 900 (23%)	2 484 (20%)	1 041 (19%)	22 855 (24%)	2 126 (22%)	930 (20%)
1-4 drugs	75 723 (67%)	7 981 (65%)	3 669 (67%)	64 519 (66%)	6 354 (65%)	3 215 (68%)
5 or more drugs (polypharmacy)	11 797 (10%)	1 776 (15%)	728 (13%)	9 822 (10%)	1 350 (14%)	618 (13%)
Prescribed medication						
Antithrombotics	56 648 (50%)	6 713 (55%)	2 939 (54%)	49 901 (51%)	5 409 (55%)	2 666 (56%)
Antihypertensives	71 375 (63%)	8 266 (68%)	3 556 (65%)	60 884 (63%)	6 568 (67%)	3 089 (65%)
Antidepressants	11 403 (10%)	1 404 (11%)	700 (13%)	9 944 (10%)	1 144 (12%)	617 (13%)
Bisphosphonates	10 553 (9%)	1 177 (10%)	581 (11%)	8 057 (8%)	815 (8%)	484 (10%)
Corticosteroids	11 052 (10%)	1 555 (13%)	747 (14%)	8 806 (9%)	1 132 (12%)	617 (13%)
Healthcare consumption						
Dental care	81 536 (72%)	1 391 (11%)	1 578 (29%)	64 833 (67%)	1 034 (11%)	1 252 (26%)
General practitioner	109 721 (97%)	11 617 (95%)	5 303 (98%)	88 682 (91%)	8 703 (89%)	4 418 (93%)
Specialist care	101 835 (90%)	10 841 (89%)	5 017 (92%)	87 359 (90%)	8 634 (88%)	4 362 (92%)
Nursing home	13 249 (12%)	2 228 (18%)	528 (10%)	12 754 (13%)	1 882 (19%)	570 (12%)
Mental health	3 661 (3%)	391 (3%)	193 (4%)	2 781 (3%)	307 (3%)	146 (3%)
Physiotherapy	7 557 (7%)	772 (6%)	385 (7%)	6 454 (7%)	580 (6%)	347 (7%)
Allied healthcare	7 596 (7%)	910 (7%)	403 (7%)	9 121 (9%)	1 008 (10%)	433 (9%)
Mortality	7 091 (6%)	1 163 (10%)	287 (5%)	7 866 (8%)	1 203 (12%)	357 (8%)

⁴Socioeconomic status determined by average income, percentage of citizens with low income, percentage of with low education level and the percentage of unemployed citizens. SES scores were determined on municipal level, thereby categorizing the low, middle and high SES.²⁷⁵COPD: Chronic obstructive pulmonary disease

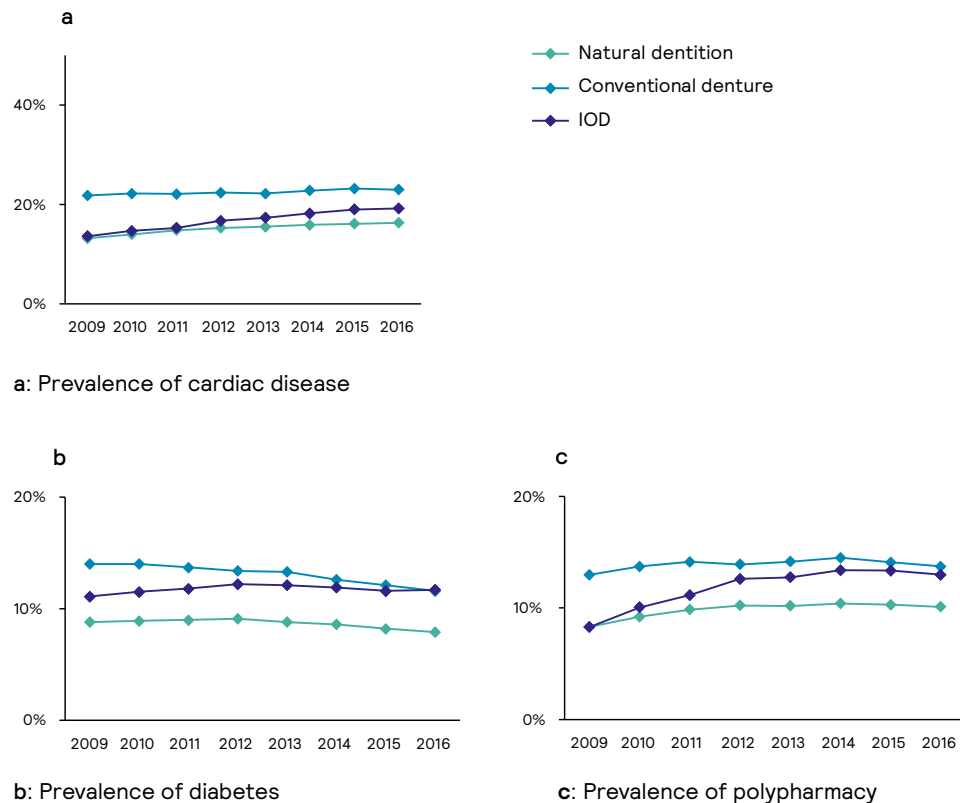


Figure 1. Prevalence of chronic conditions in elderly (aged ≥ 75 years) with differing oral status.

(67%) (Figure 2). Such differences were not found for healthcare use at general practitioners and medical specialists. These healthcare providers were visited by around 90% of the elderly from all groups. Nursing home admittance in the period 2012–2016 was highest for elderly with a conventional denture when compared to elderly with a natural dentition and IOD.

Healthcare costs

The healthcare costs per medical specialty are presented in Table 3 (a more detailed version is presented in Supplementary Data Table 2). Clear differences were found for dental care costs. Elderly with a natural dentition had the low-

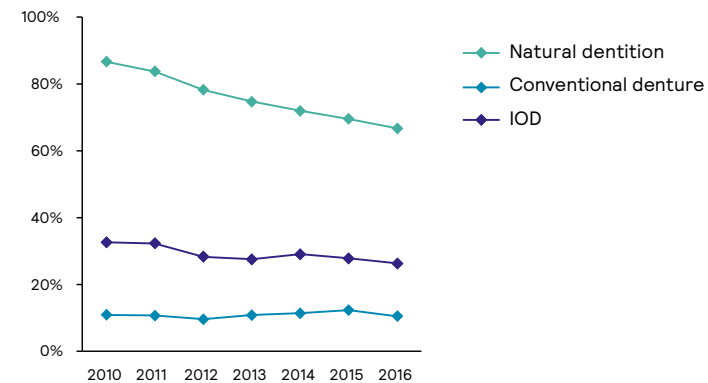


Figure 2: Use of dental care of elderly (aged ≥ 75 years) with differing oral status

est and most stable dental care costs throughout follow-up. Edentulous elderly, especially elderly with an IOD, had high costs at baseline when obtaining their new dentures, overdentures and dental implants, followed by a more stable period. Healthcare costs were highest for the edentulous population. Pharmaceutical costs were lowest for elderly with a natural dentition.

Discussion

In this cohort study differences in general health, healthcare costs and dental care use and costs between elderly with a natural dentition and edentulous elderly wearing an IOD or conventional denture were assessed. Edentulous elderly have higher prevalence of general health problems (cardiac disease, diabetes, nursing home admittance), increased medication use (polypharmacy, use of antithrombotics) and higher healthcare costs when compared to elderly with a natural dentition. Within the group of edentulous elderly, those with an IOD appeared to have a general health profile comparable to elderly with a natural dentition. Over time, however, their general health problems increased to a level comparable to elderly with a conventional denture.

General health between the groups differed significantly for cardiac disease, diabetes and polypharmacy and the use of antithrombotics. Elderly with a conven-

Table 3: Healthcare costs of Dutch elderly in the period 2009–2016.

Healthcare	2009 (baseline)			2012			2014			2016		
	ND ¹	CD ²	IOD ³	ND	CD	IOD	ND	CD	IOD	ND	CD	IOD
	n=	n=	n=	n=	n=	n=	n=	n=	n=	n=	n=	n=
	143 199	18 420	6 503	128 100	14 918	5 994	113 420	12 241	5 438	97 196	9 830	4 763
	€	€	€	€	€	€	€	€	€	€	€	€
Dental care	282	870	3 204	251	274	320	262	448	537	255	484	637
General practitioner	156	202	159	159	193	164	193	226	203	181	215	198
Specialist care	2 988	3 661	3 243	3 442	3 835	3 736	3 531	3 823	3 851	3 571	3 677	3 973
Nursing home	-	-	-	31 505	34 285	28 232	42 597	43 407	42 645	48 935	47 361	46 116
Mental health	3 345	4 246	4 395	3 026	3 363	3 615	3 726	4 236	3 377	3 697	3 593	4 817
Physiotherapy	1 010	1 158	947	1 066	1 116	1 034	1 184	1 202	1 149	1 219	1 204	1 157
Allied healthcare	231	265	203	356	413	337	277	275	271	264	269	267
Pharmacy	1 029	1 221	1 095	962	1 132	1 063	941	1 109	1 083	962	1 131	1 135

¹ND: Natural dentition²CD: Conventional denture³IOD: Implant-retained overdenture

tional denture showed the highest prevalence of chronic conditions and elderly with a natural dentition showed the lowest prevalence. Elderly with an IOD started at the level of elderly with a natural dentition, but during follow-up progressed to the level of edentulous elderly with a conventional denture. The increased prevalence of chronic conditions among the elderly was associated with increased use of polypharmacy and antithrombotics. Consequently, elderly with an IOD had both the largest increase in prevalence of chronic conditions and the largest increase in medication use and use of antithrombotics. Previous research shows comparable results regarding the general health outcomes of edentulous elderly with a conventional denture.¹⁴ Diabetes and cardiovascular disease are more prevalent among edentulous elderly.^{29,30}

Our finding that the initial prevalence of chronic conditions and medication use in elderly with an IOD is comparable to those with a natural dentition, is in line with the results from the cross-sectional study of Hoeksema et al.⁶ They also reported statistical differences in age between elderly with an IOD and conventional denture, next to the differences in frailty and complex care needs: elderly with an IOD were younger and showed better general health. In this study, however, it became clear that over time elderly with an IOD developed a general health profile comparable to elderly with a conventional denture, so their general health deteriorated. Previous research has shown that the lifestyles and diets of edentulous elderly are generally less conducive to health than those with a natural dentition.¹³ This is not only due to the loss of oral function, but also to the lower SES of most edentulous elderly,³¹ which is often related to a less healthy diet. Placing dental implants to retain a lower overdenture will result in improved oral function, but does not automatically lead to a healthier lifestyle.^{32,33} We believe that the elderly who receive an IOD represent a healthier subset of the edentulous elderly at the time they receive dental implants. However, over time their general health profile becomes increasingly similar to the edentulous elderly with a conventional denture, even though their oral function has been improved by placing dental implants. It is likely that the lifestyle accompanying edentulousness may have a negative effect on general health and that this negative effect cannot be reversed by placing dental implants.

Dental care use varied greatly among elderly depending on their oral status. In the period 2010–2016, 67% continued to visit the dentist after eight years, only 10% of the edentulous elderly visited the dentist and 30% of the elderly with an IOD. Comparing these results to other European countries, it becomes clear that overall dental attendance and use of preventive treatments of the Netherlands

is high and comparable to Sweden, Denmark, Germany and Switzerland.³⁴ In this study, only a small percentage of the elderly with a conventional denture or IOD continued to visit their dentist for routine checkups, although the guidelines for IODs advise annual recall visits to ensure good peri-implant health.^{35,36} In elderly with a natural dentition, there was a decrease in dental care utilization over time as well, although more gradually than among elderly with conventional dentures or IODs. The reason for this is unclear, but it is possible that the interest in oral health diminishes during aging as other health-related problems require more attention. Research in older adults has shown that an oral health problem (e.g. tooth loss) does not substantially influence their subjective oral health.³⁷ Although regular visits to the dentist decline during aging, visits to the general practitioner and specialist care do not, possibly because they are considered to be more important or more urgent.

Several differences in dental healthcare costs between the three groups were observed. Between 2009 and 2016, the costs for elderly with a natural dentition were the most stable and lowest, while the costs for elderly with a conventional denture or IOD were higher and fluctuated more. This difference is partially explained by the fact that elderly with a conventional denture and IOD received a new full denture at baseline. Elderly receiving an IOD, which are relatively expensive, incurred especially high costs at baseline. This is well-described in cost-effective studies, showing that IODs are generally 3 to 6 times as expensive as conventional dentures.^{38,39} Their dental costs remain quite high in the period 2010–2016, probably as a result of repair or replacement of their IODs. Throughout the follow-up period, elderly with a natural dentition also had the lowest costs for medication, general practitioner care and specialist care.

In this study elderly aged ≥ 75 years were included. Previously, it has been suggested that the definition of old age should be redefined from ≥ 65 years to ≥ 75 years, as current elderly are staying robust and active until higher age.⁴⁰ This study mainly focuses on general health outcomes. As prevalence of chronic diseases increases with age, it was decided to focus on the oldest proportion of elderly, with more chronic conditions and medication use, rather than including younger (healthier) elderly (aged 65–75 years).

Limitations

This study was based entirely on health care insurance claims. Therefore, elderly participants could only be categorized based on their received dental care

by their insurance claims at their insurance companies. No information could be obtained from elderly who did not claim dental care costs in the year 2009 with their healthcare insurer or about oral health and oral function. Therefore, this big data study represents a large part of the Dutch elderly population, but not the entire population. Information on peri-implant health, fitting of the dentures, oral pathologies (such as periodontitis or caries), oral function and sufficient functional tooth units was also unavailable. Oral health problems could therefore not be included.

Conclusions

The general health outcomes of elderly with a natural dentition are better (fewer chronic conditions, less medication use) and more stable than the outcomes of edentulous elderly with a conventional denture or IOD. Elderly with a natural dentition have higher dental care use, but lower healthcare costs than edentulous elderly. The general health of elderly with an IOD initially resembles that of elderly with a natural dentition, but over time their general health declines and becomes comparable to that of elderly with a conventional denture.

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Table 1 Supplementary Data: Characteristics of Dutch elderly persons stratified on oral health status, in the period 2009–2016.

	2009				2010			
	ND ¹	CD ²	IOD ³	p-value ⁴	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Demographic characteristics	143 199	18 420	6 503		140 088	17 618	6 427	
Age								
75–85 years	127 017 (89%)	14 824 (81%)	6 090 (94%)	≤0.001	119 528 (85%)	13 413 (76%)	5 855 (91%)	≤0.001
≥85 years	16 182 (11%)	3 596 (19%)	413 (6%)	≤0.001	20 560 (15%)	4 205 (24%)	572 (9%)	≤0.001
Socioeconomic status⁵								
Low	34 846 (24%)	5 413 (29%)	1 784 (28%)	≤0.001	34 004 (24%)	5 189 (29%)	1 775 (28%)	≤0.001
Middle	56 101 (39%)	7 658 (42%)	2 806 (43%)	≤0.001	54 924 (39%)	7 321 (42%)	2 770 (43%)	≤0.001
High	52 252 (37%)	5 349 (29%)	1 913 (29%)	≤0.001	51 160 (37%)	5 108 (29%)	1 882 (29%)	≤0.001
Chronic conditions								
Asthma	5 152 (4%)	815 (4%)	308 (5%)	≤0.001	5 076 (4%)	760 (4%)	309 (5%)	≤0.001
Cancer	95 (<1%)	18 (<1%)	9 (<1%)	0.04	700 (<1%)	78 (<1%)	36 (<1%)	0.45
Cardiac disease	18 914 (13%)	4 019 (22%)	882 (14%)	≤0.001	19 575 (14%)	3 918 (22%)	947 (15%)	≤0.001
COPD ⁶	5 357 (4%)	1 373 (8%)	423 (7%)	≤0.001	5 369 (4%)	1 299 (7%)	434 (7%)	≤0.001
Diabetes	12 665 (9%)	2 581 (14%)	723 (11%)	≤0.001	12 518 (9%)	2 457 (14%)	738 (11%)	≤0.001
High cholesterol	21 294 (15%)	2 425 (13%)	1 137 (18%)	≤0.001	21 431 (15%)	2 307 (13%)	1 176 (18%)	≤0.001
Hypertension	74 063 (52%)	10 296 (56%)	3 339 (51%)	≤0.001	73 004 (52%)	9 736 (55%)	3 372 (52%)	≤0.001
Kidney disease	571 (<1%)	127 (<1%)	31 (1%)	≤0.001	614 (<1%)	133 (1%)	30 (<1%)	≤0.001
Parkinson's disease	1 398 (1%)	230 (1%)	83 (1%)	≤0.001	1 430 (1%)	210 (1%)	79 (1%)	0.04
Rheumatoid arthritis	948 (<1%)	143 (1%)	49 (1%)	0.154	1 012 (1%)	145 (1%)	67 (1%)	0.01

	2011				2012			
	ND	CD	IOD	p-value	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Demographic characteristics	134 349	16 234	6 248		128 100	14 918	5 994	
Age								
75–85 years	109 917 (82%)	11 716 (72%)	5 507 (88%)	≤0.001	99 627 (78%)	10 130 (68%)	5 057 (84%)	≤0.001
≥85 years	24 432 (18%)	4 518 (28%)	741 (12%)	≤0.001	28 473 (22%)	4 788 (32%)	937 (16%)	≤0.001
Socioeconomic status⁵								
Low	32 484 (24%)	4 766 (29%)	1 725 (28%)	≤0.001	29 291 (23%)	4 063 (27%)	1 576 (26%)	≤0.001
Middle	52 773 (39%)	6 768 (42%)	2 702 (43%)	≤0.001	50 546 (39%)	6 247 (42%)	2 649 (44%)	≤0.001
High	49 092 (37%)	4 700 (29%)	1 821 (29%)	≤0.001	48 263 (38%)	4 608 (31%)	1 769 (30%)	≤0.001
Chronic conditions								
Asthma	4 940 (4%)	680 (4%)	312 (5%)	≤0.001	4 715 (4%)	634 (4%)	293 (5%)	≤0.001
Cancer	680 (1%)	69 (<1%)	34 (<1%)	0.47	543 (<1%)	62 (<1%)	32 (1%)	0.43
Cardiac disease	19 872 (15%)	3 593 (22%)	954 (15%)	≤0.001	19 557 (15%)	3 334 (22%)	1 002 (17%)	≤0.001
COPD ⁶	5 398 (4%)	1 241 (8%)	449 (7%)	≤0.001	5 254 (4%)	1 122 (8%)	450 (8%)	≤0.001
Diabetes	12 139 (9%)	2 225 (14%)	739 (12%)	≤0.001	11 646 (9%)	2 003 (13%)	731 (12%)	≤0.001
High cholesterol	21 466 (16%)	2 275 (14%)	1 176 (19%)	≤0.001	20 930 (16%)	2 126 (14%)	1 124 (19%)	≤0.001
Hypertension	71 148 (53%)	9 020 (56%)	3 354 (54%)	≤0.001	68 236 (53%)	8 355 (56%)	3 295 (55%)	≤0.001
Kidney disease	600 (<1%)	116 (1%)	42 (1%)	≤0.001	572 (<1%)	108 (<1%)	34 (<1%)	≤0.001
Parkinson's disease	1 432 (1%)	199 (1%)	65 (1%)	0.30	1 353 (1%)	170 (1%)	68 (1%)	0.57
Rheumatoid arthritis	1 012 (1%)	141 (1%)	69 (1%)	0.01	1 016 (1%)	133 (<1%)	70 (1%)	0.004

Table 1 Supplementary Data: 2009–2012.

	2009				2010			
	ND ¹	CD ²	IOD ³	p-value ⁴	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Medication use								
0 drugs	35 588 (25%)	3 436 (19%)	1 570 (24%)	≤0.001	33 456 (24%)	3 311 (19%)	1 394 (22%)	≤0.001
1–4 drugs	95 713 (67%)	12 594 (68%)	4 391 (68%)	≤0.001	93 713 (67%)	11 889 (67%)	4 386 (68%)	0.03
5 or more drugs	11 898 (8%)	2 390 (13%)	542 (8%)	≤0.001	12 919 (9%)	2 418 (14%)	647 (10%)	≤0.001
Prescribed medication								
Antithrombotics	62 236 (44%)	9 498 (52%)	2 900 (45%)	≤0.001	63 412 (45%)	9 224 (52%)	3 021 (47%)	≤0.001
Antihypertensives	85 518 (60%)	12 303 (67%)	3 794 (58%)	≤0.001	85 576 (61%)	11 896 (68%)	3 935 (61%)	≤0.001
Antidepressants	12 528 (9%)	2 054 (11%)	690 (11%)	≤0.001	12 743 (9%)	1 996 (11%)	736 (11%)	≤0.001
Bisphosphonates	14 135 (10%)	1 866 (10%)	656 (10%)	0.48	14 177 (10%)	1 837 (10%)	701 (11%)	0.07
Corticosteroids	14 782 (10%)	2 713 (15%)	885 (14%)	≤0.001	14 493 (10%)	2 593 (15%)	902 (14%)	≤0.001
Healthcare consumption								
Dental care	143 199 (100%)	18 420 (100%)	6 503 (100%)		121 242 (87%)	1 922 (11%)	2 098 (33%)	≤0.001
General practitioner	141 371 (99%)	18 145 (99%)	6 442 (99%)	0.002	136 698 (98%)	17 037 (97%)	6 308 (98%)	≤0.001
Specialist care	128 444 (90%)	16 622 (90%)	6 008 (92%)	≤0.001	126 580 (90%)	15 868 (90%)	5 971 (93%)	≤0.001
Nursing home	-	-	-		-	-	-	
Mental health	5 989 (4%)	959 (5%)	246 (4%)	≤0.001	6 399 (5%)	966 (5%)	296 (5%)	≤0.001
Physiotherapy	12 426 (9%)	1 822 (10%)	526 (8%)	≤0.001	13 342 (10%)	1 854 (11%)	659 (10%)	≤0.001
Allied healthcare	6 774 (5%)	1 149 (6%)	352 (5%)	≤0.001	7 734 (6%)	1 257 (7%)	416 (6%)	≤0.001
Mortality	1 864 (1%)	540 (3%)	83 (1%)	≤0.001	4 708 (3%)	1 257 (7%)	177 (3%)	≤0.001

	2011				2012			
	ND ¹	CD ²	IOD ³	p-value ⁴	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Medication use								
0 drugs	31 039 (23%)	3 062 (19%)	1 268 (20%)	≤0.001	29 103 (23%)	2 847 (19%)	1 177 (20%)	≤0.001
1–4 drugs	90 076 (67%)	10 876 (67%)	4 282 (69%)	0.03	85 895 (67%)	9 997 (67%)	4 065 (68%)	0.46
5 or more drugs	13 234 (10%)	2 296 (14%)	698 (11%)	≤0.001	13 102 (10%)	2 074 (14%)	752 (12%)	≤0.001
Prescribed medication								
Antithrombotics	63 095 (47%)	8 646 (53%)	3 055 (49%)	≤0.001	61 734 (48%)	8 017 (54%)	3 037 (51%)	≤0.001
Antihypertensives	83 546 (62%)	11 017 (68%)	3 926 (63%)	≤0.001	80 343 (63%)	10 149 (68%)	3 861 (64%)	≤0.001
Antidepressants	12 742 (9%)	1 832 (11%)	741 (12%)	≤0.001	12 298 (10%)	1 663 (11%)	721 (12%)	≤0.001
Bisphosphonates	13 694 (10%)	1 681 (10%)	689 (11%)	0.085	12 960 (10%)	1 533 (10%)	661 (11%)	0.07
Corticosteroids	13 930 (10%)	2 290 (14%)	879 (14%)	≤0.001	13 193 (10%)	2 049 (14%)	865 (14%)	≤0.001
Healthcare consumption								
Dental care	112 486 (84%)	1 747 (11%)	2 018 (32%)	≤0.001	100 207 (78%)	1 429 (10%)	1 698 (28%)	≤0.001
General practitioner	132 483 (99%)	15 743 (97%)	6 206 (99%)	≤0.001	125 705 (98%)	14 394 (97%)	5 929 (99%)	≤0.001
Specialist care	122 139 (91%)	14 597 (90%)	5 803 (93%)	≤0.001	116 277 (91%)	13 331 (89%)	5 586 (93%)	≤0.001
Nursing home	-	-	-		15 110 (12%)	2 907 (20%)	546 (9%)	≤0.001
Mental health	6 255 (5%)	827 (5%)	305 (5%)	≤0.001	4 847 (4%)	583 (4%)	234 (4%)	0.69
Physiotherapy	12 753 (9%)	1 583 (10%)	612 (10%)	≤0.001	9 266 (7%)	1 084 (7%)	453 (8%)	0.64
Allied healthcare	8 226 (6%)	1 200 (7%)	441 (7%)	≤0.001	4 361 (3%)	611 (4%)	221 (4%)	≤0.001
Mortality	5 461 (4%)	1 253 (8%)	254 (4%)	≤0.001	6 360 (5%)	1 269 (9%)	262 (4%)	≤0.001

Table 1 Supplementary Data: 2013–2016.

	2013				2014			
	ND	CD	IOD	p-value	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Demographic characteristics	121 091	13 613	5 732		113 420	12 241	5 438	
Age								
75–85 years	88 531 (73%)	8 599 (63%)	4 570 (80%)	≤0.001	76 791 (68%)	7 084 (58%)	4 042 (74%)	≤0.001
≥85 years	32 560 (27%)	5 014 (37%)	1 162 (20%)	≤0.001	36 629 (32%)	5 157 (42%)	1 396 (26%)	≤0.001
Socioeconomic status²								
Low	27 652 (22%)	3 705 (27%)	1 490 (26%)	≤0.001	36 091 (32%)	4 479 (37%)	1 977 (26%)	≤0.001
Middle	47 885 (40%)	5 724 (42%)	2 535 (44%)	≤0.001	45 941 (40%)	5 182 (42%)	2 378 (44%)	≤0.001
High	45 554 (38%)	4 184 (31%)	1 707 (30%)	≤0.001	31 388 (28%)	2 580 (21%)	1 083 (20%)	≤0.001
Chronic conditions								
Asthma	4 408 (4%)	570 (4%)	271 (5%)	≤0.001	4 104 (4%)	485 (4%)	258 (5%)	≤0.001
Cancer	482 (<1%)	50 (<1%)	33 (1%)	0.09	40 (<1%)	18 (<1%)	18 (<1%)	≤0.001
Cardiac disease	18 790 (16%)	3 026 (22%)	992 (17%)	≤0.001	18 036 (16%)	2 790 (23%)	992 (18%)	≤0.001
COPD ⁶	4 880 (4%)	988 (7%)	415 (7%)	≤0.001	4 636 (4%)	906 (7%)	390 (7%)	≤0.001
Diabetes	10 625 (9%)	1 805 (13%)	691 (12%)	≤0.001	9 696 (9%)	1 546 (13%)	647 (12%)	≤0.001
High cholesterol	20 270 (17%)	2 000 (15%)	1 089 (19%)	≤0.001	19 242 (17%)	1 798 (15%)	1 074 (20%)	≤0.001
Hypertension	63 825 (53%)	7 503 (55%)	3 138 (55%)	≤0.001	59 236 (52%)	6 720 (55%)	2 973 (55%)	≤0.001
Kidney disease	526 (<1%)	83 (1%)	34 (1%)	0.01	506 (<1%)	79 (1%)	41 (1%)	≤0.001
Parkinson's disease	1 281 (1%)	155 (1%)	59 (1%)	0.66	1 156 (1%)	123 (1%)	51 (1%)	0.84
Rheumatoid arthritis	848 (1%)	93 (1%)	62 (1%)	0.003	797 (1%)	82 (1%)	52 (1%)	0.080

	2015				2016			
	ND	CD	IOD	p-value	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Demographic characteristics	105 619	11 031	5 151		97 196	9 830	4 763	
Age								
75–85 years	64 678 (61%)	5 696 (52%)	3 513 (68%)	≤0.001	51 795 (53%)	4 363 (44%)	2 828 (59%)	≤0.001
≥85 years	40 941 (39%)	5 335 (48%)	1 638 (32%)	≤0.001	45 401 (47%)	5 467 (56%)	1 935 (41%)	≤0.001
Socioeconomic status²								
Low	32 024 (30%)	3 891 (35%)	1 816 (35%)	≤0.001	29 447 (30%)	3 463 (35%)	1 668 (35%)	≤0.001
Middle	41 591 (40%)	4 624 (42%)	2 260 (44%)	≤0.001	38 196 (39%)	4 102 (42%)	2 080 (44%)	≤0.001
High	32 004 (30%)	2 516 (23%)	1 075 (21%)	≤0.001	29 553 (31%)	2 265 (23%)	1 015 (21%)	≤0.001
Chronic conditions								
Asthma	3 802 (4%)	444 (4%)	235 (5%)	≤0.001	3 290 (3%)	368 (4%)	236 (5%)	≤0.001
Cancer	46 (<1%)	27 (<1%)	9 (<1%)	≤0.001	47 (<1%)	18 (<1%)	18 (<1%)	≤0.001
Cardiac disease	16 983 (16%)	2 554 (23%)	977 (19%)	≤0.001	15 866 (16%)	2 257 (23%)	916 (19%)	≤0.001
COPD ⁶	4 239 (4%)	808 (7%)	364 (7%)	≤0.001	3 805 (4%)	679 (7%)	341 (7%)	≤0.001
Diabetes	8 640 (8%)	1 339 (12%)	597 (12%)	≤0.001	7 703 (8%)	1 135 (12%)	558 (12%)	≤0.001
High cholesterol	17 855 (17%)	1 609 (15%)	973 (19%)	≤0.001	16 125 (17%)	1 439 (15%)	923 (19%)	≤0.001
Hypertension	54 081 (51%)	5 911 (54%)	2 829 (55%)	≤0.001	48 879 (50%)	5 138 (52%)	2 575 (54%)	≤0.001
Kidney disease	455 (<1%)	67 (1%)	35 (1%)	0.002	390 (<1%)	52 (<1%)	21 (<1%)	0.16
Parkinson's disease	1 054 (1%)	94 (1%)	38 (1%)	0.07	946 (1%)	75 (<1%)	31 (<1%)	0.01
Rheumatoid arthritis	712 (1%)	63 (1%)	54 (1%)	0.002	652 (1%)	59 (<1%)	44 (<1%)	0.07

Table 1 Supplementary Data: 2013–2016.

	2013				2014			
	ND	CD	IOD	p-value	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Medication use								
0 drugs	27 701 (23%)	2 669 (20%)	1 119 (20%)	≤0.001	25 900 (23%)	2 484 (20%)	1 041 (19%)	≤0.001
1–4 drugs	81 049 (67%)	9 017 (66%)	3 882 (68%)	0.11	75 723 (67%)	7 981 (65%)	3 669 (67%)	0.001
5 or more drugs	12 341 (10%)	1 927 (14%)	731 (13%)	≤0.001	11 797 (10%)	1 776 (15%)	728 (13%)	≤0.001
Prescribed medication								
Antithrombotics	59 423 (49%)	7 376 (54%)	3 016 (53%)	≤0.001	56 648 (50%)	6 713 (55%)	2 939 (54%)	≤0.001
Antihypertensives	76 016 (63%)	9 220 (68%)	3 719 (65%)	≤0.001	71 375 (63%)	8 266 (68%)	3 556 (65%)	≤0.001
Antidepressants	11 812 (10%)	1 542 (11%)	695 (12%)	≤0.001	11 403 (10%)	1 404 (11%)	700 (13%)	≤0.001
Bisphosphonates	11 763 (10%)	1 361 (10%)	619 (11%)	0.02	10 553 (9%)	1 177 (10%)	581 (11%)	0.002
Corticosteroids	12 073 (10%)	1 844 (14%)	805 (14%)	≤0.001	11 052 (10%)	1 555 (13%)	747 (14%)	≤0.001
Healthcare consumption								
Dental care	90 470 (75%)	1 472 (11%)	1 574 (28%)	≤0.001	81 536 (72%)	1 391 (11%)	1 578 (29%)	≤0.001
General practitioner	118 104 (98%)	13 018 (96%)	5 630 (98%)	≤0.001	109 721 (97%)	11 617 (95%)	5 303 (98%)	≤0.001
Specialist care	108 696 (90%)	12 025 (88%)	5 299 (92%)	≤0.001	101 835 (90%)	10 841 (89%)	5 017 (92%)	≤0.001
Nursing home	13 527 (11%)	2 518 (18%)	537 (9%)	≤0.001	13 249 (12%)	2 228 (18%)	528 (10%)	≤0.001
Mental health	4 702 (4%)	557 (4%)	238 (4%)	0.31	3 661 (3%)	391 (3%)	193 (4%)	0.41
Physiotherapy	8 113 (7%)	891 (7%)	419 (7%)	0.14	7 557 (7%)	772 (6%)	385 (7%)	0.14
Allied healthcare	7 049 (6%)	910 (7%)	323 (6%)	≤0.001	7 596 (7%)	910 (7%)	403 (7%)	0.002
Mortality	6 883 (6%)	1 291 (9%)	294 (5%)	≤0.001	7 091 (6%)	1 163 (10%)	287 (5%)	≤0.001

¹ ND: Natural dentition² CD: Conventional denture³ IOD: Implant-retained overdenture

	2015				2016			
	ND	CD	IOD	p-value	ND	CD	IOD	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Medication use								
0 drugs	24 448 (23%)	2 308 (21%)	1 014 (20%)	≤0.001	22 855 (24%)	2 126 (22%)	930 (20%)	≤0.001
1–4 drugs	70 301 (67%)	7 169 (65%)	3 450 (67%)	0.003	64 519 (66%)	6 354 (65%)	3 215 (68%)	≤0.001
5 or more drugs	10 870 (10%)	1 554 (14%)	687 (13%)	≤0.001	9 822 (10%)	1 350 (14%)	618 (13%)	≤0.001
Prescribed medication								
Antithrombotics	53 525 (51%)	6 056 (55%)	2 849 (55%)	≤0.001	49 901 (51%)	5 409 (55%)	2 666 (56%)	≤0.001
Antihypertensives	66 275 (63%)	7 395 (67%)	3 338 (65%)	≤0.001	60 884 (63%)	6 568 (67%)	3 089 (65%)	≤0.001
Antidepressants	10 707 (10%)	1 267 (11%)	667 (13%)	≤0.001	9 944 (10%)	1 144 (12%)	617 (13%)	≤0.001
Bisphosphonates	9 306 (9%)	990 (9%)	542 (11%)	≤0.001	8 057 (8%)	815 (8%)	484 (10%)	≤0.001
Corticosteroids	10 194 (10%)	1 356 (12%)	682 (13%)	≤0.001	8 806 (9%)	1 132 (12%)	617 (13%)	≤0.001
Healthcare consumption								
Dental care	73 448 (70%)	1 360 (12%)	1 433 (28%)	≤0.001	64 833 (67%)	1 034 (11%)	1 252 (26%)	≤0.001
General practitioner	97 936 (93%)	10 007 (91%)	4 844 (94%)	≤0.001	88 682 (91%)	8 703 (89%)	4 418 (93%)	≤0.001
Specialist care	94 102 (89%)	9 711 (88%)	4 701 (91%)	≤0.001	87 359 (90%)	8 634 (88%)	4 362 (92%)	≤0.001
Nursing home	12 742 (12%)	1 995 (18%)	542 (11%)	≤0.001	12 754 (13%)	1 882 (19%)	570 (12%)	≤0.001
Mental health	3 078 (3%)	321 (3%)	161 (3%)	0.68	2 781 (3%)	307 (3%)	146 (3%)	0.26
Physiotherapy	6 964 (7%)	691 (6%)	365 (7%)	0.14	6 454 (7%)	580 (6%)	347 (7%)	0.003
Allied healthcare	8 410 (8%)	965 (9%)	420 (8%)	0.02	9 121 (9%)	1 008 (10%)	433 (9%)	0.01
Mortality	7 701 (7%)	1 166 (11%)	388 (8%)	≤0.001	7 866 (8%)	1 203 (12%)	357 (8%)	≤0.001

⁴ p-value: p-value determined between three subgroups⁵ Socioeconomic status determined by average income, percentage of citizens with low income, percentage of with low education level and the percentage of unemployed citizens. SES scores were determined on the municipal level, thereby categorizing low, middle and high SES²⁷.⁶ COPD: Chronic obstructive pulmonary disease

Table 2 supplementary data: healthcare costs of Dutch elderly persons in the period 2009-2016.

	2009			2010			2011			2012		
	ND	CD	IOD	ND	CD	IOD	ND	CD	IOD	ND	CD	IOD
	€	€	€	€	€	€	€	€	€	€	€	€
Healthcare												
Dental care	282	870	3 204	245	264	248	252	240	265	251	274	320
			≤0.001			≤0.001			≤0.001			≤0.001
General practitioner	156	202	159	143	183	149	153	185	161	159	193	164
			≤0.001			≤0.001			≤0.001			≤0.001
Specialist care	2 988	3 661	3 243	3 269	3 867	3 619	3 421	3 942	3 875	3 442	3 835	3 736
			≤0.001			≤0.001			≤0.001			≤0.001
Nursing home	-	-	-	-	-	-	-	-	-	31 505	34 285	28 232
												≤0.001
Mental health	3 345	4 246	4 395	3 210	3 616	4 205	3 081	3 560	4 081	3 026	3 363	3 615
			≤0.001			≤0.001			≤0.001			≤0.001
Physiotherapy	1 010	1 158	947	1 035	1 089	953	1 072	1 102	997	1 066	1 116	1 034
			≤0.001			≤0.001			≤0.001			≤0.001
Allied healthcare	231	265	203	247	265	236	261	269	239	356	413	337
			≤0.001			≤0.001			≤0.001			≤0.001
Pharmacy	1 029	1 221	1 095	1 039	1 224	1 090	1 031	1 199	1 123	962	1 132	1 063
			≤0.001			≤0.001			≤0.001			≤0.001

	2013			2014			2015			2016		
	ND	CD	IOD	ND	CD	IOD	ND	CD	IOD	ND	CD	IOD
	€	€	€	€	€	€	€	€	€	€	€	€
Healthcare												
Dental care	255	335	369	262	448	537	258	425	572	255	484	637
			≤0.001			≤0.001			≤0.001			≤0.001
General practitioner	174	206	183	193	226	203	169	194	181	181	215	198
			≤0.001			≤0.001			≤0.001			≤0.001
Specialist care	3 593	3 894	3 901	3 531	3 823	3 851	3 443	3 635	3 652	3 571	3 677	3 973
			≤0.001			≤0.001			≤0.001			≤0.001
Nursing home	38 051	38 587	34 861	42 597	43 407	42 645	47 337	46 256	45 089	48 935	47 361	46 116
			≤0.001			≤0.001			≤0.001			≤0.001
Mental health	3 226	3 538	4 053	3 726	4 236	3 377	4 035	4 973	4 690	3 697	3 593	4 817
			≤0.001			≤0.001			≤0.001			≤0.001
Physiotherapy	1 128	1 191	1 065	1 184	1 202	1 149	1 200	1 164	1 158	1 219	1 204	1 157
			≤0.001			≤0.001			≤0.001			≤0.001
Allied healthcare	275	286	270	277	275	271	264	253	269	264	269	267
			≤0.001			≤0.001			≤0.001			≤0.001
Pharmacy	919	1 096	1 050	941	1 109	1 083	942	1 142	1 113	962	1 131	1 135
			≤0.001			≤0.001			≤0.001			≤0.001

¹ND: Natural dentition ²CD: Conventional denture

³IOD: Implant-retained overdenture

⁴p-value: p-value determined between 3 subgroups

Chapter 3

General health status of Dutch elderly receiving implant-retained overdentures: a 9-year big data cross-sectional study

Mieke H Bakker

Arjan Vissink

Gerry M Raghoobar

Anita Visser

This chapter is an edited version of the manuscript:
Clinical Implant Dentistry and Related Research 2021;1-8

Abstract

Background Very little information is available on the general health of elderly who are provided with an implant-retained overdenture (IOD). We compared the general health status of three groups of elderly (≥ 75 years): elderly with a natural dentition, elderly supplied with an IOD and elderly wearing a conventional denture.

Materials and methods Data on healthcare costs were obtained from records of Dutch health insurers that are collected by Vektis. Data on general health (chronic diseases, medication use and polypharmacy) were acquired for elderly patients with a natural dentition, an IOD and a conventional denture in 2009 and 2017. Data on the general health of elderly who received an IOD were also acquired from 2010 through 2016.

Results On average, the general health of elderly who received an IOD was comparable to general health of elderly with a natural dentition and was better than the general health of elderly with a conventional denture (lower prevalence of diabetes, cardiac disease and hypertension). The general health profile of elderly receiving an IOD was consistent during all years.

Conclusions The general health of elderly with a natural dentition or IOD is better than those with a conventional denture.

Introduction

Edentulous patients often experience functional and psychosocial problems related to their conventional dentures due to an impaired load-bearing capacity and poor retention. Placing dental implants to retain a removable overdenture is regarded the first choice of treatment for resolving such denture-related problems.^{1,2} Placing implants to retain an overdenture is regarded a safe, reliable treatment option with high survival rates ($>95\%$), even in studies with a follow-up up to 20 years.³⁻⁵ Moreover, mandibular implant-retained overdentures (IOD) show better retention and stability than conventional dentures, thereby enhancing chewing ability and bite force.^{6,7} This has a positive effect on patient satisfaction and quality of life,⁸⁻¹¹ resulting in a cost-effective treatment strategy, despite the high fabrication costs.^{12,13} In line with the increased oral function and patient satisfaction, improvements in nutritional status, social wellbeing and eventually general health can be expected as well.

Although many studies have been published on oral functioning of patients with IODs, data on the relationship between IOD treatment and general health and nutritional status remains scarce. Previous studies on nutritional status suggested that IODs have a positive effect on nutritional status,^{14,15} but no conclusive evidence is available yet.^{10,16,17} Thus far, only one study focused on the impact of IODs on general health in elderly.⁸ This cross-sectional study showed that community-dwelling elderly wearing an IOD reported less frailty, better general health, and better physical function than elderly wearing a conventional denture. This difference in health status between IOD and conventional denture wearers was studied in elderly ≥ 75 years of age. Although the results of that study suggest that elderly with IODs have, on average, better general health than elderly with conventional dentures, it is hard to draw definitive conclusions, as we do not know if these differences are already present when the dental implants are placed. Therefore, the aim of our study was to assess the general health status of edentulous elderly (≥ 75 years) at the time that they received an IOD as well as to compare their health status with the health status of elderly with a conventional denture or a natural dentition. The general health status of these three groups in 2009 was compared with the health status of matching groups in 2017. Additionally, the general health status of new IOD wearers was assessed annually between 2010 and 2016 to determine whether the average health status of new IOD wearers was consistent over a longer period as well as to determine whether there were age-related differences between elderly aged 75-85 and ≥ 85 years.

Materials and methods

This study was performed in collaboration with Vektis, an organization that warehouses the data on all health care declarations in the Netherlands.

Three groups of elderly (≥ 75 years) were distinguished by oral status: elderly with a natural dentition, edentulous elderly who received a conventional denture (first or replaced denture) and elderly who were treated with dental implants to retain an IOD. The latter two groups of elderly received the corresponding dental treatments in 2009 or 2017. All groups were categorized by oral status based on dental insurance declarations recorded in the Vektis database.

For these three groups the following variables were collected:

- Medical conditions. Asthma, cancer, high cholesterol, diabetes, cardiac disease, hypertension, kidney disease, Parkinson's disease and rheumatoid arthritis. The diagnosis was based on prescribed medication derived from a pharmacy-based cost group model;¹⁹ the use of a specific type of prescribed medication was used as a marker for chronic conditions.
- Medication use. The following types of medications for elderly patients were recorded: antithrombotics, bisphosphonates, inhalation corticosteroids, antihypertensives and antidepressants. The use of five or more medications (polypharmacy) of the previously described drugs was also recorded.
- Socioeconomic status (SES) by municipality of residence. SES was based on data provided by the Netherlands Institute for Social Research.²⁰ Variables to determine SES were the average income, percentage of individuals with low income, percentage of individuals with low education level and percentage of unemployed individuals. Based on the SES scores, municipalities were ranked into three groups: the 30% of municipalities with the lowest scores were ranked as low SES, the 30% with the highest scores were ranked as high SES and the remaining 40% were ranked as middle SES.

To assess whether the results of the elderly with IODs in 2009 and 2017 were not coincidental, Vektis collected data on the health status of elderly that received an IOD between 2010 and 2016. In this period all elderly who received an IOD were assessed annually. To identify possible age-related differences between elderly receiving IODs, two subgroups based on age were formed (75 to 85 years and ≥ 85 years).

Statistics

Descriptive statistics were used to report prevalence of chronic diseases, polypharmacy, medication use and SES. Statistical differences were calculated between elderly with different oral status using Chi² tests. Chi² tests were also used to determine statistically significant differences over time (2009–2017) between 'younger' (75–85 years) and 'older' (85 years and over) elderly receiving an IOD. SPSS IBM Statistics version 23.0 (SPSS, Chicago, IL, USA) was used for statistical analysis of the results.

Results

Oral status: natural dentition, conventional denture or IOD

Table 1 presents demographic characteristics, chronic conditions, medication use and healthcare consumption of elderly categorized by oral status. Almost all variables were statistically significant between the groups with differing oral health status, which is a consequence of the large study population (>100.000 elderly). This often results in statistically significant outcomes that may not be clinically relevant.²¹ Therefore, we focused on clinically relevant differences between groups, defined as $\geq 5\%$ difference in prevalence.

Elderly with an IOD were more frequently aged between 75–85 than elderly with a natural dentition or conventional denture. Also, elderly with an IOD or conventional denture had more frequently low SES than elderly with a natural dentition. With regard to systemic disease, clear differences were found in the prevalence of cardiac disease, hypertension and diabetes between the groups. Elderly with a conventional denture had higher prevalence of cardiac disease, hypertension and diabetes than elderly with a natural dentition or IOD (Figure 1a,b,c). Furthermore, polypharmacy, and the use of antithrombotic and antihypertensive drugs was highest in elderly with a conventional denture.

Health status of elderly treated with an IOD between 2009–2017

Characteristics of elderly who received IODs between 2009 and 2017 are shown in Table 2. Implants are mostly (90%) placed in elderly before the age of 85. Medication use and the presence of chronic health conditions of elderly aged 75 to 85 and ≥ 85 corresponded with these variables in the general ageing popu-

Table 1: Demographic characteristics, chronic diseases and medication use among elderly categorized by oral status in 2009 and 2017.

Demographic characteristics	2009			2017			p-value ⁴ between oral status	n (%)	n (%)	n (%)	p-value between oral status
	ND ¹	CD ²	IOD ³	ND	CD	IOD					
	n= 143 199	n= 18 420	n= 6 503	n= 237 450	n= 17 787	n= 4 631					
Age											
75–85 years	127 017 (89%)	14 824 (81%)	6 090 (94%)	205 111 (86%)	13 585 (76%)	4 230 (91%)	≤0.001	4 230 (91%)	4 230 (91%)	4 230 (91%)	≤0.001
≥85 years	16 182 (11%)	3 596 (19%)	413 (6%)	32 339 (14%)	4 202 (24%)	401 (9%)	≤0.001	401 (9%)	401 (9%)	401 (9%)	≤0.001
Socioeconomic status											
Low	34 846 (24%)	5 413 (29%)	1 784 (28%)	70 671 (30%)	6 134 (35%)	1 505 (32%)	≤0.001	1 505 (32%)	1 505 (32%)	1 505 (32%)	≤0.001
Middle	56 101 (39%)	7 658 (42%)	2 806 (43%)	96 300 (40%)	7 544 (42%)	2 083 (45%)	≤0.001	2 083 (45%)	2 083 (45%)	2 083 (45%)	≤0.001
High	52 252 (37%)	5 349 (29%)	1 913 (29%)	70 479 (30%)	4 109 (23%)	1 043 (23%)	≤0.001	1 043 (23%)	1 043 (23%)	1 043 (23%)	≤0.001
Chronic conditions											
Asthma	5 152 (4%)	815 (4%)	308 (5%)	9 180 (4%)	832 (5%)	222 (5%)	≤0.001	222 (5%)	222 (5%)	222 (5%)	≤0.001
Cancer	95 (<1%)	18 (<1%)	9 (<1%)	96 (<1%)	27 (<1%)	18 (<1%)	0.044	18 (<1%)	18 (<1%)	18 (<1%)	≤0.001
Cardiac disease	18 914 (13%)	4 019 (22%)	882 (14%)	22 982 (10%)	3 086 (17%)	521 (11%)	≤0.001	521 (11%)	521 (11%)	521 (11%)	≤0.001
Diabetes	12 665 (9%)	2 581 (14%)	723 (11%)	22 190 (10%)	2 694 (15%)	592 (13%)	≤0.001	592 (13%)	592 (13%)	592 (13%)	≤0.001
High cholesterol	21 294 (15%)	2 425 (13%)	1 137 (18%)	54 129 (23%)	4 055 (23%)	1 158 (25%)	≤0.001	1 158 (25%)	1 158 (25%)	1 158 (25%)	0.002
Hypertension	74 063 (52%)	10 296 (56%)	3 339 (51%)	120 984 (51%)	10 465 (59%)	2 463 (53%)	≤0.001	2 463 (53%)	2 463 (53%)	2 463 (53%)	≤0.001
Kidney disease	571 (<1%)	127 (<1%)	31 (1%)	560 (<1%)	84 (<1%)	36 (1%)	≤0.001	36 (1%)	36 (1%)	36 (1%)	≤0.001
Parkinson's disease	1 398 (1%)	230 (1%)	83 (1%)	2 374 (1%)	178 (1%)	70 (2%)	≤0.001	70 (2%)	70 (2%)	70 (2%)	≤0.001
Rheumatoid arthritis	948 (<1%)	143 (1%)	49 (1%)	2 174 (1%)	232 (1%)	74 (2%)	0.154	74 (2%)	74 (2%)	74 (2%)	≤0.001
Antithrombotics	62 236 (44%)	9 498 (52%)	2 900 (45%)	106 724 (45%)	9 929 (56%)	2 255 (49%)	≤0.001	2 255 (49%)	2 255 (49%)	2 255 (49%)	≤0.001
Antihypertensives	85 518 (60%)	12 303 (67%)	3 794 (58%)	140 808 (59%)	12 264 (69%)	2 797 (60%)	≤0.001	2 797 (60%)	2 797 (60%)	2 797 (60%)	≤0.001
Antidepressants	12 528 (9%)	2 054 (11%)	690 (11%)	22 187 (9%)	2 059 (12%)	549 (12%)	≤0.001	549 (12%)	549 (12%)	549 (12%)	≤0.001
Bisphosphonates	14 135 (10%)	1 866 (10%)	656 (10%)	15 842 (7%)	1 374 (8%)	248 (5%)	0.478	248 (5%)	248 (5%)	248 (5%)	≤0.001
Corticosteroids	14 782 (10%)	2 713 (15%)	885 (14%)	22 879 (10%)	2 286 (13%)	561 (12%)	≤0.001	561 (12%)	561 (12%)	561 (12%)	≤0.001
Polypharmacy	11 898 (8%)	2 390 (13%)	542 (8%)	18 707 (8%)	2 351 (13%)	396 (9%)	≤0.001	396 (9%)	396 (9%)	396 (9%)	≤0.001

¹ND: natural dentition

²CD: conventional denture

³IOD: implant-retained overdenture

⁴p-value indicates whether age, socioeconomic status, chronic conditions and prescribed medication significantly differ between elderly with differing oral status (ND, CD, IOD)

⁵Percentage of ND, CD and IOD subjects that have a certain socioeconomic status or suffer from a certain chronic condition, use a certain drug, etc.

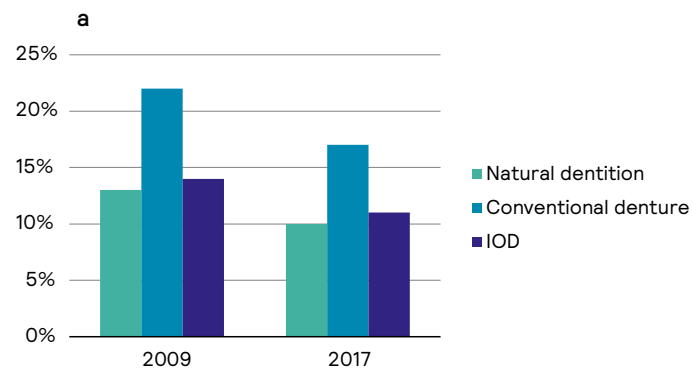


Figure 1: Prevalence of chronic conditions in elderly (aged ≥ 75 years) with differing oral status a: Prevalence of cardiac disease

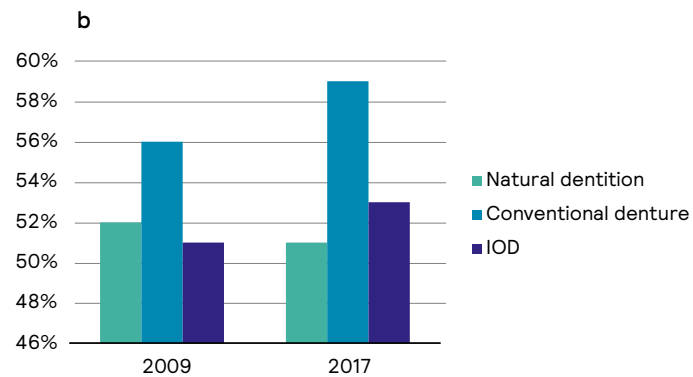


Figure 1b: Prevalence of hypertension

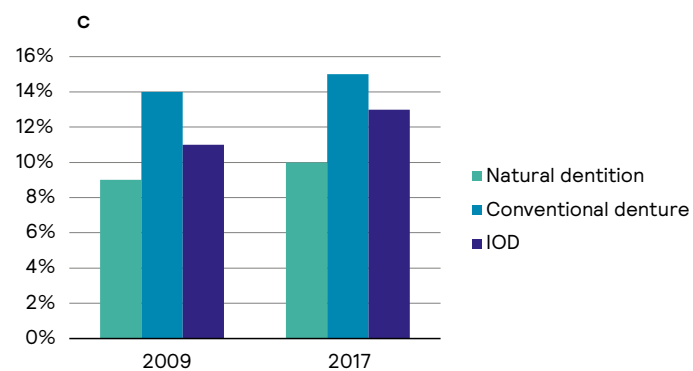


Figure 1c: Prevalence of diabetes

lation with the exception of diabetes and high cholesterol. The prevalence of diabetes was lower among elderly aged ≥ 85 who received an IOD.

Discussion

General health of elderly who received an IOD and elderly with a natural dentition appears to be better than elderly wearing a conventional denture. In our study, this finding was fairly consistent over time. Placing dental implants to support an IOD is a more common treatment in elderly between 75 and 85 than in elderly aged ≥ 85 years. Common general health conditions such as cardiac disease, hypertension and diabetes are less prevalent among elderly patients receiving dental implants to retain an IOD than patients wearing conventional dentures.

This nine-year cross-sectional study confirmed the observations of Hoeksema et al.¹⁸ that elderly with a natural dentition and elderly who received an IOD had on average better general health than elderly wearing a conventional denture. At least part of this difference in general health status between these two groups is probably because the average age of elderly who received an IOD for the first time was lower than that of elderly wearing a conventional denture. However, it is still unknown whether this positive difference continues over time or the average general health of IOD wearers gradually approaches that of conventional denture wearers. This is an issue that requires further research.

With regard to conditions affecting general health, the prevalence of cardiac disease and hypertension was on average lower in elderly with a natural dentition and IOD than in elderly with a conventional denture. For elderly with a natural dentition or IOD, the prevalence figures for cardiac disease and hypertension were within the same range as prevalence figures for these diseases in the general population in the Netherlands, while compared to the general population the prevalence of diabetes was significantly lower in elderly who were provided with an IOD.²² The overall prevalence of diabetes in Dutch elderly (≥ 75 years) is about 25%, while in our study the prevalence in elderly who received an IOD was 5%–14%, and was lowest in the very old. A possible explanation for this discrepancy is that patients or their caregivers were more reluctant about implant placement in diabetic elderly. This might be due to the general belief that the risk of implant failure is higher in diabetic subjects due to impaired wound

Table 2: SES, prevalence of chronic conditions and medication use in Dutch citizens (75–85 years and ≥85 years) receiving IODs in the period 2009–2013.

	2009		2010		2011		2012		2013		p-value
	75 – 85	≥85	75 – 85	≥85	75 – 85	≥85	75 – 85	≥85	75 – 85	≥85	p-value
	n=	n=	n=	n=	n=	n=	n=	n=	n=	n=	
	5 045 (92%)	413 (8%)	4 584 (91%)	462 (9%)	5 167 (90%)	544 (10%)	3 883 (92%)	357 (8%)	4 424 (91%)	460 (9%)	
Socioeconomic status											
Low	1 388 (27%)	125 (30%)	1 243 (27%)	133 (29%)	1 408 (27%)	151 (28%)	972 (25%)	112 (31%)	1 096 (25%)	131 (29%)	0.081
Middle	2 151 (43%)	169 (41%)	1 995 (44%)	175 (38%)	2 184 (42%)	228 (42%)	1 738 (45%)	123 (35%)	1 935 (44%)	186 (40%)	0.174
High	1 506 (30%)	119 (29%)	1 346 (29%)	154 (33%)	1 575 (31%)	165 (30%)	1 173 (30%)	122 (34%)	1 393 (31%)	143 (31%)	0.860
Chronic conditions											
Asthma	234 (5%)	15 (4%)	216 (5%)	18 (4%)	265 (5%)	20 (4%)	187 (5%)	18 (5%)	198 (4%)	14 (4%)	0.151
Cancer	-	-	14 (<1%)	9 (2%)	14 (<1%)	9 (2%)	9 (<1%)	-	11 (<1%)	-	0.614
Cardiac disease	695 (14%)	90 (22%)	651 (14%)	96 (21%)	688 (13%)	136 (21%)	512 (13%)	83 (23%)	578 (12%)	100 (18%)	≤0.001
Diabetes	575 (11%)	34 (8%)	497 (11%)	34 (7%)	639 (12%)	51 (7%)	479 (12%)	24 (7%)	574 (11%)	39 (5%)	0.006
High cholesterol	897 (18%)	31 (8%)	829 (18%)	48 (10%)	1 022 (20%)	68 (10%)	821 (21%)	53 (15%)	959 (19%)	70 (12%)	0.001
Hypertension	2 630 (52%)	203 (49%)	2 473 (54%)	241 (52%)	2 842 (55%)	301 (52%)	2 166 (56%)	188 (53%)	2 423 (49%)	269 (41%)	0.128

Kidney disease	18 (<1%)	9 (2%)	19 (<1%)	-	18 (<1%)	9 (2%)	16 (<1%)	-	16 (<1%)	9 (2%)	≤0.001
Parkinson's disease	52 (1%)	9 (2%)	49 (1%)	9 (2%)	65 (1%)	9 (2%)	53 (1%)	9 (3%)	78 (1%)	9 (2%)	0.765
Rheumatoid arthritis	35 (1%)	-	60 (1%)	9 (2%)	55 (1%)	9 (2%)	44 (1%)	9 (3%)	59 (1%)	9 (2%)	0.278
Prescribed medication											
Antithrombotics	2 302 (46%)	195 (47%)	2 147 (47%)	220 (48%)	2 373 (46%)	327 (60%)	1 824 (47%)	198 (55%)	2 049 (46%)	254 (55%)	≤0.001
Bisphosphonates	519 (10%)	47 (11%)	477 (10%)	61 (13%)	469 (9%)	65 (12%)	366 (9%)	38 (11%)	396 (9%)	49 (11%)	0.978
Inhaled corticosteroids	687 (14%)	53 (14%)	608 (13%)	50 (11%)	725 (14%)	73 (13%)	531 (14%)	39 (11%)	592 (13%)	52 (11%)	0.210
Antihypertensives	2 973 (59%)	257 (62%)	2 850 (62%)	289 (63%)	3 233 (63%)	386 (71%)	2 423 (62%)	231 (65%)	2 692 (61%)	303 (66%)	0.035
Antidepressants	534 (11%)	47 (11%)	510 (11%)	54 (12%)	545 (11%)	61 (11%)	430 (11%)	51 (14%)	514 (12%)	61 (13%)	0.298
Polypharmacy	431 (9%)	35 (8%)	423 (9%)	40 (9%)	468 (9%)	65 (12%)	378 (10%)	44 (12%)	389 (9%)	41 (9%)	0.931

¹p-value <0.05, determined between 2 subgroups (elderly aged 75–85 and aged 85 and over)

Continuation of table 2: Years 2014–2017.

Sex	2014		2015		2016		2017		p-value			
	75 – 85	≥85	75 – 85	≥85	75 – 85	≥85	75 – 85	≥85				
	n= 4 305 (90%)	n= 472 (10%)	n= 4 080 (90%)	n= 474 (10%)	n= 4 873 (91%)	n= 511 (9%)	n= 4 230 (91%)	n= 401 (9%)				
Low	1 467 (34%)	173 (37%)	1 403 (34%)	161 (34%)	1 602 (33%)	164 (32%)	1 375 (33%)	130 (32%)	0.972			
Middle	1 921 (45%)	189 (40%)	1 749 (43%)	192 (40%)	2 132 (44%)	231 (45%)	1 912 (45%)	171 (43%)	0.325			
High	917 (21%)	110 (23%)	928 (23%)	121 (26%)	1 139 (23%)	116 (23%)	943 (22%)	100 (25%)	0.226			
Chronic diseases												
Asthma	205 (5%)	20 (4%)	0.610	191 (5%)	15 (3%)	0.133	215 (4%)	30 (6%)	0.132	202 (5%)	20 (5%)	0.849
Cancer	-	-	-	-	-	9 (<1%)	9 (<1%)	9 (2%)	≤0.001	18 (<1%)	-	0.396
Cardiac disease	546 (13%)	99 (21%)	≤0.001	498 (12%)	97 (20%)	≤0.001	555 (11%)	120 (23%)	≤0.001	454 (11%)	67 (17%)	≤0.001
Diabetes	524 (12%)	35 (7%)	0.002	503 (12%)	32 (7%)	≤0.001	681 (14%)	49 (10%)	0.006	547 (13%)	45 (11%)	0.327
High cholesterol	1 019 (24%)	66 (14%)	≤0.001	1 016 (25%)	78 (16%)	≤0.001	1 252 (26%)	92 (18%)	≤0.001	1 081 (26%)	77 (19%)	0.005
Hypertension	2 347 (55%)	261 (55%)	0.747	2 195 (54%)	248 (52%)	0.541	2 726 (56%)	274 (54%)	0.315	2 265 (54%)	198 (50%)	0.110

Kidney disease	9 (<1%)	9 (2%)	≤0.001	10 (<1%)	-	0.613	17 (<1%)	9 (2%)	≤0.001	18 (<1%)	18 (5%)	≤0.001
Parkinson's disease	60 (1%)	9 (2%)	0.375	51 (1%)	9 (2%)	0.241	68 (1%)	9 (2%)	0.508	52 (1%)	18 (5%)	≤0.001
Rheumatoid arthritis	50 (1%)	9 (2%)	0.164	56 (1%)	9 (2%)	0.361	62 (1%)	9 (2%)	0.357	65 (2%)	9 (2%)	0.280
Prescribed medication												
Antithrombotics	2 017 (47%)	264 (56%)	≤0.001	1 890 (46%)	257 (54%)	0.001	2 318 (48%)	300 (59%)	≤0.001	2 033 (48%)	222 (55%)	0.005
Bisphosphonates	348 (8%)	37 (8%)	0.853	304 (7%)	37 (8%)	0.781	313 (6%)	38 (7%)	0.377	227 (5%)	21 (5%)	0.912
Inhaled corticosteroids	552 (13%)	64 (14%)	0.650	523 (13%)	43 (9%)	0.019	603 (12%)	75 (15%)	0.136	526 (12%)	44 (11%)	0.394
Antihypertensives	2 648 (62%)	306 (65%)	0.159	2 518 (62%)	306 (65%)	0.228	3 082 (63%)	344 (67%)	0.169	2 548 (60%)	249 (62%)	0.467
Antidepressants	495 (11%)	45 (10%)	0.201	475 (12%)	54 (11%)	0.872	611 (13%)	58 (11%)	0.439	504 (12%)	45 (11%)	0.682
Polypharmacy	398 (9%)	47 (10%)	0.613	366 (9%)	54 (11%)	0.085	429 (9%)	58 (11%)	0.056	367 (9%)	29 (7%)	0.323

*p-value <0.05, determined between 2 subgroups (elderly aged 75–85 and aged 85 and over)

healing, despite a recent study showing that controlled diabetes should not be regarded as a contraindication for implant placement.²³

Limitations

A limitation of the study is the potential bias with regard to the inclusion of elderly with a natural dentition; this figure was lower than would have been expected for the general population in the Netherlands. This discrepancy is inherent to the Vektis database, which contains all the insured primary and specialist healthcare costs in the Netherlands. Most of the costs (>90% of each treatment) of conventional dentures and IOD treatment are covered by obligatory healthcare insurance, while for elderly with a natural dentition, most dental treatment costs are not covered by this insurance. Patients can optionally acquire supplementary insurance to cover their dental costs, but not all patients do so. Because Vektis only records dental costs that are reimbursed by obligatory or supplementary insurance, elderly without dental insurance are not included in the database. This leads to a lower number of elderly with a natural dentition in the database than in the general population. A possible explanation of this discrepancy is that the general health of elderly with a natural dentition but without dental insurance may be better than the health of those with a natural dentition and a dental insurance. As a result, elderly with reasonable oral health, and often better general health, may decide not to pay for supplementary dental insurance, and are therefore not registered in the Vektis database.

As a consequence of this big data study most outcomes are statistically significant, but not all are also clinically meaningful. This is a common issue with big data studies.²¹ There has been some debate in observational studies with big data which differences have actually value for clinical practice.²⁴ Clinical significance is defined as the smallest meaningful change in an observed effect but this is not defined as a standard value. Therefore, in this study we focused on clinically meaningful differences between elderly patients.

Conclusions

We conclude that general health of elderly with a natural dentition or an IOD is on average better than the general health of elderly with a conventional denture. Our study also shows that IOD treatment is more often done in elderly 75–85 years than those ≥ 85 years. Although our study indicates that the health status of elderly with IODs (lower prevalence of diabetes, cardiac disease and hyper-

tension) is consistently better at the moment of implant placement than that of elderly with conventional dentures, future studies should be performed to determine whether this difference continues over the long term, or whether the general health of these groups tends to converge.

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Chapter 4

Mandibular implant-supported overdentures in (frail) elderly: a prospective study with 20-year follow-up

Mieke H Bakker

Arjan Vissink

Henny JA Meijer

Gerry M Raghoobar

Anita Visser

This chapter is an edited version of the manuscript:

Clinical Implant Dentistry and Related Research 2019;21:586–592

Abstract

Purpose To prospectively assess long-term (20 year) clinical, radiographic and patient-reported outcomes of an elderly population provided with mandibular implant-supported overdentures.

Materials and methods A total of 53 elderly (aged ≥ 60 years at the time of treatment) were provided with two endosseous implants supporting a mandibular overdenture and a conventional maxillary denture. Outcome parameters – including implant loss, plaque index, gingival index, bleeding index, presence of calculus, probing depth and satisfaction with implant-supported overdenture – were scored 1, 5, 10 and 20 years after prosthetic treatment. Radiographic analysis was performed to assess peri-implant bone changes. At the 20-year evaluation, frailty (Groningen Frailty Index) and quality of life (EuroQol 5D) were additionally assessed.

Results A total of 15 patients completed the 20-year follow-up. The 20-year implant survival rate was 92.5%. Plaque index, bleeding index and probing depth increased slightly over time, while gingival index and presence of calculus remained unchanged. Radiographic analysis revealed minor marginal bone loss during the first 10 years and no further loss thereafter. Participants were very satisfied with their prosthesis and reported a good quality of life. At the 20-year evaluation, 64.3% of the patients were classified as frail.

Conclusions The long-term survival of implants supporting a mandibular overdenture is high. Although most elderly in the study became frail over time, peri-implant health and marginal bone level remained at a satisfactory level.

Introduction

Over time, the majority of the edentulous patients provided with conventional dentures experience functional problems with their mandibular dentures. They often report lack of stability and retention, as well as decreased chewing ability.¹ Patients with these problems can benefit from endosseous implants in the mandible. Placement of two dental implants to support a mandibular overdenture (IOD) increases stability and retention and consequently improves chewing ability and bite force.²⁻⁴ Patients provided with a mandibular overdenture (IOD) show improved masticatory function, a better quality of life and are generally very satisfied with their overdenture.⁴⁻⁸

Placement of dental implants to support a mandibular overdenture is regarded a safe and predictable treatment. However, little is known about the long-term results (≥ 10 years of follow-up) of IODs, especially in elderly who become frail over time. The latter is of great importance as the number of elderly with IODs is rapidly increasing.⁹

Along with the process of human ageing, a decline in oral health can be expected, as the increase in cognitive and physical disabilities in frail elderly can lead to poor oral hygiene.¹⁰⁻¹² In addition, frail elderly usually visit the dental office less frequently due to immobility and cognitive decline.^{11,13} Multimorbidity and polypharmacy, common in frail elderly, may also lead to xerostomia and hyposalivation.¹⁴ This can cause oral health problems such as impaired oral comfort and loss of teeth due to tooth decay, which in turn can lead to masticatory problems and oral pain. All these factors contribute to deteriorating oral health and declining quality of life.

Poor oral hygiene is presumed to be a severe risk for peri-implant health, leading to chronic inflammation and ultimately to loss of implants and loss of oral function.¹⁵⁻¹⁷ However, it is still unclear whether the age-related decline in general and oral health has an impact on peri-implant health in the elderly patients. Therefore, this study aimed to prospectively assess the long-term (20-years) outcomes of implant-supporting mandibular overdentures in an elderly population aged ≥ 80 years at the time of the last follow-up visit. The clinical outcomes included implant survival, bleeding index and marginal bone loss, and the patient-reported outcomes included patient satisfaction and quality of life at the 20-year evaluation.

Materials and methods

Patient selection and treatment

Patients enrolled in this study originated from the previous prospective trials of Heijdenrijk et al. and Batenburg et al.¹⁸⁻²⁰ The short-term, medium-term and long-term results (10-years) of these studies have been reported previously.²¹⁻²⁴ For the present 20-year follow-up study, we included all patients from the studies of Heijdenrijk et al. and Batenburg et al. who were aged ≥ 60 years at the time of implant placement. All patients were edentulous at the start of the study and reported lack of retention and stability of their conventional denture. They were subsequently provided with two endosseous implants to support a mandibular overdenture on a bar-clip system. All patients wore conventional maxillary dentures.

Depending on the previous study in which they were enrolled, the participants received various treatments.

Those enrolled in the study of Batenburg et al.¹⁸ received one of the following treatments:

- Brånemark implant system with a machined surface (Nobel Biocare Holding AG, Zürich, Switzerland).
- IMZ cylinder implant system with titanium-sprayed surface (TPS) coating (Dentsply Friadent, Mannheim, Germany).
- ITI solid screw implant system with TPS coating (Institut Straumann AG, Basel, Switzerland).

Those enrolled in the study of Heijdenrijk et al.^{9,20} received one of the following treatments:

- IMZ cylinder implant system with TPS coating, one- or two-stage placement.
- ITI solid screw implant system with TPS coating.

Table 1 shows implant characteristics at baseline. Implant placement was followed by a three-month healing period. New maxillary conventional dentures and mandibular implant-supported overdentures on a bar-clip system were then fabricated by experienced dentists.

Table 1: Implant characteristics at baseline

Study	Implant type	Length	Diameter	One or two stage	Number of patients
Batenburg ¹⁸	Brånemark	10 – 15 mm	3.75 mm	two stage	13
Batenburg ¹⁸	IMZ	10 – 15 mm	4 mm	two stage	7
Batenburg ¹⁸	ITI	10 – 16 mm	4.1 mm	one stage	6
Heijdenrijk ^{19, 20}	IMZ	11 – 15 mm	4 mm	one stage	8
Heijdenrijk ¹⁹	IMZ	11 – 15 mm	4 mm	two stage	7
Heijdenrijk ²⁰	ITI	10 – 16 mm	4.1 mm	one stage	12

Oral hygiene instructions were given on regular basis starting two weeks after abutment placement (two-stage implant placement) or two weeks after implant placement (one-stage implant placement).

During the first 10 years after implant placement, patients were recalled yearly for dental check-ups in the hospital. Participants were evaluated at baseline (T_0) and at 1 year (T_1), 5 years (T_5), 10 years (T_{10}) and 20 years (T_{20}) after placement of the mandibular overdenture. Characteristics of the group at baseline are listed in **Table 2**. Bone quality at baseline was assessed according to Lekholm and Zarb on a lateral cephalometric radiograph.²⁵ Mandibular height was measured on a rotational panoramic radiograph.

Most participants had to be referred to a local dentist after 10 years of follow-up due to physical decline and reduced mobility, which prevented them from travel-

Table 2: Patient characteristics at baseline

Patient characteristics	n = 53
Age in years (median, IQR)	69 (63-72)
Gender (male/female)	22/31
Edentulous period lower jaw in years (median, IQR)	25 (15-36)
Mandibular bone height in mm (median, IQR)	16 (14.5-18)
Median bone quality (score 1-4) (IQR)	3 (2-3)
Total implants placed	106

ing to the hospital. If patients were unable to attend to the 20-year follow-up in the hospital, they were visited at home for the evaluation. During the home visits, intraoral radiographs could not be made.

The Groningen Medical Ethical Committee provided a waiver (file number M17.217679) for this observational study as it was not an experimental study with test subjects as defined in the Medical Research Involving Human Subjects Act. Written informed consent was obtained from all participants, and the study was performed in accordance with the Declaration of Helsinki.

Clinical analysis

The following clinical parameters were scored:

- Implant loss; removal or loss of an implant any time after surgery was regarded as implant loss.
- Plaque index; presence of plaque was scored by the Mombelli plaque index.²⁶ as follows: score 0 = no detection of plaque; score 1 = plaque detected only by running a probe across the smooth marginal surface of an implant; score 2 = plaque can be seen by the naked eye; score 3 = abundant soft matter.
- Calculus index; presence of calculus was scored as follows; score 0 = no calculus; score 1 = calculus present.
- Peri-implant health was scored using the following 3 parameters:
 - The degree of inflammation of the peri-implant tissue was scored using the Loë and Silness index²⁷ as follows: score 0 = normal gingiva; score 1 = mild inflammation and slight change in color, edema but no bleeding on probing (BOP); score 2 = moderate inflammation with redness, edema, glazing and BOP; score 3 = severe inflammation with marked redness and edema, ulcerations or spontaneous bleeding.
 - The Bleeding-index according to Mombelli²⁶ scored the presence of bleeding as follows: score 0 = no bleeding when a periodontal probe was passed along the gingival margin adjacent to the implant; score 1 = isolated bleeding spot visible; score 2 = blood forms a confluent red line on the gingival margin; score 3 = heavy or profuse bleeding.
 - Pocket depth was measured on four sides of the implant (buccally, mesially, lingually, distally) using a periodontal probe (Merit B, Hu Friedy, Chicago, IL, USA). Probing depth was defined as the distance between marginal border of the mucosa and the tip of periodontal probe.

Radiographic analysis

To analyze bone level over time, standardized intraoral radiographs were obtained using a beam direction device as described by Meijer et al.²⁸ A digital sliding gauge was used to analyze bone level. The measurements were made along the implant axis from a fixed reference point to the level of bone. Measurements were carried out on mesial and distal side of the implants. The radiographs at 20-year follow-up were compared to baseline radiographs to determine any implant loss.

Patient-reported outcomes at the 20-year follow-up

Patients received questionnaires on demographic characteristics including age, marital status, living situation, education, income and health (underlying diseases, use of drugs). This was followed by questions regarding dental visits, oral hygiene, ability to independently remove their IOD, and satisfaction with the prosthetic device. Satisfaction was scored on a VAS scale ranging 1 to 10. A higher score indicated a higher satisfaction. Patients (and caretakers) were asked if there was any implant loss in the last 10 years.

Validated questionnaires to assess frailty and quality of life were used. Frailty was scored by using Groningen Frailty Indicator (GFI).²⁹ This questionnaire consists of 15 items and determines losses of function in physical, cognitive, social and psychological domains. The total score ranges from 0 to 15; a score of ≥ 4 is regarded as frail.

Health-related quality of life was assessed by EuroQoL-5D (EQ-5D) and the EuroQoL VAS (EQ VAS).³⁰ This instrument combines 5 domains: mobility, self-care, pain, daily activities and psychological status. An index score is determined for every participant; the total score of EQ-5D ranges from 0 to 1, EQ VAS ranges from 0 to 100. A higher score indicates a better quality of life.

Data analysis

For the clinical analysis, the worst score of each item per person was assumed to be representative for the status at the time of that evaluation. The radiographic analysis used the worst score per implant as a representative score. Data was analyzed using IBM SPSS Statistics 23 (SPSS Inc., IBM Company, IBM Corporation, Chicago, IL, US). A significance level of $p < 0.05$ was chosen. The Shapiro-Wilk test was used to assess normality of the data ($p < 0.05$). Median and interquartile rang-

es were provided for the not normally distributed clinical parameters. Mean and standard deviation were used for normally distributed parameters. The Friedman test was used to assess differences in clinical parameters over time (significance level $p < 0.05$). Post hoc analysis was carried out with the Wilcoxon signed rank test using the Bonferroni correction ($p < 0.01$). Radiographic analysis was performed using repeated measures ANOVA ($p < 0.05$) and post hoc the Bonferroni test.

Results

The original study groups of Heijdenrijk and Batenburg consisted of 53 patients in total. All patients were present at T_0 . After 1 year, one patient did not attend due to sickness ($n=52$). At T_5 , five patients did not attend due to sickness and two patients had died ($n=46$). After 10 years, four patients had moved without leaving an address, seven did not attend due to sickness and five patients had died ($n=35$). At the T_{20} evaluation, another 26 patients had died and one patient had moved without leaving an address ($n=15$). Three patients could not come to the hospital for a general check-up: two patients were homebound and too sick to attend a check-up and one patient could not visit because she was admitted in a nursing home due to severe dementia. At T_{20} these three patients were therefore visited at home.

Post hoc analysis showed no differences in radiographic and clinical parameters at T_0 and T_1 between the elderly attending at T_{20} and the elderly not attending T_{20} (lost to follow-up) (Supplementary data table 1). Elderly who attended T_{20} were younger and had a shorter edentulous period at baseline, but bone quality and bone height were comparable to the elderly who did not attend T_{20} .

Clinical parameters

During the first 10 years of the study, seven implants were lost. Two of these implants were lost by one patient after 5 years. After 10 years, one implant was lost. Therefore, eight out of 106 implants were lost during the 20-year evaluation period, resulting in an implant survival rate of 92.5%.

Table 3 provides an overview of the clinical parameters. Significant differences over time were found for the plaque index, bleeding index and probing depth. Pairwise comparisons showed that plaque scores at T_{20} were significantly higher than at T_0 , T_1 and T_5 , indicating that oral hygiene had deteriorated. Bleeding index,

Table 3: Clinical parameters at T_0 , T_1 , T_5 , T_{10} and T_{20}

Clinical parameters	T_0 (n = 53)	T_1 (n = 52)	T_5 (n = 46)	T_{10} (n = 34)*	T_{20} (n = 14)*	Significance (p-value)**
Plaque index (median, IQR)	0 (0:1)	0 (0:1)	0 (0:2)	0 (0:2)	2 (1.75;2) a,b,c	<0.001
Presence of calculus (median, IQR)	0 (0:1)	0 (0:1)	0 (0:1)	0 (0:1)	0 (0:1)	Not significant
Gingival index (median, IQR)	0 (0:0.5)	0 (0:0)	0 (0:1)	0 (0:0)	0 (0:1)	Not significant
Bleeding index (median, IQR)	1 (0:1)	1 (0:1)	1 (0:1)	0 (0:0) ^{d,e}	1 (0:2)	0.013
Probing depth (median, IQR)	3 (3:4)	3 (3:4)	3 (3:3)	3 (3:3)	3.5 (3;4.3)	0.015

* One patient lost both implants before T_{10} and was reimplanted. These parameters were excluded

** Statistical difference over time using the Friedman test ($p < 0.05$)

^a p-value <0.01 between T_0 and T_{20}

^b p-value <0.01 between T_1 and T_{20}

^c p-value <0.01 between T_5 and T_{20}

^d p-value <0.01 between T_0 and T_{10}

^e p-value <0.01 between T_5 and T_{10}

gingival index and presence of calculus at T_{20} were comparable to those at baseline, while probing depth had increased slightly.

Radiographic analysis

The radiographic analysis of the implants over 20 years is shown in Table 4. Over time, an increase in marginal bone loss was seen during the first 10 years of follow-up, while no further bone loss was seen thereafter.

Patient-reported outcomes

Patient-reported outcomes are summarized in Table 5. At the 20 years evaluation, the median age of the participants was 85.5 years. At T_{20} , 64.3% of the elderly were frail (GFI score ≥ 4). Patient satisfaction with the overdenture was satisfactory, and quality of life (EQ-5D, EQ VAS) was high. A recent dental visit was reported by 78.6% of the elderly. Almost all (92.9%) subjects brushed their implants and overdenture independently. One elderly could not remove the mandibular implant-supported overdenture herself, but needed help from her husband and homecare providers.

Table 4: Radiographic analysis to determine bone loss

Bone loss	Bone loss between T ₀ and T ₁ (n = 102)	Bone loss between T ₀ and T ₅ (n = 90)	Bone loss between T ₀ and T ₁₀ (n = 61)	Bone loss between T ₀ and T ₂₀ (n = 22)	Significance (p-value) *
Bone loss in mm (mean, SD)	0.45 (0.7)	0.82 (1.04)	1.20 (1.20) ^a	1.14 (0.85) ^{b,c}	0.003

* Statistical difference over time using repeated measures ANOVA (p<0.05)

^a p-value <0.008 between change in marginal bone level of T₁ and T₁₀

^b p-value <0.008 between change in marginal bone level of T₁ and T₂₀

^c p-value <0.008 between change in marginal bone level of T₅ and T₂₀

Table 5: Patient-reported outcomes at T₂₀

Patient-reported outcomes	n = 14
Age (median, IQR)	85.5 (84.8-87.8)
GFI (median, IQR) ^a	5 (1-7)
Frail (GFI ≥4) (n, %)	9 (64.3)
Satisfaction (mean, SD)	7 (2.5)
Quality of Life (EQ-5D) ^b (median, IQR)	0.79 (0.45-0.87)
Quality of Life (EQ VAS) ^c (mean, SD)	68.2 (15.4)
Recent dental visit (<1 year ago) (n, %)	11 (78.6)
Independent daily oral hygiene (n, %)	13 (92.9)
Able to remove denture independently (n, %)	13 (92.9)

^a GFI: Groningen Frailty Indicator

^b EQ-5D: EuroQol-5D

^c EQ VAS: EuroQol Visual Analogue Scale

Discussion

This long-term prospective study on mandibular overdentures supported by two implants and a bar-clip attachment in an elderly population (aged ≥80 years at 20-years follow-up) showed high implant survival and limited changes in peri-implant parameters and marginal bone level, despite deteriorated oral hygiene.

Overall implant survival rate after 20 years of follow-up was 92.5%. This percentage is in line with other studies with a long follow-up. Vercruyssen et al. showed a survival rate of 95.5% after 23 years of loading of two implants supporting an overdenture in the mandible, and Ueda et al. reported a survival rate of 85.9% after 24 years.^{31,32} These studies, however, had a retrospective study design and also included patients <60 years. The long-term results might suggest that the longer the follow-up period the more implants are lost, but careful evaluation of literature showed that failure of dental implants mainly occurs soon after placement.^{33,34} In our study as well, three out of eight lost implants were lost within the first year after placement.

Radiographic analysis showed some marginal bone loss during the first 10 years after implant placement and hardly any additional bone loss thereafter. Several other studies (up to 16 years) have shown comparable or even better scores on preservation of bone level.^{31,32,35}

In the present study, plaque scores had increased at the 20-year follow-up. This was expected, as a decline in oral health and difficulties in maintaining oral self-care and hygiene are common in frail elderly.³⁶ Nearly all elderly cleaned their overdenture and implants themselves, but the high plaque scores on implants and overdentures indicated that cleaning is challenging for them. Other studies showed comparable results: as frailty advances, oral health deteriorates.³⁴

In this study no significant differences regarding plaque scores or other implant parameters in patients who were frail versus patients who were not frail at T₂₀. This could only be studied at the 20-years follow-up in a small group of patients, because frailty was not measured during previous follow-ups. No further detailed information on this subject was provided. Frailty and quality of life in this study were assessed only at T₂₀. There are two reasons for this. At the beginning of the study, no validated frailty questionnaires were available and all participants were relatively young (60 years of age) and in good health. Their health and functioning declined over the next 20 years.

One of the major benefits of an IOD is the potential to adapt the suprastructure to a patient's needs. When necessary, a bar-clip system can be removed easily and replaced by locators or even healing caps when appropriate, thereby simplifying the oral hygiene routine.³⁷ This way, elderly may profit as long as possible from their IOD.

The focus of this study was on peri-implant health. Prosthetic care and aftercare was not taken into account for reason that in previous studies from our research group (long-term) care and aftercare was described in detail.^{38,39} This included also mucositis and adjustments of prostheses. In those studies it was shown that the need for prosthetic and surgical aftercare was minor.

When elderly become frail and require complex care they need assistance by caretakers or nurses, but many institutionalized elderly are not cooperative about receiving oral hygiene by others.⁴⁰ Nevertheless, the high plaque index and deteriorated oral hygiene we observed in this study did not result in excessive peri-implant bone loss or unfavorable peri-implant parameters. Despite the frailty and deteriorated oral hygiene of the participants, this study shows that the IOD is a durable treatment option and that it contributes to a high quality of life. A possible qualification is that most elderly in this study continued to visit their dentist on a yearly basis, which might be an important factor in preventing severe peri-implantitis.

Strengths and limitations

The strength of this study is the long follow-up period in an elderly population with advancing frailty. The main limitation is that many patients died during follow-up. As no differences were found between clinical and radiographic outcomes at T_0 and T_1 for elderly who attended the T_{20} evaluation and those who did not, this study provides credible insight into long-term follow-up of dental implants in an elderly population.

Clinical guidelines

When placing dental implants in an aging population aiming to retain an overdenture it should be taken into account that the elderly patient will eventually become frail. In case elderly become frail and care-dependent it may be difficult to maintain a good oral hygiene and visit the dentist regularly. Therefore we would like to promote the idea that the suprastructures placed can be adjusted or

downsized when appropriate. For example, a bar-clip system can be converted into locator-systems when oral hygiene deteriorates and dental visits are difficult. Furthermore, dental care professionals should consider home visits when visiting the dental office is not optional anymore. Taken together this may result in longer preservation of healthy peri-implant tissues and a well-functioning overdenture.

Conclusions

Despite the deterioration of oral hygiene in elderly with increasing frailty, the long-term (20-years) survival of dental implants supporting a mandibular overdenture is high.

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Supplementary data table 1: Patient characteristics and clinical parameters at T₀ and T₁ of the patients attending the T₂₀ evaluation compared to patients not attending at T₂₀

Patient characteristics at T ₀	Patients attending T ₂₀ (n = 14)*	Patients not attending T ₂₀ (n = 39)	p-value
Age in years (median, IQR)	63 (62-65.25)	69 (65-73)	0.001
Gender (female, %)	10 (71.4%)	21 (53.8%)	Not significant
Edentulous period in the lower jaw (median, IQR)	15 (6.5-30)	30 (20-38)	0.012
Mandibular bone height in mm (median, IQR)	16 (14-19)	15 (15-18)	Not significant
Bone quality (median, IQR)	3 (2-3)	3 (2-3)	Not significant
Clinical parameters at T₀			
Plaque index (median, IQR)	0 (0;1)	0 (0;1)	Not significant
Presence of calculus (median, IQR)	0 (0;1)	0 (0;1)	Not significant
Gingival index (median, IQR)	0 (0;1)	0 (0;0)	Not significant
Bleeding index (median, IQR)	1 (0;1.25)	1 (0;1)	Not significant
Probing depth (median, IQR)	4 (2.75;4)	3 (3;4)	Not significant
Bone loss between T₀ and T₁			
Bone loss in mm (mean, SD)	0.22 (0.36)	0.52 (0.78)	Not significant

* One patient lost both implants before T10 and was reimplanted. These parameters were excluded

Chapter 5

Self-reported oral health problems and the ability to organize dental care of community-dwelling elderly aged ≥ 75 years

Mieke H Bakker

Arjan Vissink

Sophie LW Spoorenberg

Klaske Wynia

Anita Visser

This chapter is an edited version of the manuscript:
BMC Oral Health 2020;20:185.

Abstract

Background It is unclear how many community-dwelling elderly (aged ≥ 75 years) experience oral health problems (e.g. pain, dry mouth, chewing problems) and how they manage their dental care needs. This study aimed to assess self-reported oral health problems in elderly who are frail or have complex care needs, and their ability to manage their dental care needs when reporting oral pain.

Materials and methods 3533 community-dwelling elderly participating in the “Embrace” project were asked to complete questionnaires regarding oral status and oral health problems. Frailty was assessed with the Groningen Frailty Indicator (GFI). Intermed for Elderly Self-Assessment (IM-E-SA) was used to determine complexity of care needs. Next, elderly who reported oral pain were interviewed about their oral pain complaints, their need for dental care, and their ability to manage their dental care. For statistical analyses Chi²-tests and the one-way ANOVA were used.

Results 1622 elderly (45.9%) completed the questionnaires. Dry mouth (11.7%) and oral pain (6.2%) were most frequently reported. Among the elderly reporting oral pain, most were registered at a local dentist and could go there when needed (84.3%). Robust elderly visited the dentist independently (87%). Frail (55.6%) and complex (26.9%) elderly more often required assistance from caregivers.

Conclusions Dry mouth and oral pain are most reported oral health problems among community-dwelling elderly. Elderly with complex care needs report most oral health problems. In case an elderly seeks dental treatment to alleviate an oral pain complaint, most elderly in this study were able to manage dental care needs and organize transport to the dentist. Frail and complex elderly often need assistance from caregivers to visit the dentist. Therefore healthcare professionals should keep in mind that when frailty progresses, visiting a dentist may become more and more difficult and the risk for poor oral health increases.

Introduction

Globally the population is growing and aging.^{1,2} This development will have great impact on all healthcare systems. As people grow older, staying vital and healthy becomes challenging as elderly increasingly become frail and care-dependent.³ Frailty is defined as a state in which older adults are vulnerable to sudden changes in health status because of a decline in physiological function and reserve.³ Recent studies have shown that the prevalence of multimorbidity and polypharmacy rapidly increases with age, resulting in complex care needs in elderly.^{4,5} Complex care needs may arise when elderly are suffering from multiple chronic diseases and polypharmacy and are treated by various medical healthcare professionals.⁶

In the last two decades, as a result of improved dental care in the previous century, edentulism is decreasing and more and more elderly retain their natural dentition until high age or receive dental implants.⁷ Elderly with a natural dentition and elderly provided with dental implants to retain an overdenture (implant-retained overdenture: IOD) have a high risk of developing oral problems, especially when oral hygiene maintenance and dental visits become difficult due to frailty.^{8,9} But even full dentures can become problematic when the denture fit is poor.⁸ Frail and care-dependent elderly therefore have a relatively high risk of poor oral health and subsequently of oral pain (pain originating from oral tissues).¹⁰ This is a great hazard as poor oral health and oral pain have a negative effect on general health and quality of life, and can limit social interactions.^{11,12}

Regular dental visits are therefore advised in order to prevent poor oral health. Research in the United States (US) has shown that only 46% of community-dwelling elderly visit the dentist for a general check-up, and this figure decreases as these elderly get older and subsequently become more frail.¹³ When elderly can no longer live independently at home, they are often admitted in a nursing home. Studies showed that after dental examination 70% of the residents had oral health problems and were in need of dental treatment.¹⁴⁻¹⁶ Oral pain among community-dwelling is well described in literature.^{17,18} For example, Hoeksema et al.¹⁹ reported high a prevalence (22%) of oral pain among community-dwelling elderly. However, the proportion of community-dwelling elderly who experience oral health problems such as dry mouth, oral pain and chewing problems and if these elderly are able to manage their dental care needs – especially when suffering from oral pain – remains unclear. Therefore, the aim of this study was to

assess self-reported oral health problems (such as oral dryness, pain, chewing problems) in community-dwelling elderly (aged ≥ 75 years) who are frail or have complex care needs. Next, it was assessed if and how these elderly are able to manage their dental care needs when suffering from oral pain.

Materials and methods

Participants and study design

We asked all community-dwelling elderly (aged ≥ 75 years) living in the northern region of the Netherlands who were participating in the ongoing Embrace program for person-centered care to participate in our study.²⁰⁻²³ The Embrace program (“SamenOud” [aging together] in Dutch) focuses on elderly patients of general practitioners (GPs). Embrace is an integrated care service aimed to prolong the ability of older adults to age at home for as long as possible by providing comprehensive, coherent, person-centered, proactive, and preventive care and support. For an extensive description of the program see Spoorenberg et al. and Uittenbroek et al.²⁰⁻²³ The Medical Ethical Committee of the University Medical Center Groningen (the Netherlands) approved the Embrace study proposal (reference METc2011.108). Regarding the present study, they concluded that additional approval for assessing perceived oral health and the need for treatment was not required. The study was performed in accordance with the principles expressed in the Declaration of Helsinki.

Procedures and assessments

Between July 2017 and February 2018, a total of 3533 community-dwelling elderly participating in Embrace and living in the northern parts of the Netherlands received self-reporting questionnaires regarding demographics (age, sex, general health (underlying diseases, use of drugs)). In addition, oral status (natural dentition (including fixed implant-retained structures), conventional denture or IOD) and oral health problems (oral pain, chewing problems, swallowing problems, dry mouth, feeling of insecurity regarding their oral status) experienced in the last three months were scored.

The elderly also completed a number of validated health-related questionnaires:

- Groningen Frailty Indicator (GFI): assesses physical and psychological frailty

among elderly. This valid and reliable 15-item instrument results in a score ranging from 0 to 15, with higher scores corresponding with a higher level of frailty. A score of ≥ 4 is regarded as frail.²⁴

- The INTERMED for the Elderly Self-Assessment (IM-E-SA): assesses the need for complex care of elderly. This valid and reliable instrument⁶ consists of 20 questions in four domains (biological, psychological, social and healthcare), and it provides insight in perceived physical and cognitive abilities as well as healthcare needs. Scoring ranges from 0-60, with a higher score corresponding to a higher need for complex care. A cut-off value of ≥ 16 was used to define elderly in need for complex care.⁶

Elderly who completed all questionnaires were included in this study. Elderly with incomplete questionnaires were excluded from this study.

Case complexity

Participating elderly were categorized based on their IM-E-SA and GFI scores in three groups; (1) robust elderly, (2) frail elderly and (3) elderly with complex care needs. Robust elderly were defined as resilient persons in good health. Robust elderly showed low levels of frailty ($GFI < 4$) and a low level of complex care needs ($IM-E-SA < 16$). Frail elderly were defined as having a higher level of frailty ($GFI \geq 4$), but a low level of complex care needs ($IM-E-SA < 16$). Elderly with complex care needs were characterized by a high IM-E-SA score ($IM-E-SA \geq 16$).

Interview on oral pain

Elderly reporting oral pain were included for further research. Studies have shown that oral pain is a strong motivator to visit the dentist,^{25,26} but it is unclear whether community-dwelling elderly are able to visit the dentist when they are suffering from oral pain. In this study researcher (MHB) contacted elderly with oral pain in the last three months by telephone for a structured interview. This was done within two weeks after the questionnaire had been returned. This interview was held to obtain additional information on the reported pain complaints and how these elderly organize their dental care needs. Information acquired by the interview:

- Actual status of reported oral pain.
- Severity of actual pain on a visual analog scale of 1 to 10, where 10 indicates severe pain.

- Etiology of oral pain.
- History of oral pain.
- Location of oral pain.
- Medication and actions the participant had already taken regarding the reported oral pain (e.g., taking painkillers, visiting a dentist, using mouthwash, additional dental cleaning, consulting friends, visiting a general practitioner).
- Regular visits to the dentist.
- Transport to the dentist.

In case oral pain was still present and the dentist or a specialist had not been visited thus far, the research team advised the patient to visit a dentist. After the structured interview all participants received a letter containing a short summary of the interview including the given advice to make an appointment with the dentist. If the oral pain complaint was complicated (e.g., burning mouth syndrome, pain related to previous head and neck oncology treatment) and the earlier consulted dentist could not alleviate the pain complaint, the patient was advised to return to the dentist and inform whether it would be possible to be referred to a maxillofacial surgeon. Elderly who were advised to visit a dentist or specialist were contacted again after six to eight weeks. In this second interview, the participants were asked whether they had visited a dentist or maxillofacial surgeon and what the current status of their oral pain complaint was. Elderly were excluded when they did not give consent to the interview or when they could not be contacted or did not answer the telephone.

Statistical analysis

A significance level of $p < 0.05$ was chosen for all tests. The Shapiro-Wilkins test was used to assess normality of the data ($p < 0.05$). Median and interquartile ranges were provided for the not normally distributed clinical parameters. Mean and standard deviation were used for normally distributed parameters. Chi² tests were used to assess significant differences between elderly with different risk profiles. For normally distributed variables one-way ANOVA was used, post hoc analysis was performed using independent-samples t-test. $p < 0.05$ was determined as cut-off value. Because interviews were used to assess oral pain, no missing data were encountered. Data analysis was performed with IBM SPSS Statistics 23 (SPSS Inc., IBM Company, IBM Corporation, Chicago, IL, US).

Results

Respondents

Demographics of the respondents are shown in **Table 1**. Next, the flowchart of this study is shown in **Figure 1**. All 3533 elderly who participated in Embrace were eligible and invited to join this study. In total, 1622 elderly (45.9%) returned the questionnaires. Dry mouth (11.7%) and oral pain (6.2%) were most reported oral health problems. Elderly with complex care needs reported most frequently oral pain, dry mouth, swallowing problems, chewing problems and an insecure feeling. Elderly who reported oral pain ($n=100$, 6.2%) were telephoned within two weeks after the questionnaire had been returned and invited to participate in an additional structured interview, of which 89 (89%) responded positively (eight elderly decided not to participate in the interview, and three elderly could not be contacted).

First interview

Of the 89 respondents reporting oral pain, 32.6% ($n=29$) were still suffering from oral pain at the time of the interview, and 38.2% ($n=34$) reported that the pain had or has lasted for over six weeks (**Table 2**). There were no statistically significant differences between respondents with different risk profiles. In order to relieve their oral pain, 56.2% of the elderly had already visited the dentist. Among the participants, 10.1% ($n=9$) could not remember their reported pain complaint and seemed to have no complaints anymore. The most frequently reported pain problems were toothache (23.6%) and denture-related (fitting) complaints (24.7%) (**Table 2**). Minor dental complaints, i.e. complaints that did not require painkillers or urgent dental treatment (such as sensitive teeth), were reported by 23.6% of the elderly. The type of complaints did not differ between respondents with different risk profiles. Most oral pain complaints were related to the lower jaw (43.8%). Of all participants, 9% stated their oral complaint was located throughout the oral cavity, no specific location could be determined.

Most elderly participants reported that they were registered at a local dentist (85.4%) and had been visiting their local dentist within the last year (75.3%) for regular dental care. They were often able to visit the dentist independently (70.8%). Robust elderly were in most cases able to go to the dentist independently (87.0%), in contrast to frail (44.4%) and complex elderly (46.2%), who required more assistance from caregivers ($p < 0.001$).

Table 1: Patient characteristics

Patient characteristics (n,%)	Robust (n=1133)	Frail (n=226)	Complex (n=263)	Total (n=1622)	p-value between groups
Demographics					
Female	597 (52.7%) ^a	145 (64.2%)	155 (58.9%)	897 (55.3%)	0.003
Age (mean, ± SD)	82 ± 4.5 ^{a,b}	83 ± 3.9	82 ± 4.1	82 ± 4.4	0.023
Oral status					
Natural dentition	523 (46.2%) ^b	99 (43.8%)	89 (33.8%)	711 (43.8%)	0.001
IOD	131 (11.6%)	27 (11.9%)	31 (11.8%)	189 (11.7%)	0.984
Conventional denture	479 (42.3%) ^b	100 (44.2%)	143 (54.4%)	722 (44.5%)	0.002
Oral health problems					
Oral pain	58 (5.1%) ^b	15 (6.6%)	27 (10.3%)	100 (6.2%)	0.007
Chewing problems	52 (4.6%) ^b	14 (6.2%)	26 (9.9%)	92 (5.7%)	0.003
Swallowing problems	14 (1.2%) ^b	6 (2.7%)	16 (6.1%)	36 (2.2%)	<0.001
Dry mouth	105 (9.3%) ^{a,b}	34 (15%)	51 (19.4%)	190 (11.7%)	<0.001
Insecurity	41 (3.6%) ^c	12 (5.3%)	24 (9.1%)	77 (4.7%)	0.001
Total number of oral health problems					
1 problem	163 (14.4%) ^{a,b}	56 (24.8%)	69 (26.2%)	288 (17.8%)	<0.001
2 problems	38 (3.4%) ^b	11 (4.9%)	24 (9.1%)	73 (4.5%)	<0.001
3 problems	7 (0.6%) ^b	1 (0.4%)	9 (3.4%)	17 (1%)	<0.001
4 problems	-	-	-	-	-
5 problems	2 (0.2%)	-	-	2 (0.1%)	0.386

^a Statistically significant difference ($p < 0.05$) between robust and frail elderly

^b Statistically significant difference ($p < 0.05$) between robust and complex elderly

Figure 1: Flow diagram of patient inclusion process

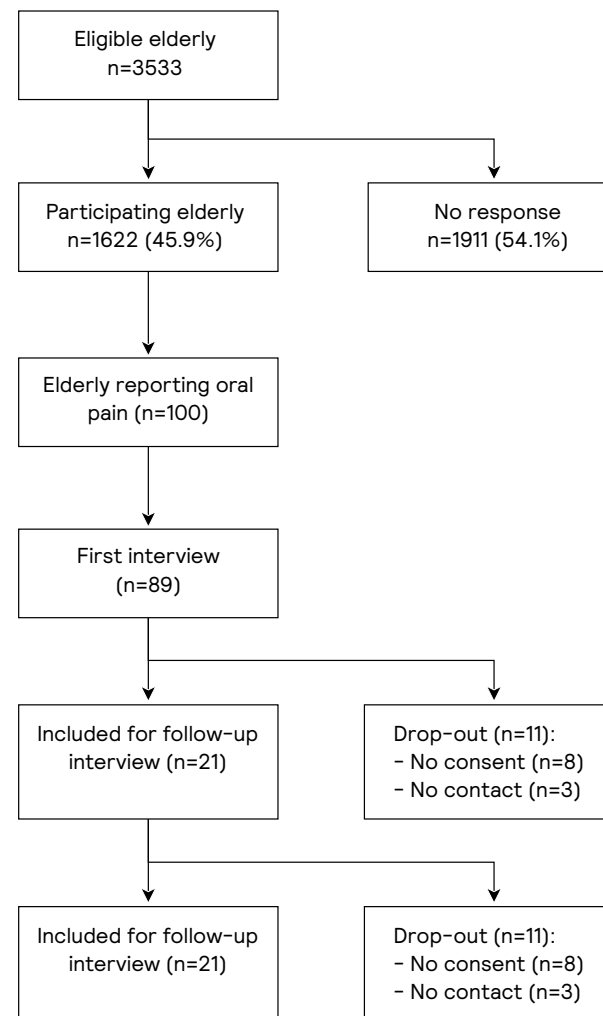


Table 2: First semi-structured interview

First interview (n,%)	Robust (n=54)	Frail (n=9)	Complex (n=26)	Total (n=89)	p-value between groups
Experiencing oral pain at time of interview	16 (29.6%)	2 (22.2%)	11 (42.3%)	29 (32.6%)	0.412
Oral pain lasted >6 weeks	19 (35.2%)	3 (33.3%)	12 (46.2%)	34 (38.2%)	0.631
VAS ¹ pain score (mean, ± SD)	6.1 ± 2.5	6.0 ± 1.4	5.5 ± 1.9	5.8 ± 2.1	0.855
No pain complaint or cannot remember	5 (9.3%)	1 (11.1%)	3 (11.5%)	9 (10.1%)	0.881
Measures taken to relieve oral pain complaints					
Visited the dentist for oral pain complaint	35 (64.8%)	3 (33.3%)	12 (46.2%)	50 (56.2%)	0.100
Other measures (painkillers, mouth rinse)	6 (11.1%)	1 (11.1%)	2 (7.7%)	9 (10.1%)	1.000
Type of oral pain complaint					
Toothache	15 (27.8%)	2 (22.2%)	4 (15.4%)	21 (23.6%)	0.471
Denture-related complaint	10 (18.5%)	3 (33.3%)	9 (34.6%)	22 (24.7%)	0.241
Minor dental complaint	12 (22.2%)	2 (22.2%)	7 (26.9%)	21 (23.6%)	0.893
Complicated pain complaints	6 (11.1%)	-	1 (3.8%)	6 (6.7%)	0.212
Periodontal disease (increased tooth mobility)	3 (5.6%)	1 (11.1%)	1 (3.8%)	4 (4.5%)	1.000
Peri-implant pain (peri-implant tissue)	2 (3.7%)	-	1 (3.8%)	4 (4.5%)	0.545
Fractured teeth, radix relict	1 (1.9%)	-	1 (3.8%)	2 (2.2%)	0.635
Location of the oral pain complaint					
Upper jaw	13 (24.1%)	2 (22.2%)	6 (23.1%)	21 (23.6%)	0.990
Lower jaw	23 (42.6%)	6 (66.7%)	10 (38.5%)	39 (43.8%)	0.326
Both jaws	7 (13%)	-	3 (11.5%)	10 (11.2%)	0.779
Soft tissues	5 (9.3%)	-	3 (11.5%)	8 (9%)	0.750
Not an oral complaint: jaw joint or skin	1 (1.9%)	-	1 (3.8%)	2 (2.2%)	0.635

Dental visits					
Registered with local dentist	47 (87%)	7 (77.8%)	22 (84.6%)	76 (85.4%)	0.668
Recent dental visit (<1 year)	42 (77.8%)	5 (55.6%)	20 (76.9%)	67 (75.3%)	0.350
Transport to local dentist					
Able to visit local dentist independently	47 (87%) ^{a,b}	4 (44.4%)	12 (46.2%)	63 (70.8%)	<0.001
Uses local services	4 (7.4%) ^b	-	7 (26.9%)	11 (12.4%)	0.045
Requires assistance from family or caregiver	3 (5.6%) ^{a,b}	5 (55.6%)	7 (26.9%)	15 (16.9%)	<0.001
Elderly experiencing oral pain during the first interview					
Advised local dentist	10 (18.5%)	1 (11.1%)	8 (30.8%)	19 (21.4%)	0.334
Requires specialist care	1 (1.9%)	1 (11.1%)	-	2 (2.2%)	0.276
Receives specialist care	3 (5.6%)	-	-	3 (3.4%)	0.672
Recent or upcoming dental appointment or no appointment needed	2 (3.7%)	-	3 (11.5%)	5 (5.6%)	0.367

¹ VAS: visual analogue scale

^a Statistically significant difference ($p < 0.05$) between robust and frail elderly

^b Statistically significant difference ($p < 0.05$) between robust and complex elderly

After the interview 21.4% of elderly with oral pain (n=19) were advised to visit a local dentist and 2.2% were advised to return to their dentist and inform if they could be referred to specialist care (n=2), as these elderly had been suffering from oral pain that could not be resolved by their local dentist (e.g. burning mouth problems). All elderly were contacted after six to eight weeks for a follow-up interview.

Follow-up interview

The 21 elderly who were advised to visit a dentist or specialist were telephoned for a follow-up interview, of which 19 elderly could be contacted (Table 3). Most

of these elderly (n=15, 78.9%) had visited or has an upcoming appointment at their dentist or an oral and maxillofacial surgeon. Only four elderly had not visited their dentist. This was because they did not feel the need to visit the dentist and there were other urgent matters.

Discussion

The world population is aging and the number of individuals living in community-dwelling elderly has grown.^{1,2} In addition, as a result of improved dental care, edentulism is decreasing and more elderly people are retaining their natural dentition.⁷ However, frail and care-dependent elderly people are at high risk for oral health problems and pain.¹⁰ Thus far it remains unclear how many community-dwelling elderly experience oral health problems whether they are able to manage their dental care, especially when suffering from oral pain. This study showed that among community-dwelling elderly most reported oral health problems were dry mouth (11.7%) and oral pain (6.2%). Elderly with complex care needs report most frequently oral pain, dry mouth, chewing problems, swallowing problems and a feeling of insecurity. Frail and complex elderly often need assistance of caregivers to visit the dental office.

The prevalence of 6.2% elderly with oral pain differed substantially from the results of Hoeksema et al.,¹⁹ who reported a 22% prevalence of oral pain among a comparable group of elderly. The reason for this difference might be related to the difference in the evaluation period during which oral pain was experienced: in the study of Hoeksema et al., this period was 'during the last two years',¹⁹ while in our study we asked about pain 'during the last three months'. Other studies have shown prevalence of oral pain and/or oral discomfort at time of the questionnaire ranging from 5.4% to 33.6% among community-dwelling elderly.^{17,27}

Another problem with the interpretation of the reported pain prevalence is that most studies do not report symptoms of the oral pain complaint. Only Gluzman et al.⁷ provided insight into the symptoms of the complaint. Among their 125 medically-compromised and homebound elderly they found that 15.1% had toothache. This is comparable to the prevalence of toothache in our study (21.3%) which was the second most frequently reported pain complaint, after denture-related pain complaints (24.7%).

Table 3: Second semi-structured interview

Second interview (n,%)	Robust (n=10)	Frail (n=1)	Complex (n=8)	Total (n=19)	p-value between groups
Still experiencing pain	10 (100%)	1 (100%)	4 (50%)	15 (78.9%)	0.033
VAS ¹ pain (mean, SD)	4.8 ± 2.0	2	5 ± 1.6	4.9 ± 1.8	0.391
Visited a dentist or has an appointment	7 (70%)	1 (100%)	7 (87.5%)	15 (78.9%)	0.675
Transport to local dentist					
Able to visit local dentist independently	2 (20%)	-	5 (62.5%)	7 (36.8%)	0.303
Uses local services for transport	-	1 (100%)	-	1 (5.3%)	0.091
Required assistance from family or caregiver	2 (20%)	-	1 (12.5%)	2 (10.5%)	0.636
Reasons for not visiting the dentist					
No urgency, other (health) problems require more attention	3 (30%)	-	1 (12.5%)	4 (21%)	1.000

¹ VAS: visual analogue scale

Previous studies using these the same risk profiles (robust, frail and complex care needs) among community-dwelling elderly as has been used in our study show similar outcome: frail elderly and elderly with complex care needs show worse general (activities of daily living, quality of life) and oral health outcomes^{19,28} when compared to robust elderly. Other studies have shown similar results among older adults with increasing frailty.^{27,29}

Wan et al. studied 200 community-dwelling elderly with orofacial pain.³⁰ They reported that 10.5% of the community-dwelling elderly could not remember the onset of the pain, comparable to 10.1% of the elderly reporting oral pain in our study who could not remember their oral complaint. This consistent result might be due to an age-related mild memory loss. This means that self-assessment questionnaires given to the elderly should be interpreted with caution because the answers could be biased. Questions on more recent events (e.g., a few weeks in the past) might reduce the risk of such a bias.

This study has shown that 75% of the elderly who live independently at home and feel the need to receive dental care are able to visit the dentist in the Netherlands. Almost 70% of them were still able to visit the dentist independently.

The study of Skaar and O'Conner in the US showed that only 46% of community-dwelling elderly yearly visited the dentist.¹³ These differences in dental care use may be explained by the fact that in the past when these elderly were young, dental care was provided by the healthcare system in the Netherlands and these elderly are used to regularly visit the dentist. Next, the elderly in our study were suffering from oral pain, which resulted understandably in a higher need for dental treatment and therefore resulted in higher dental care use.

During the second interview, some elderly indicated that they had not visited the dentist or maxillofacial surgeon. The reason for not visiting the dentist or specialist was that elderly felt no need at the moment and had other problems (usually health problems) that required more attention. Similar conclusions were reached in the study of Gaszynska et al.³¹ involving care home residents. Elderly who did not visit the dentist within the last 12 months reported that they experienced problems with accessibility, had other major health problems or felt no need to visit the dentist. Their study population lived in a residential care home, which may have affected the high number of elderly reporting difficulties visiting the dentist. Because these elderly did not live independently at home, they required more help with transportation to visit the dental office. This is in contrast to our study population of elderly living independently at home. When our study population grows older and cannot longer live independently at home, they might encounter the same issues with transport to the dentist.

Strengths and limitations

The strength of this study is the large study population and the focus in this study on oral pain which is thus far hardly described in literature, making this study unique. The limitation is the rather low response rate (45.9%). These relatively low response rates are commonly seen in elderly research projects.³²⁻³⁴ It is most likely that the elderly who did not return the questionnaire and did not participate in this study are older, more frail and have higher needs for complex care. It is very likely that these community-dwelling elderly also have more oral health problems, more oral pain complaints and more problems visiting the dentist.

Elderly are often facing many difficulties with their general health. It seems that oral health in the elderly population when compared to other big health issues is not a first a priority.³⁵ Another possible limitation is the use of self-assessment questionnaires and structured interviews to assess oral health. Even though the structured interview was performed by a researcher who was a dentist, no intra-

oral examination was conducted, which means that the reported symptoms could not be confirmed clinically.

Conclusion

Dry mouth and oral pain are the most reported oral health problems among community-dwelling elderly. Elderly with complex care needs report most oral health problems. In case an elderly seeks dental treatment to alleviate an oral pain complaint, most elderly in this study were able to organize dental care and transport to the dentist. Frail and complex elderly often need assistance from caregivers to visit the dentist.

Clinical significance

As long as elderly live independently at home and feel a personal need to receive dental care, they are able to manage their dental care. Elderly with complex care needs report more oral health problems. Therefore healthcare professionals should keep in mind that when frailty progresses, visiting the dentist may become more and more difficult and the risk for poor oral health increases.

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Chapter 6

Are edentulousness, oral health problems and poor health-related quality of life associated with malnutrition in community-dwelling elderly (aged 75 years and over)? A cross-sectional study

Mieke H Bakker

Arjan Vissink

Sophie LW Spoorenberg

Harriët Jager-Wittenaar

Klaske Wynia

Anita Visser

This chapter is an edited version of the manuscript:

Nutrients 2018;10:1965

Abstract

Background As the population ages, the risk of becoming malnourished increases. Research has shown that poor oral health can be a risk factor for malnutrition in institutionalized elderly. However, it remains unclear whether oral health problems, edentulousness and health-related quality of life also pose a risk for malnutrition in community-dwelling older adults.

Materials and methods In this cross-sectional observational study, 1325 community-living elderly (aged ≥ 75 years) were asked to complete questionnaires regarding nutritional status, oral status (natural dentition, edentulous with conventional denture, or implant-supported overdenture (IOD)), oral health problems, health-related quality of life (HRQoL), frailty, activities of daily living (ADL) and complexity of care needs. Univariate and multivariate logistic regression analyses were performed with nutritional status as dependent variable.

Results Of the respondents, 51% (n=521) were edentulous, 38.8% (n=397) had a natural dentition and 10.2% (n=104) had an IOD. Elderly with complex care needs were malnourished most frequently, followed by frail and robust elderly (10%, 4.5% and 2.9%, respectively). Malnourished elderly reported more frequent problems with chewing and speech when compared with well-nourished elderly (univariate analysis). However, multivariate analysis did not show an association between malnutrition and oral health problems and edentulousness, although HRQoL was associated with malnutrition (odd ratio (OR) 0.972, confidence interval (CI) 0.951-0.955).

Conclusions Based on the results of this cross-sectional study, it can be concluded that poor HRQoL is significantly associated with malnutrition; however, edentulousness and oral health problems are not.

Introduction

Worldwide, life expectancy is increasing.¹ This also applies to the northern region of the Netherlands; 30% of the regional inhabitants will be >65 years by 2020.² Staying vital and healthy during aging is challenging for many elderly, as many chronic diseases (e.g., diabetes, mental disease, coronary artery disease, organ problems, cancer) and health-related problems (e.g., malnutrition) commonly develop.^{3,4} Usually, more than one chronic disease is present in elderly, a condition known as multimorbidity. Multimorbidity is frequently accompanied by polypharmacy, i.e., the use of multiple medicines. Recent studies have shown that the prevalence of multimorbidity and polypharmacy rapidly increases with age.^{5,6}

Multimorbidity, polypharmacy, advanced age, and frailty are associated with an increasing risk of becoming malnourished.⁷⁻¹¹ Among community-dwelling elderly aged ≥ 75 years, the prevalence of malnutrition is 2.6% and increases rapidly when elderly become institutionalized or hospitalized (13.8% and 38.7%, respectively).⁷⁻⁹ Preventing malnutrition is crucial in this vulnerable group; malnutrition is associated with lower activities of daily living (ADL), lower quality of life (QoL), longer hospital stay and rehabilitation, higher risk of falls, higher infection rates, poor wound healing and higher mortality rates.¹²⁻¹⁶

The causes of malnutrition are multifactorial.¹⁷ Oral health problems such as tooth loss, toothache and chewing complaints are mentioned as contributing factors to malnutrition, especially in institutionalized elderly.^{18,19} In this context it should be noted that the oral health of institutionalized elderly is generally poor, and that this poor oral health is usually present at the time of admission.²⁰ This indicates that poor oral health develops before elderly are admitted to a nursing home. A recent study showed that community-dwelling elderly with a natural dentition or implant-supported overdentures (IOD) are less frail and have a better QoL than edentulous elderly.²¹ This raises the following two questions. In a community-dwelling population, (1) does retaining one's natural dentition or having an IOD at older age also limit the risk of being malnourished? (2) are oral health problems (e.g., masticatory problems and dental pain) and a low health-related quality of life (HRQoL) associated with the risk of being malnourished? To address these questions, we assessed whether oral status (natural dentition, edentulous with conventional denture or an IOD), oral health problems and low HRQoL are associated with malnutrition in community-dwelling elderly aged ≥ 75 years.

Materials and Methods

Study design and participants

We performed a cross-sectional study among community-dwelling eligible elderly (n=1325) participating in Embrace ('SamenOud' [translated into English as 'ageing together']). These elderly were patients of general practitioners (GPs) enrolled in Embrace. For details see the extensive description of the program Embrace published elsewhere.²²⁻²⁵ The Medical Ethical Committee of the University Medical Center Groningen, Groningen, the Netherlands, assessed the study proposal and concluded that formal approval was not required (reference METc2011.108). The study was performed in accordance with the principles expressed in the Declaration of Helsinki.

Procedure and assessments

Between June 2015 and November 2015, demographic characteristics such as age, sex, marital status, living situation, education level, income, and health (underlying diseases, use of drugs) were collected at baseline, along with data from four validated health-related questionnaires:

- Frailty was assessed by the Groningen Frailty Indicator (GFI) (26). This instrument assesses physical and psychological frailty among elderly. The total score ranges from 0–15, with a higher score indicating a higher level of frailty. Someone with a score of ≥ 5 was regarded as frail.²⁶
- The INTERMED for the Elderly Self-Assessment (IM-E-SA) was used to assess the complexity of care needs.²⁷ It consists of 20 questions in four domains: biological, psychological and social needs, and healthcare. The total score ranges from 0–60, with a higher score indicating more need for complex care. Someone with a score of ≥ 16 was regarded as in need of complex care.
- The level of dependency in activities of daily living was assessed using the Katz-15.²⁸ This index includes six physical ADL items, seven instrumental ADL activities and two additional ADL items. The total score ranges from 0–15, with a higher score indicating more dependency in performing daily activities.
- EuroQoL-5D (EQ-5D) was used to assess health-related quality of life (HRQoL).²⁹ It consists of five questions: mobility, self-care, pain, usual

activities and psychological status. The total score ranges from 0–1, with a higher score indicating a better perceived HRQoL. The second part of the EQ-5D is a Visual Analogue Scale (VAS). This EQ VAS was used to mark current health status on a 20 cm vertical scale, with end points of 0 and 100. A higher score indicates a better HRQoL.

Risk profiles

Based on scores of IM-E-SA and GFI, participants were classified into three groups: robust elderly, frail elderly and elderly with complex care needs. Robust elderly were defined as not having complex care needs and low levels of frailty (IM-E-SA < 16 and GFI < 5). Frail elderly were defined as having a higher level of frailty, but low level of complex care needs (IMESA < 16 and GFI ≥ 5). Elderly with complex care needs were defined as having substantial and ongoing healthcare needs, often resulting from chronic illness or disabilities (IM-E-SA ≥ 16).

Nutritional status, oral status and self-reported oral health

All 1325 participants within Embrace and with a baseline assessment received an additional questionnaire consisting of 10 questions related to nutritional status and 13 questions on oral status, oral health, dental care and oral function. In case a questionnaire was incomplete, elderly were telephoned and interviewed so they could complete the questionnaire. If completing a questionnaire was not possible, the participant was excluded from this study.

- The nutritional status questionnaire included self-reported body length, current body weight, and body weight one and six months ago and ability to eat. Nutritional status was defined as being malnourished (according to the guidelines of the Dutch Malnutrition Steering Group) or well-nourished.³⁰ Malnutrition was assessed according to the guidelines of the Dutch Malnutrition Steering Group, which states that malnutrition among elderly aged ≥ 75 years is defined by a set of risk indicators of malnutrition: a BMI < 20 kg/m² and/or unintentional weight loss of $> 5\%$ in one month and/or unintentional weight loss of $> 10\%$ in six months.³⁰
- The oral status and oral health questionnaire²¹ included presence of a natural dentition, an IOD or edentulous (conventional denture). Oral health was assessed by presence or absence of problems related to pain or dry mouth, oral function (masticatory and speech problems), and oral self-care (cleaning

habits, dental visits). In addition, participants were asked to rate their satisfaction with their oral status on a 10-point scale, ranging from 0 (very poor) to 10 (very good). Previous research showed that elderly experienced no problems with completing these questionnaires.²¹

Statistics

SPSS IBM Statistics version 23.0 (SPSS, Chicago, IL, USA) was used for statistical analysis of the results. Chi² tests and Fisher's exact tests were used to analyze differences between subgroups risk profile and oral status. Demographic variables, oral status, risk profiles, general health and oral health were analyzed for differences between malnourished and well-nourished elderly using Mann-Whitney U-tests and Chi² tests. For non-normally distributed variables median and interquartile ranges (IQR) were reported as measures of dispersion. A *p*-value <0.05 was defined as statistically significant. If more than two groups were compared (e.g. oral status, risk profile), the Fisher-Freeman-Halton test was applied. Post hoc analysis per group was performed with Mann-Whitney U-tests or Chi² tests, depending on normally or non-normally distributed variables.

Univariate logistic regression models were constructed to determine the odds ratio (OR) between the dependent variable (nutritional status) and independent variables, i.e., demographics (education and marital status), oral health (chewing problems, speech problems, eating problems) and general health (Katz-15 and EQ-5D). A multivariate logistic regression was used to control for a confounding effect. In this model, the statistically significant independent variables (*p* < 0.05) of the univariate logistic regression model were entered in the multivariate analysis. Adjusted OR and corresponding 95% confidence intervals (CI) were determined. The Wald test (*p* < 0.05) was used to determine whether the effect was significant. Multicollinearity was tested and was regarded a problem when Tolerance was <0.1 or the variance inflation factor >10. These values were not seen for our variables, but after careful consideration it was decided to enter only the GFI and IM-E-SA scores, while the risk profiles (based on the scores of GFI and IM-E-SA) were not entered in the multivariate model to prevent the incorrect interpretation of multivariate analysis.

Results

Respondents

All 1325 elderly were eligible and were invited to participate (Figure 1) in this study. A total of 78.6% (n=1041) gave their consent and returned the questionnaires. Out of 284 not participating patients, 18.8% (n=249) were not willing to complete the questionnaires and 2.6% (n=35) did not participate for unknown reasons. Another 1.4% (n=19) had to be excluded due to missing or incomplete data. This resulted in a total of 1022 participating elderly (response rate 77.1%).

Patient characteristics and nutritional status

Table 1 shows the patient characteristics and differences in characteristics between malnourished and well-nourished participants. In total, 4.8% of the participants were malnourished. Significantly more elderly in the malnourished group lived alone or were single and had a low education level compared to those in the well-nourished group.

Figure 1: Flow diagram of patient inclusion process

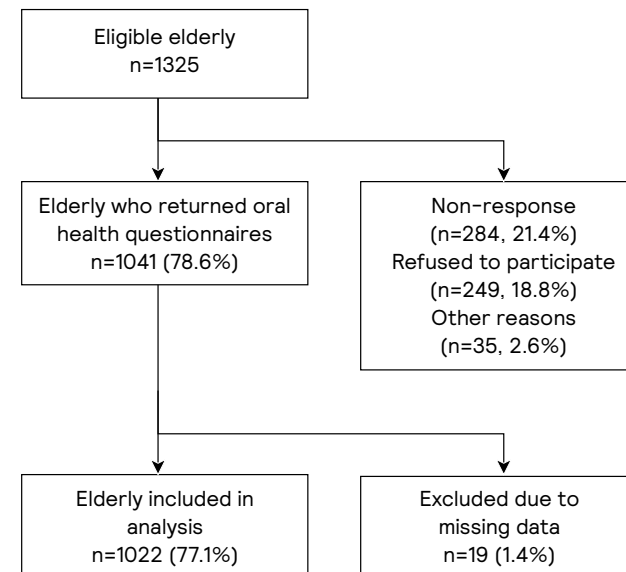


Table 1: Nutritional status and patient-characteristics.

Patients	Malnourished (n=49, 4.8%)	Well-nourished (n=973, 95.2%)	Total (n=1022)	p-value between nutritional status
Demographics				
Age (median, IQR)	80 (77-84)	81 (79-85)	80 (77-84)	0.208
Sex (women)	35 (71.4%)	563 (57.9%)	598 (58.6%)	0.074
Marital status - widow, divorce, single	31 (63.3%)	429 (44.2%)	460 (45.1%)	0.009
Sheltered home ^a	7 (14.3%)	96 (9.9%)	103 (10.1%)	0.327
Low education level ^b	28 (58.2%)	387 (39.8%)	415 (40.7%)	0.011
Low income ^c	18 (48.6%)	301 (38.9%)	319 (39.3%)	0.235
Oral status				
Natural dentition	20 (40.8%)	377 (38.7%)	397 (38.8%)	0.772
Edentulous	24 (49%)	497 (51.1%)	521 (51%)	0.774
IOD	5 (10.2%)	99 (10.2%)	104 (10.2%)	1.00
Risk profile				
Complex	22 (44.9%)	197 (20.2%)	219 (21.4%)	≤0.001
Frail	10 (20.8%)	214 (22.0%)	224 (21.9%)	0.850
Robust	17 (35.4%)	562 (57.8%)	579 (56.7%)	0.002
General health				
Polypharmacy ^e	32 (66.7%)	550 (56.6%)	582 (56.9%)	0.168
Number of chronic conditions (median, IQR) ^d	2 (1-4)	2 (1-3)	2 (1-3)	0.761
Frailty (GFI, median, IQR) ^f	5 (3-7)	4 (2-6)	4 (2-6)	≤0.001
Complex care (INTERMED, median, IQR) ^g	13 (9-18.5)	10 (6-14)	10 (6-15)	0.001
Activities of daily living (Katz-15, median, IQR) ^h	2 (0-4)	1 (0-3)	1 (0-3)	0.004
Health-related quality of life (EQ-5D, median, IQR) ⁱ	0.775 (0.610-0.843)	0.807 (0.719-0.893)	0.807 (0.693-0.861)	0.004
Health-related quality of life (EQ VAS, median, IQR) ^j	60 (50-72.5)	75 (60-80)	75 (60-80)	≤0.001
Oral health				
Irregular dental visits ^k	21 (42.9%)	462 (47.5%)	483 (47.3%)	0.527

Poor oral hygiene ^l	4 (8.2%)	33 (3.2%)	33 (3.2%)	0.068
Chewing problems ^m	12 (24.5%)	104 (10.7%)	116 (11.4%)	0.003
Eating problems ^m	5 (10.2%)	22 (2.3%)	27 (2.6%)	0.008
Speech problems ^m	2 (4.1%)	5 (0.5%)	7 (0.7%)	0.041
Recent history of dental pain (<6 months)	8 (16.3%)	98 (10.1%)	106 (10.4%)	0.154
Dry mouth during day or night ^m	15 (30.6%)	207 (21.5%)	222 (21.7%)	0.124
Dry mouth during day ^m	3 (6.1%)	75 (7.7%)	78 (7.6%)	1.000
Dry mouth during night ^m	13 (26.5%)	189 (19.5%)	202 (19.8%)	0.226
Insecurity ^{m,n}	2 (4.1%)	16 (1.6%)	18 (1.8%)	0.213
Satisfaction (median, IQR) ^o	8 (7-8)	8 (7-8)	8 (7-8)	0.410

^a Sheltered home: living in a sheltered accommodation or a home for the elderly. ^b Low education level: (less than) primary school or low vocational training. ^c Low income: <€1450 per month. ^d Number of chronic diseases: total number of present chronic diseases out of listing of 18 chronic diseases (e.g., diabetes mellitus, osteoporosis). ^e Polypharmacy: use of more than four drugs. ^f GFI: Groningen Frailty Indicator. ^g IM-E-SA: INTERMED for the Elderly Self-assessment. ^h Katz-15: Katz extended. ⁱ EQ-5D: EuroQoL-5D. ^j EQ VAS: EuroQoL Visual Analogue Scale. ^k Irregular dental visit: not visiting a dentist over the past 2 years. ^l Poor oral hygiene: not brushing at least once a day. ^m Complaint is 'often' or 'very often'. ⁿ Feeling insecure or ashamed about oral status. ^o Feeling satisfied with oral status (range 0-10, higher score means more satisfied)

Higher scores of GFI and IM-E-SA were found among malnourished elderly. Katz-15 scores were higher, while EQ-5D and EQ VAS were significantly lower in the malnourished group. Complaints with chewing, eating hard foods and speech problems were reported significantly more often by malnourished elderly.

Risk profile and malnutrition

Nutritional levels differed significantly between risk profiles (Table 1). To gain further insight into this observation, risk profiles were defined as dependent variables in Table 2. Based on their levels of frailty and need for complex care, participants were assigned to the robust, frail and complex care needs groups. The robust group consisted of 579 participants (56.7%), the frail group of 224 (21.9%) and the complex care needs group of 218 (21.4%). The robust group

consisted of significantly more participants with a natural dentition and fewer edentulous elderly than the frail and complex group. Malnutrition was most frequent in the complex group (10%) when compared to the frail (4.5%) and robust (2.9%) groups.

Univariate and multivariate logistic regression analysis

Table 3 shows results of the univariate and multivariate logistic analysis with nutritional status as dependent variable. Univariate analysis showed that marital status and education were both associated with nutritional status. Single-living (OR 2.176) and a low education level (OR 2.116) showed a higher risk of malnutrition. No significant differences in oral status were found. The risk profiles robust and complex (OR 3.692) showed a statistically significant difference in nutritional status ($p \leq 0.001$). Higher GFI, IM-E-SA and Katz-15 scores and lower EQ-5D and EQ VAS scores showed an increased risk for malnutrition. The multivariate analysis using nutritional status as a dependent variable is shown in the right column. When controlling for confounding variables in the model, only the EQ VAS (HRQoL) remained statistically significant as a risk factor for malnutrition (OR 0.972, 95% CI 0.951-0.995; $p=0.015$).

Table 2: Overview of risk profiles and oral status and malnutrition.

Patients	Complex (n=219, 21.4%)	Frail (n=224, 21.9%)	Robust (n=579, 56.7%)	Total (n=1022)	p-value between subgroups risk profile
Oral status					
Natural dentition	76 (34.9%) ^b	71 (31.7%) ^c	249 (43%)	387 (38.8%)	0.005
Edentulous	125 (57.3%) ^b	133 (59.4%) ^c	263 (45.4%)	521 (51%)	≤ 0.001
IOD	17 (7.8%)	20 (8.9)	67 (11.6%)	104 (10.2%)	0.228
Total	219 (100%)	224 (100%)	579 (100%)	1022 (100%)	0.002
Malnutrition					
Malnutrition	22 (10%) ^{a, b}	10 (4.5%)	17 (2.9%)	49 (4.8%)	≤ 0.001

^a $p < 0.05$ Complex and frail elderly

^b $p < 0.05$ Complex and robust elderly

^c $p < 0.05$ Frail and robust elderly

Discussion

This study focused on malnutrition and associating factors among community-dwelling elderly aged ≥ 75 years. We found a general prevalence of malnutrition of about 5% for community-dwelling elderly, which is in accordance with previous research.^{8,31} Oral health complaints were reported more frequently by malnourished elderly. However, in a multivariate model, oral health complaints and edentulism were not significantly associated with malnutrition, while a low HRQoL was.

The prevalence of malnutrition was higher in complex care elderly than in robust and frail elderly. This higher prevalence of malnutrition in elderly with complex care needs is associated with their greater number of comorbidities and substantial healthcare needs.^{32,33} This might be due to the fact that robust elderly have a better general health (i.e., less polypharmacy, fewer comorbidities), a more independent ADL and a higher QoL when compared to elderly with complex care needs.²¹ These more favorable conditions probably result in a more resilient health status for the robust elderly, which makes them less vulnerable to potential health risks such as malnutrition. Frail elderly are less independent than robust elderly, but do not appear to be at greater risk for malnutrition. Elderly with complex care needs already have to cope with deteriorating general health and a more dependent ADL level, and are at higher risk for malnutrition.

Complaints about chewing, eating hard foods and speech problems were reported significantly more often by malnourished elderly. However, the multivariate analysis malnutrition did not show a significant association with oral health, which might seem to be inconsistent, as chewing problems and edentulousness and malnutrition are often related.³⁴ This lack of a significant association might be due to interactions amongst variables. This issue was also mentioned by El Osta et al.³⁵ They reported that tooth loss and loss of functional units (FTU) resulted in a higher risk for malnutrition among older adults. Similar to our study, their univariate analysis revealed that the subjective oral health indicators, prosthetic status and FTUs were statistically associated with malnutrition, while oral status was no longer an independent risk factor when applying a multivariate analysis. The number of FTUs could not be taken into account in our study, as we only used self-reported data. The edentulous elderly were those elderly who reported the absence of all their teeth. The Dutch health insurance reimburses most of the costs for a complete denture. Therefore, it is standard care in the Netherlands that edentulous patients are provided with a complete

Table 3: Univariate and multivariate^a logistic regression analysis using nutritional status as dependent variable.

	Univariate logistic regression analysis			Multivariate logistic regression analysis				
	B (SE)	OR ^b	95% CI ^c	p-value	B (SE)	OR ^b	95% CI ^c	p-value
Demographics								
Age	0.029	1.026	0.969 – 1.085	0.380				
Sex	0.272	1.816	0.965 – 3.419	0.065				
Marital status: single, widow, divorced	0.240	2.176	1.201 – 3.943	0.010	0.329	1.714	0.899 – 3.268	0.101
Living status: sheltered	0.422	0.658	0.287 – 1.504	0.321				
Low education level	0.300	2.116	1.175 – 3.810	0.012	0.325	1.691	0.895 – 3.195	0.105
Low income	0.337	1.489	0.769 – 2.882	0.238				
Oral status								
Edentulous (reference)		1	-	-				
Natural dentition	0.310	1.099	0.598 – 2.018	0.762				
IOD	0.504	1.046	0.390 – 2.807	0.929				
Risk profile								
Robust (reference)		1	-	-				
Complex	0.333	3.692	1.921 – 7.096	≤0.001				
Frail	0.407	1.545	0.696 – 3.427	0.285				
General health								
Chronic conditions ^d	0.077	1.072	0.922 – 1.246	0.366				
Polypharmacy ^e	0.313	0.652	0.353 – 1.203	0.171				
Frailty (GFI)^f								
Frailty (GFI) ^f	0.050	1.218	1.106 – 1.342	≤0.001	0.085	1.068	0.904 – 1.262	0.437
Complex care (IM-E-SA) ^g	0.021	1.070	1.027 – 1.115	0.001	0.038	0.973	0.903 – 1.049	0.481
ADL (Katz-15) ^h	0.047	1.157	1.055 – 1.267	0.002	0.078	0.977	0.839 – 1.137	0.763
Health-related quality of life (EQ-5D) ⁱ	0.736	0.067	0.016 – 0.285	≤0.001	1.348	0.339	0.024 – 4.763	0.423
Health-related quality of life (EQ VAS) ^j	0.008	0.963	0.947 – 0.979	≤0.001	0.011	0.972	0.951 – 0.995	0.015
Oral health								
Irregular dental visits	0.296	0.830	0.465 – 1.481	0.527				
Poor oral hygiene	0.555	2.893	0.975 – 8.583	0.055				
Chewing problems	0.348	2.707	1.368 – 5.354	0.004	0.438	2.014	0.853 – 4.753	0.110
Eating problems	0.519	4.907	1.775 – 13.567	0.002	0.714	1.478	0.365 – 5.994	0.584
Speech problems	0.850	8.230	1.556 – 45.533	0.013	1.001	5.630	0.791 – 40.070	0.084
Recent dental pain	0.401	1.738	0.792 – 3.814	0.168				
Dry mouth during day or night	0.320	1.628	0.870 – 3.047	0.127				
Insecurity ^k	0.765	2.540	0.567 – 11.370	0.223				
Satisfaction ^l	0.115	0.888	0.709 – 1.112	0.301				

^a R²=0.114 (Nagelkerke), 0.036 (Cox&Snell) χ^2 0.212

^b OR: Odds ratio.

^c 95%CI: 95% confidence interval.

^d Number of chronic diseases: total number of present chronic diseases out of listing of 18 chronic diseases (e.g., diabetes mellitus, osteoporosis).

^e Polypharmacy: use of more than four drugs.

^f GFI: Groningen Frailty Indicator.

^g IM-E-SA: INTERMED for the Elderly Self-assessment.

^h Katz-15: Katz extended.

ⁱ EQ-5D: EuroQoL-5D.

^j EQ VAS: EuroQoL Visual Analogue Scale.

^k Feeling insecure or ashamed about oral status.

^l Feeling satisfied with oral status (range 0-10, higher score is more satisfied)

denture. However, it is unclear how often dentures are worn. Sometimes, only the upper denture is worn or the denture is worn for a limited amount of time during the day.³⁶ We would suggest future research to focus on the number of FTUs (especially during eating), next to oral status and oral health.

HRQoL, determined by the EQ VAS, showed a significant association with malnutrition in both the univariate and multivariate models. Previous research showed that 28% of the variability of HRQoL can be explained by the Oral Health Related Quality of Life (OHRQoL).³⁷ Specific oral health-related problems, i.e. speech and chewing problems, were reported in this study and showed a significant association initially, and may have affected the OHRQoL and ultimately the HRQoL. An interesting topic for future research would be to determine the influence of these reported oral health problems on both OHRQoL and HRQoL, and their effect on malnutrition. Additional research within large groups of malnourished elderly regarding oral health and oral status would also be of interest.

Strengths and limitations

The main strengths of the study are the large study population and high response rate. The study population provides credible insight into general and oral health of elderly living at home. It is a good representation of the current population of community-dwelling elderly and both their oral and general health status. Respondents differed significantly from non-respondents in regards to age, education, living status, income and polypharmacy (data not shown). The non-respondents were older, had a lower education level and lower monthly income, lived more often in a sheltered community and used more medication. Only demographic characteristics of the non-respondents were available.

A limitation is related to the low prevalence of malnutrition ($\approx 5\%$) in the elderly assessed, resulting in a low predictive value for the defined associated factors. The small numbers of elderly with malnutrition may have influenced extrapolation of the univariate and multivariate logistic analyses. Finally, our study was a cross-sectional study, and malnutrition can be a temporary state, and the results should be interpreted with this in mind. Future research should therefore focus on a larger group of community-dwelling elderly who are followed for a specific period (cohort study) in which the effect of oral status, oral health problems and (oral) HRQoL on nutritional status can be observed over time. Furthermore, following a population over time enables the determination of risk factors for malnutrition instead, and not just associating factors.

Clinical implication

Malnutrition is usually related to a decline in general health in elderly. Although our study did not show that edentulism is associated with malnutrition, malnutrition is associated with poor HRQoL. Maintaining good oral health (absence of pain, inflammation and tooth decay) and oral function (chewing ability and aesthetics) are presumably a relevant contributing factor to maintaining a high level of OHRQoL and HRQoL. Therefore, care professionals should focus on maintaining good oral health and a high HRQoL.

Conclusions

Based on the results of this cross-sectional study edentulousness and self-reported oral health problems are not associated with malnutrition, however, a poor HRQoL is.

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Chapter 7

General discussion

General discussion

The improvements in dental care in recent decades have resulted in a growing proportion of elderly who have retained their natural dentition until high age. In the event that elderly become edentulous and experience denture problems, dental implants are placed to retain an overdenture. The number of elderly provided with such overdentures has increased rapidly, resulting in three sub-groups in the elderly population with differing oral status: those with a natural dentition, an implant-retained overdenture (IOD) or a conventional denture. It is often suggested that retaining a natural dentition is favorable for social wellbeing and general health. It is unknown, however, whether oral status is associated with general health. The general aim of the studies described in this PhD thesis was therefore to assess the association between oral status (natural dentition, conventional denture, IOD) and general health, frailty, quality of life, nutritional status, oral pain complaints and dental care utilization of elderly (aged ≥ 75 years). In addition, it was assessed whether the placement of dental implants to retain an overdenture, a treatment that is known to improve oral function and quality of life, has a positive effect on general health and whether this dental concept remains successful in the long term (≥ 20 years) when elderly tend to become frail. The main outcomes of this PhD study were:

- Elderly with a natural dentition have better general health on average than edentulous elderly.
- At the time of implant placement, elderly who received implants to retain an IOD have a general health that is on average similar to the health of elderly with a natural dentition.
- The general health profile of elderly with an IOD declines at a higher rate than that of elderly with a natural dentition and ultimately resembles the health profile of elderly with a conventional denture.
- Dental implants to retain an IOD are successful in the long term, even in frail elderly.

These major research outcomes – and additional minor outcomes – are described in detail in the previous chapters of this theses and are discussed in general terms in the present chapter.

Oral status and general health

To gain insight into the association between oral status and general health, an eight-year, prospective follow-up, big data study was conducted with three cohorts of elderly (Chapter 2). At baseline, these cohorts consisted of 143 199 elderly with a natural dentition, 18 420 elderly with a conventional denture and 6 503 elderly with implants to retain an overdenture (IOD). During the eight-year period of the study, elderly with a natural dentition had on average better general health outcomes and lower medication use than elderly with an IOD or conventional denture. For example, the prevalence of cardiac disease, diabetes and medication use was significantly lower in elderly with a natural dentition than in edentulous elderly. Further analyses showed that general health at baseline of elderly who received implants to retain an overdenture resembled the general health profile of elderly with a natural dentition. This health advantage, however, declined with time: during eight-year follow-up, the general health profile of elderly with implants to retain an IOD gradually became similar to that of edentulous elderly with conventional dentures. The better general health at baseline of elderly with an IOD might be related to patient selection for IOD treatment.

Based on one of our studies (Chapter 3), it became clear that elderly who were provided with an IOD were relatively young and healthy when compared to elderly with conventional dentures. We hypothesized that dentists might be reluctant when recommending or placing dental implants in frail elderly and/or other medically compromised patients. Elderly who receive dental implants presumably belong to a healthier subset of edentulous elderly, so it is not surprising that the general health of elderly with IODs declined more rapidly after a certain age and became similar to the general health of elderly with conventional dentures.

Another factor that might explain this decline in general health of elderly with IODs is that lifestyles and diets of edentulous elderly are less conducive for maintaining a favorable general health status. Edentulous elderly often choose softer and less healthy foods than elderly with a natural dentition.¹ This might be a result of the, on average, lower socioeconomic status of edentulous elderly (Chapter 2). Lower SES is associated with lower food expenditure and purchasing of unhealthier food,² but also higher prevalence of smoking and lower physical activity.³ Such unhealthier food and lifestyle choices can, for example, be related to a lack of knowledge and limited access to information about healthy lifestyles.⁴

An important observation in our study was that the well-supported positive effect of IODs on masticatory performance and oral function,⁵⁻⁸ as assessed by multiple studies in this domain, did not always result in improved lifestyles of these elderly and therefore did not improve general health outcomes. In this respect, since IOD wearers have better masticatory performance on average than conventional denture wearers, it would be interesting to determine whether active dietary/lifestyle coaching for IOD wearers might positively influence general health outcomes.

Oral status and healthcare use

The studies reported in this PhD thesis showed similarities in general healthcare use between the three groups of elderly with differing oral status (Chapters 2 and 3). General practitioners and medical specialists were visited at least once a year by more than 85% of all elderly over a period of eight years, and no differences in this respect were found between elderly with a natural dentition, conventional denture or IOD. These favorable findings on healthcare use might be a result of the Dutch healthcare system. Basic health insurance covering all costs for general practitioners, medical specialists, hospitalization and admittance to nursing homes is compulsory in the Netherlands, which apparently favors timely healthcare use.

However, dental care use among these elderly is lower. Over a period of eight years, dental care use, which was 100% at baseline in our cohort because of the design of the study, dropped to 67% in elderly with a natural dentition, to 10% in elderly with conventional dentures, and to 26% in elderly with IODs. Although elderly with a natural dentition would be expected to continue visiting their dentists for at least routine check-ups, as they become frail, other medical matters may become more urgent and interfere with visiting a dentist.⁹ Frailty-related factors are commonly cited as reasons why elderly stop visiting their dentists.⁹ In this respect it is also important to realize that for dental consultations, elderly have to visit a dental practice, while for medical care the family doctor can visit the elderly at home (or at the nursing home). Since the study population was followed over eight years and were all aged ≥ 75 years at baseline, it is likely that many elderly developed health-related and frailty-related difficulties over time. The relatively small group of elderly with conventional dentures who visited their dentists probably did so only in case of a problem, for example when their denture fractures or needs rebasing. Notably, a lower percentage of elderly with IODs continued to visit a dentist, which is also worrying. For patients with IODs,

clinical maintenance guidelines are in place that are established by the Dutch Association of Oral Implantology (NVOI). These guidelines emphasize that patients with dental implants require a general check-up at least once a year.^{10,11} Regular visits to a dentist by IOD wearers is considered important to ensure healthy peri-implant tissue and a correctly functioning overdenture.¹² If IOD wearers visit the dentist only when prosthetic or oral problems occur, this delay might result in the loss of implants, which could have been prevented with timely measures. Many elderly may be insufficiently aware of the potential risks of implant loss and the importance of aftercare. Although clinical guidelines are available, the importance of annual dental visits is apparently not widely known among older adults. It is possible that many elderly believe that regular dental care is required only for patients with a natural dentition. Dentists should contact IOD wearers if they fail to appear for their routine annual visit.

Another interesting difference between elderly with differing oral status concerns the admittance of patients from these groups to nursing homes. Unfortunately, the Vektis database could only provide data on nursing home admissions from 2012 to 2016, but even this short period showed that a higher percentage of elderly with conventional dentures were admitted to nursing homes than elderly with a natural dentition or IOD. The, on average, poorer general health of elderly with conventional dentures might play an important role in this difference. As IOD treatment can be invasive and requires a lot of effort from patients, it is not often recommended for elderly who are increasingly frail and require more assistance from caregivers. IOD treatment is therefore in general reserved for elderly who have reasonable life expectancy and who are certain to receive the required daily aftercare. On the other hand, fabrication of conventional dentures is a relatively simple procedure and can be done until high age. It is even possible to fabricate a new conventional denture at bedside after admission to a nursing home, as long as elderly are still cooperative. As increasing numbers of edentulous patients are being provided with IODs at a younger age, it is important to gain more insight into the need for aftercare at high age. It is likely that more and more of these elderly will also be admitted to nursing homes as they age. These elderly need caregivers who are aware of the importance of aftercare.

Oral status and dental/healthcare costs

Dental care costs differ for elderly with differing oral status. Elderly with a natural dentition usually had the lowest and most stable dental care costs during all eight years of the study (Chapter 2). Elderly with conventional dentures or

IODs had especially high costs at baseline (2009), which is when they received their implants and overdenture. During the first 2 to 3 years after receiving the implants and IODs, their dental costs were comparable to those of elderly with a natural dentition. Thereafter, the costs for both conventional dentures and IODs increased by a factor of 1.5 to 2, while the costs for elderly with a natural dentition remained at the same level. Presumably, elderly with a natural dentition, who also visit the dentist most often, have lower costs because many oral problems can be prevented with regular visits. This is in contrast to elderly with conventional dentures or IODs, who do not visit the dentist regularly and often make an appointment only when they have problems with their dentures and/or implants. Previous research has shown that the care and aftercare of IODs should not be neglected, as the costs for peri-implantitis treatment and reimplantation are high.¹² In this respect it is also important to note that IODs are generally 3 to 6 times as expensive as conventional dentures.¹³

Other healthcare costs, such as GP care, specialist care and pharmacy, show a somewhat similar pattern: elderly with a natural dentition have the lowest overall healthcare costs, which is probably because they are healthier on average. However, the differences in general healthcare costs between the three groups of elderly with differing oral status are smaller than the differences in dental care costs, and the general healthcare costs do not increase as rapidly as the dental care costs for elderly with a conventional dentures or IOD.

IODs and general health

The cross-sectional study of Hoeksma et al. in 2016¹⁴ showed that elderly who received dental implants to retain an IOD had better general health (less frailty, better physical condition) on average than edentulous elderly who received new conventional dentures. This finding was confirmed in our study (Chapter 2). However, this favorable health status of edentulous elderly at the time they are provided with dental implants and an IOD might be coincidental. We therefore conducted a cross-sectional study on this topic over a longer period of time (nine years), determining each year the general health of elderly at the time they received an IOD (Chapter 3). All elderly who received dental implants and an IOD were included (n=44 685). During these nine years, the study showed that the general health profile of elderly who were newly provided with IODs remained stable, and indeed resembled that of elderly with a natural dentition. Nevertheless, the prevalence of diabetes, cardiac disease and hypertension was lower than expected when comparing this group to a control population of elderly in

the Netherlands. This might be due to the general belief that the risk of implant failure and/or surgical complications are higher in health-compromised patients, despite studies showing that conditions such as controlled diabetes should not be contraindications for implant placement.¹⁵ One possibility is that dentists and elderly patients are reluctant to proceed with implant placement if these patients have a compromised health.

Long-term success of IODs in frail elderly

Thus far, most research on IODs has been conducted in a relatively young and healthy population, and has shown good treatment outcomes such as high levels of implant survival and patient satisfaction. To determine whether this treatment modality is also a good option in an ageing population that will become increasingly frail, we conducted a long-term study on IODs in an elderly population (Chapter 4). The study showed that overall survival of the implants was high (92.5% after 23 years), peri-implant bone loss was minor and peri-implant health was good, with the exception of a higher plaque index at high age. The increase in plaque index might be the result of cognitive and physical decline, resulting in elderly either forgetting or being physically unable to perform daily oral hygiene or visit an oral care professional. Except for one participant (who was admitted to a nursing home), all participants indicated that they cleaned their implants and overdentures themselves. The participants were unaware that in most cases their oral hygiene habits were poor, or they simply did not want someone else to clean their implants and IOD for them. Another factor that can have a major effect on plaque score is the presence of dry mouth. The use of multiple drugs (polypharmacy), which is also commonly seen in frail elderly, is directly associated with a high risk of dry mouth (Appendix).⁶ The reduction of salivary secretion affects the self-clearance of the oral cavity. In patients with Sjögren syndrome, characterized by low salivary flow, debris was deposited more rapidly on implant surfaces, which led to slightly higher plaque and bleeding scores when compared to healthy controls.¹⁶ It is likely that a similar process is seen in our study population, but as a result of medication-induced dry mouth.

Plaque accumulation around the implants (all implants were placed in the interforaminal area of the mandible) did not lead to peri-implant health issues, however (Chapter 4). This might be due to the strict care and aftercare protocols for this specific research population. The elderly participating in this study were closely monitored by the dental research team. Most participants (78.6%) continued to visit the dentist once a year for a general check-up, which is much higher

than the 26% reported in our big data study (Chapter 2). Additional professional cleaning or hygiene instructions were given when the patients were seen at the dentist. These frequent visits to dental professionals might have had a positive influence on the dental health awareness and peri-implant health of the elderly in this study. Based on the findings of this 20-year follow-up study, age itself should not be a factor when considering whether or not to place implants to support an overdenture as long as aftercare can be performed at the clinic, the home or the nursing home of the patient.

Oral status, oral pain complaints and dental care utilization

In a large group of community-dwelling elderly with increasing frailty and complex care needs (n=1622), we identified a subgroup of 100 elderly (6.2%) who reported having oral pain within the last three months (Chapter 5). Our research question was whether these elderly are able to manage their dental care needs when they experience oral pain. We concluded that most frail elderly and elderly with complex care needs are able to arrange transport to the dental office when they require dental treatment to deal with their oral pain. These elderly either used local transportation such as bus or taxi, or they received assistance from caregivers. The few elderly who did not visit the dentist despite having oral pain reported that they did not feel a need to visit a dentist or they had other problems (usually health problems) that required more attention. When the need for dental treatment was urgent, transport was never an issue.

Furthermore, the 6.2% of the elderly in our study with pain complaints is significantly lower than the 22% reported by Hoeksema et al.,¹⁴ who studied prevalence of oral pain in community-dwelling elderly in the same region of the Netherlands as we did. An important difference between these studies was that Hoeksema et al.¹⁴ focused on oral pain experienced within the last two years, while we studied oral pain experienced within the last three months. By lengthening the period in which oral pain occurred, this automatically leads to a larger group of elderly that report oral pain. The two-year period used by Hoeksema et al.¹⁴ was substantially longer, yet the reported oral pain complaints only increased up to 22%. It is possible that more elderly have experienced oral pain complaints within the last two years, but that they simply forgot their complaint. Our study showed that 10% of the elderly contacted within two weeks after completing the questionnaire did not remember their oral pain complaint, which can be the result of some mild memory loss. Other studies on oral pain/discomfort in community-dwelling elderly reported prevalence ranging from 5.4% to 33.6%,^{18,19} but again, the time interval

between experiencing and reporting oral pain differed from that in our study. Few studies have been published on the prevalence of oral pain complaints in the elderly population.

Although the prevalence of oral pain in the elderly is relatively low, we expect that the number of elderly with oral pain will increase in the near future as more and more elderly retain their natural dentition until high age – even until death. Especially in the last part of life, elderly have a high risk of becoming frail and care-dependent, and oral self care and visits to the dental office will be more difficult to arrange. When oral self-care declines and routine check-ups are skipped, the risk of developing oral problems will increase. Most oral problems, such as caries, can be adequately treated at an earlier stage, but when frail elderly are not regularly examined by a dentist, it is likely that they will eventually have oral pain complaints. When these elderly are finally admitted to nursing homes, their oral health is usually very poor.²⁰

Oral status and malnutrition

In elderly, the risk of becoming malnourished increases with age. One hypothesis was that good oral function can prevent malnutrition.²¹ To test this hypothesis, we performed a study involving 1041 community-dwelling elderly (Chapter 6). The results of this study revealed that oral status (natural dentition, conventional denture, IOD) was not associated with malnutrition, while frailty and complex care needs were: malnutrition occurred more often in frail elderly (4.5%) and elderly with complex care needs (10%) compared with robust elderly (2.9%). Although malnourished elderly reported more chewing and eating problems, multivariate analysis showed that these factors were not significantly associated with malnutrition. It is possible that chewing and eating problems also affect masticatory performance and oral function. However, we determined oral health problems only with questionnaires. In future research, inclusion of measurements of masticatory performance and oral function is advised as this is the only way to gain more detailed insight into the reported chewing and eating problems.

A previous study showed that health-related quality of life (HRQoL) was associated with malnutrition, and 28% of HRQoL is influenced by oral health-related quality of life (OHRQoL).²² Thus, the reported oral health problems (chewing and eating problems) in our PhD study may have had a negative effect impact on OHRQoL and thereby have exerted a negative effect on HRQoL. However, we did not assess OHRQoL in our study and therefore could not study the impact of

chewing and eating problems on OHRQoL in our study population. Future research should include the possible link between oral health problems, HRQoL/OHRQoL, masticatory performance and malnutrition.

Strengths and limitations

Previous studies have described the benefits of retaining a natural dentition until high age.⁸ A natural and functional dentition has a positive effect on diet (type of food consumed), quality of life, cognition and longevity. The studies described in this thesis showed that elderly with a natural dentition have fewer chronic conditions and lower medication use than edentulous elderly. Unfortunately, in the big data studies we were unable to determine oral status at the individual level, so we had no data on aspects such as oral function, correctly fitted dentures and presence of dental infections. In the big data studies, elderly were categorized as having a natural dentition regardless of the number of remaining teeth (Figure 1). The big data studies we performed therefore do not provide detailed information on actual oral health and oral function.

A major limitation of many studies on the oral function of elderly subjects is the absence of standard indicators for evaluating oral health, as also pointed out by Müller et al.⁸ Several options have been suggested, such as functional indicators (functional tooth units (FTU) (Figure 2), masticatory test), presence of disease (decayed and missing teeth, filled surfaces (DMFS)), and patient-reported outcomes (oral health-related quality of life). However, each of these options focus-



Figure 1: An 85-year-old patient with a natural dentition with posterior teeth, but a limited number of functional tooth units



Figure 2: A natural dentition with poor oral function due to the absence of posterior teeth in a 78-year-old patient

es on only one aspect of oral health, so generally accepted standard indicators to assess oral health in the elderly are still not available. A definition of good oral health is needed for future global research on the impact of oral status and oral health on general health.

Future directions

In the coming decades, the number of elderly will continue to increase. More and more elderly will retain their natural dentition or will be provided with an IOD. Dental care professionals will be challenged to maintain good oral health in this ageing population with differing oral status and to not lose sight of them when they become frail. But positive trends should also be mentioned. According to estimates, the number of elderly will stabilize after 2040²³ and their oral health will become better than today's elderly, as attention for their oral health improves. We will likely attain a new equilibrium in the dental care system with a higher proportion of elderly patients with a higher standard of oral hygiene. We have already seen significant improvements in oral health among young adults over the last 40 years.²⁴ Between 1987 and 2017, DMFS (the number of decayed, missed or filled surfaces) declined from 28.6 to 6.3 in 23-year old subjects.²⁴ Consequently, future generations of elderly are likely to have lower DMFS scores and better daily oral hygiene than today's generation, and the dental healthcare will continue to improve giving these elderly the potential to retain their natural dentition until high age. If the DMFS scores in the population remain at a low level, it is possible that these future generations of elderly will not undergo the

extensive dental restoration that characterizes the current generation. This will minimize their demand and need for complex dental care until high age.

Elderly who suffer from dementia are special category. They have a high risk of developing oral health problems such as severe gingivitis and periodontitis, mucosal lesions, retained roots and dental caries,^{25,26} while at the same time these problems are difficult for most caregivers to recognize. This is due to the inability of elderly with dementia to explain their oral health complaints and the fact that most caregivers are not trained to recognize oral pathology.²⁷ Furthermore, treatment of oral health problems in elderly with dementia can be challenging due to their agitated behavior and reduced cooperation. Previous research has shown that dental care utilization decreases markedly as soon as elderly are diagnosed with dementia.²⁸ If poor oral health develops in elderly with dementia, pain and oral discomfort can not be expressed to caretakers and will and subsequently negatively influence their behavior. Moreover, the increased severity of the oral inflammation processes, especially related to periodontal disease, can lead to a systemic inflammatory state.²⁹ In patients with Alzheimer's disease, previous research has shown that periodontitis is associated with accelerated cognitive decline.³⁰ It will be very interesting to investigate the link between oral health (not restricted to periodontal disease), inflammatory markers, the oral microbiome and dementia, and to find possibilities to prevent the disease or influence its course.

To perform oral health research effectively, a clear definition of oral health is needed. Previous methods usually focused on a single variable, such as the use of the DMFS or functional tooth units (FTUs), i.e., the number of pairs of occluding teeth. A reduced number of FTUs can lead to difficulty in chewing, swallowing and the avoidance of certain foods.¹ A more detailed method is a masticatory performance test. This involves testing the mixing ability using two-color chewing gum, and has been shown to be more appropriate for determining oral function.³¹ However, these methods focus on masticatory function, which is only one aspect of oral health. We believe that a clear, commonly accepted, definition of oral health will be an important aid for comparing research outcomes between various groups of elderly patients on a global level.

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Appendix

Orale bijwerkingen van door ouderen veelgebruikte medicamenten

Mieke H Bakker

Arjan Vissink

Cees de Baat

Anita Visser

This chapter is an edited version of the manuscript:

Ned Tijdschr Tandheelkd 2017;124;645-652.

Samenvatting

De komende decennia is in de westerse wereld sprake van een dubbele vergrijzing. Dit houdt in dat zowel het aantal ouderen als de gemiddelde leeftijd toeneemt. De toegenomen levensverwachting betekent tevens steeds meer ouderen die lijden aan een of meerdere systemische ziekten waarvoor medicamenten worden gebruikt. Op dit moment gebruikt 45% van de 65-plussers 5 of meer medicamenten en 20% van de 75-plussers zelfs 10 of meer medicamenten. Hoe meer medicamenten worden gebruikt, des te groter is de kans op bijwerkingen en dus ook orale bijwerkingen, zoals het gevoel van een droge mond of het ontwikkelen van candidose, angio-oedeem, hyperplasie van de gingiva, lichenoid reactie van het orale slijmvlies, smaakstoornissen, halitose en osteonecrose. Gezien het brede scala aan orale bijwerkingen, is het voor tandartsen van belang om een goed inzicht te hebben in de medicamenten die ouderen gebruiken en kennis te hebben van de daarbij behorende (orale) bijwerkingen.

Inleiding

In Nederland is er sprake van een dubbele vergrijzing: zowel het aantal ouderen als de gemiddelde leeftijd neemt toe. Ouderen, vooral 75-plussers, hebben een grotere kans op het ontwikkelen van systemische ziekten, zoals diabetes mellitus, reumatoïde artritis en cardiovasculaire ziekten. Ouderen met meerdere van deze systemische ziekten (multimorbiditeit) staan onder behandeling van een of meer artsen en gebruiken doorgaans meerdere medicamenten naast elkaar. Bij gebruik van 5 of meer medicamenten per dag is er sprake van polyfarmacie. Onderzoek heeft uitgewezen dat circa 45% van de 65-plussers 5 of meer medicamenten gebruikt en 20% van de 75-plussers zelfs 10 of meer.^{1,2} Een pillendoosje met daarop aangegeven het tijdstip wanneer medicamenten moeten worden ingenomen, kan dan handig zijn (afb. 1a). Ook de door apothekers verstrekte zogenoemde baxterrollen kunnen een oudere helpen (afb. 1b). Het nadeel van een pillendoosje of een baxterrol is dat ouderen zich daardoor veelal minder bewust zijn welke medicamenten ze precies gebruiken en waarvoor. Ook zijn zij zich doorgaans niet bewust van mogelijke bijwerkingen.² Gezien het brede scala aan orale bijwerkingen dat kan optreden bij gebruik van medicatie, is het voor tandartsen van belang om een goed inzicht te hebben in de medicamenten die de patiënt gebruikt, en kennis te hebben van de daarbij behorende orale bijwerkingen. In deze bijdrage wordt specifiek ingegaan op orale bijwerkingen die veelal het gevolg zijn van door ouderen veelgebruikte medicamenten.



Afbeelding 1a: Bij polyfarmacie is het juiste gebruik en het juiste tijdstip van inname van de medicamenten belangrijk. Een pillendoos met timer kan daarbij een goed hulpmiddel zijn.



Afbeelding 1b: De baxterrol bestaat uit een rol met zakjes die in een doos zit. In ieder zakje zitten de medicamenten die op hetzelfde moment dienen te worden ingenomen.

Medicamentgebruik door ouderen

Bepaalde medicamenten worden veel door ouderen gebruikt. Informatie over medicamenten en medicamentgebruik in Nederland wordt verzameld in de GIPdatabank (Genees- en hulpmiddelen Informatie Project van het Zorginstituut Nederland). **Tabel 1** geeft weer hoeveel inwoners in Nederland een bepaald medicament gebruiken.³ Welke medicamentgroepen het meest worden gebruikt door 65-plussers en waarvoor zij worden voorgeschreven, staat vermeld in **tabel 2**. **Tabel 3** geeft een overzicht van de orale bijwerkingen deze groepen medicamenten kunnen veroorzaken.

Orale bijwerkingen van medicamenten

Het gebruik van (meer soorten) medicamenten (naast elkaar) kan tot ongewenste bijwerkingen leiden. Een deel van deze bijwerkingen betreft de mond. Een aantal van deze bijwerkingen is zeldzaam en wordt zelden in de algemene mondzorgpraktijk gezien. Soms resulteren deze bijwerkingen echter wel in een acute situatie waarbij snel handelen is gewenst. Een voorbeeld hiervan is een plotseling optredende zwelling van de tong bij het gebruik van ACE-remmers (**afb. 2**). Na jarenlang probleemloos gebruik hiervan kan plotseling een dergelijke reactie optreden (zie subparagraaf 'angio-oedeem'). In Nederland zijn ruim 14.000 geregistreerde medicamenten beschikbaar en er zijn oneindig veel combinaties van medicamen-



Afbeelding 2: Angio-oedeem bij gebruik van ACE-remmers.

ten mogelijk die elk een scala aan bijwerkingen kunnen veroorzaken.⁴ In dit artikel wordt ingegaan op de meest voorkomende orale bijwerkingen van medicamenten die door ouderen worden gebruikt. Verschillende groepen medicamenten kunnen dezelfde orale bijwerking geven (**tabel 3**). Daarnaast wordt advies gegeven hoe deze bijwerking kan worden verholpen of verlicht. Tot de orale bijwerkingen waarmee tandartsen regelmatig worden geconfronteerd, behoren het gevoel van een droge mond (xerostomie), een verminderde speekselsecretie (hyposalie) en de daarmee samenhangende verhoogde kans op het ontwikkelen van cariës, candidose en klachten over gebitsprothesen. Andere (relatief) veelvoorkomende en/of gemakkelijk te herkennen medicamentgerelateerde orale bijwerkingen zijn angio-oedeem (**afb. 2**), gingivahyperplasie (**afb. 3**), lichenoid reacties, verkleuring van gebitselementen, smaakstoornissen en halitose. Naast de orale bijwerking van medicamenten die behoren tot de in **tabel 2** vermelde groepen, wordt ook kort ingegaan op medicamentgerelateerde osteonecrose van de kaak (medication-related osteonecrosis of the jaw: MRONJ), aangezien relatief veel ouderen medicatie gebruiken, bijvoorbeeld voor het remmen van demineralisatie van bot of de gevolgen van metastasen van tumoren in het skelet, die deze bijwerking kan hebben.

Tabel 1: Top 20 van meest gebruikte medicamenten in Nederland (GIPdatabank, 2017)

Top 20	Medicament	Aantal personen	Medicament-groep	Werking	Bijwerking
1	Diclofenac	1.199.000	NSAID	Pijnstillend, ontstekingsremmend, koortsverlagend	Maagdarmklachten
2	Amoxicilline	1.159.000	Breed-spectrum antibioticum	Bacteriedodend	Maagdarmklachten, candidiasis, smaakstoornis
3	Omeprazol	1.094.000	Protonpompremmer	Vermindert aanmaak maagzuur	Droge mond, angio-oedeem
4	Simvastatine	1.087.000	Cholesterolsyntheseremmer	Verlaagt cholesterol	
5	Metoprolol	1.012.000	B-blokker	Verlaagt hartslag en bloeddruk	Droge mond
6	Macrogol combinatiepreparaten	983.480	Laxans	Stimuleert stoelgang	Buikpijn
7	Overige emollientia en protectiva	829.160	Verzorgende huid crème	Beschermt huid tegen uitdroging	
8	Salbutamol	808.540	β2-sympathicomimeticum	Verwijding luchtwegen	Candidiasis, cariës
9	Colecalciferol	746.160	Vitamine D	Opname calcium en fosfaat uit voedsel	Te hoog vitamine D gehalte
10	Acetylsalicylzuur	737.960		Pijnstillend, koortsverlagend en ontstekingsremmend	Verminderde bloedstolling, maagklachten
11	Pantoprazol	710.060	Protonpompremmer	Vermindert aanmaak maagzuur	Droge mond, angio-oedeem
12	Nitrofurantoïne	701.040	Antibioticum	Bacteriedodend	Maagdarmklachten, candidiasis, smaakstoornis
13	Amoxicilline met enzymremmer	687.240	Antibioticum	Bacteriedodend	Maagdarmklachten, candidiasis, smaakstoornis
14	Doxycycline	682.110	Antibioticum	Bacteriedodend	Maagdarmklachten, candidiasis, smaakstoornis
15	Metformine	631.230	Glycemieverlager	Verlaagt bloedglucose	Smaakstoornis, maagdarmklachten
16	Codeïne	629.820	Hoestprikkel-dempend middel	Dempt hoestprikkel en pijnstillend	Obstipatie en sufheid
17	Naproxen	617.810	NSAID	Pijnstillend, ontstekingsremmend, koortsverlagend	Maagdarmklachten

18	Hydrochloorthiazide	615.660	Diureticum	Plastablet, verlaagt bloeddruk en verbetert pompkracht	Droge mond
19	Desloratadine	611.150	Antihistaminicum	Anti-allergie medicament	Droge mond
20	Triamcinolon	607.760	Corticosteroid	Remt ontstekingen en overgevoelheidsreacties	Meer kans op infectie, maagdarmklachten

De droge mond

De meest voorkomende orale bijwerking van door ouderen veelgebruikte medicamenten is xerostomie.^{2,5} Ongeveer 30% van de ouderen klaagt over chronische monddroogheid.^{6,7} Vaak is onduidelijk of hier daadwerkelijk hyposialie (verminderde speekselsecretie) aan ten grondslag ligt of dat het alleen een droog gevoel in de mond (xerostomie) betreft.^{8,9} In zijn algemeenheid geldt: hoe meer medicamenten worden gebruikt, des te vaker de patiënt klaagt over xerostomie (afb. 4).^{10,11} Uit de top 10 van door 65-plussers gebruikte medicamenten worden vooral protonpompremmers, ACE-remmers en diuretica geassocieerd met een droge mond (tabel 2).¹² Ook medicamenten uit andere groepen (tabel 2) kunnen, zeker als zij in combinatie met andere medicamenten worden gebruikt, worden gelinkt aan het ontwikkelen van xerostomie. Omdat van deze medicamenten dat effect minder evident is, is bij deze medicamentgroepen de bijwerking droge mond vaak niet expliciet vermeld.

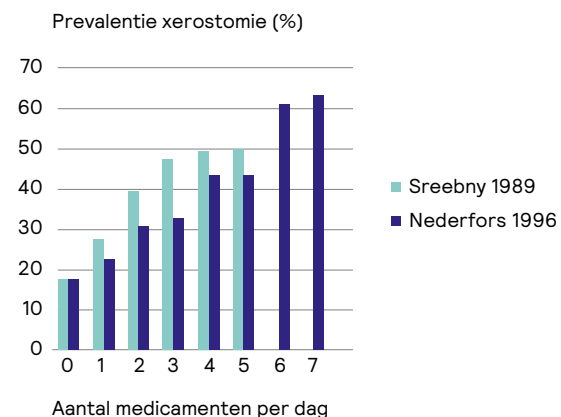
Al dan niet bewezen, kan een medicamentgeïnduceerde of -gerelateerde xerostomie, vooral als hier een daadwerkelijke hyposialie (mede) aan ten grondslag ligt, een veelheid aan gevolgen hebben, zoals slecht slapen, een slechte zelfreiniging van de mond, een verhoogd risico op het ontwikkelen van in het bijzonder cervicale cariës en candidose (afb. 5 t/m 7).⁵ Ook kan hyposialie leiden tot problemen met het eten: het kauwen en slikken van voedsel wordt bemoeilijkt. Dit kan ertoe leiden dat minder wordt gegeten en eerder wordt gekozen voor vloeibaar dan vast voedsel met ondervoeding tot gevolg. Ten slotte kan er sprake zijn van verminderde smaak (dysgeusie) en een vieze adem (halitose).¹³ In een aantal gevallen kan de speekselvloed nog worden gestimuleerd door het zuigen op snoepjes of pepermunt, maar dit is niet bevorderlijk voor dentate patiënten aangezien het cariërisico dan nog groter is.^{7,14,15} Als de patiënt hier baat bij vindt, moet dus het gebruik van suikervrij snoep en snoep met een milde zuurgraad (geen citroenzuur, wel eventueel producten met appelzuur) worden geadviseerd.



Afbeelding 3: Hyperplasie van gingiva onder mesostructuur. Dergelijke hyperplasieën kunnen het gevolg zijn van selectieve calciumantagonisten, zoals amlodipine (tabel 2).

Candidose

Candida albicans, een commensaal van de mondholte, geeft in een evenwichtig oraal milieu geen klachten. Wanneer het orale milieu verstoord raakt, kan deze gist zich ontwikkelen tot een orale schimmelinfectie. Deze verstoring kan komen door gebruik van medicamenten: een *Candida*-infectie wordt vooral gezien bij gebruik van antibiotica en inhalatiecorticosteroiden (afb. 7).¹⁶ Een gebitsprothese die niet goed schoongemaakt wordt (in het bijzonder gebitsprothesen van met een weekblijvende basis zoals een tijdelijke Softliner of een meer permanente molloplastlaag) en die 's nachts ingehouden wordt, vormt een risico voor het vormen van schimmels.¹⁷ Het eenvoudigweg goed schoonmaken van de gebitsprothese en deze 's nachts droog opbergen, voorkomt gewoonlijk het ontwikkelen van candidiasis.¹⁸ Orale candidose kan worden behandeld door een lokaal werkend antimycoticum voor te schrijven. Polyenen, zoals nystatine, en imidazolen, zoals miconazol, zijn effectief in het bestrijden van deze schimmelinfectie. Wel kan miconazol de werking van vitamine K-antagonisten ontregelen en een combinatie van deze twee medicamenten wordt afgeraden. Het is ook van belang de gebitsprothese goed te reinigen met bijvoorbeeld een chloorhexidine-oplossing om re-infectie tegen te gaan.¹⁹ *Candida*-species kunnen zich namelijk nestelen in de kunststof van gebitsprothesen.



Afbeelding 4: De kans op het ontwikkelen van xerostomie neemt toe naarmate dagelijks meer medicamenten worden gebruikt.

Angio-oedeem

Angio-oedeem is een plotselinge, diffuse zwelling van bijvoorbeeld tong, lippen, aangezicht of orofarynx en houdt een paar dagen aan (afb. 2). Vaak is de ene kant van de tong of het aangezicht meer gezwollen dan de andere kant. De oorzaak van deze zwelling ligt meestal in het gebruik van ACE-remmers. ACE-remmers zijn antihypertensiva en behoren tot de door ouderen veel gebruikte medicamenten (tabel 2). De activiteit van het renine-angiotensinealdosteronsysteem (RAAS) wordt verminderd en resulteert in een lagere bloeddruk. RAAS is onderdeel van het hormonale systeem dat ervoor zorgt dat de bloeddruk constant blijft. ACE-remmers zorgen dat ACE (angiotensin I convertie enzym) wordt geremd. Hierdoor wordt geen angiotensine II gevormd en verlaagt de bloeddruk. ACE-remmers remmen niet alleen de omzetting van angiotensine I naar angiotensine II, maar ook de afbraak van bradykinine. Er wordt gedacht dat bradykinine, een sterke vasodilator, een rol speelt in het ontstaan van angio-oedeem. Normaliter wordt bradykinine afgebroken door kininase II, dat sterk lijkt op het angiotensin I convertie enzym. In geval van angio-oedeem worden verhoogde niveaus bradykinine aangetroffen, die zorgen voor extravasatie van plasma en zwelling van het gelaat.^{20,21} Angio-oedeem kan na jarenlang probleemloos gebruik van ACE-remmers plotseling optreden. Minder vaak wordt angio-oedeem veroorzaakt door angiotensine II-antagonisten, prostaglandi-

Tabel 2: Top 10 van de meest gebruikte medicamentgroepen door patiënten van 65 jaar en ouder in 2015 (GIPdatabank, 2017).

Top 10	Medicamentgoepen bij ouderen (65 jaar en ouder)	Medicamenten	Indicatie	Gebruikers per 1.000 Zwv-verzekerden
1	Protonpompremmers	Omeprazol, Pantoprazol	Maagzuurremmers/ middelen tegen ulcus pepticum en gastro-oesofageale reflux	233
2	Antitrombotica (vitamine K-antagonisten, trombocytenuitremmers)	Fenprocoumon (Marcoumar®), Acenocoumarol, NOAC (Pradaxa®), Carbasalaatcalcium (Ascal®), Dipyridamol (Persantin®), Clopidogrel (Plavix®, Grepid®)	Trombose, infarct	228
3	Antilipemica enkelvoudig (statinen)	Simvastatine (Zocor®), Atorvastatine (Lipitor®), Rosuvastatine (Crestor®)	Bij te hoog cholesterolgehalte in bloed	222
4	β-blokkers	Atenolol, Bisoprolol (Emcor®), Metoprolol (Selokeen®)	Hartfalen, hypertensie	189
5	ACE-remmers	Captopril, Enalapril (Renitec®), Perindopril	Hartfalen, hypertensie	115
6	Selectieve calciumantagonisten	Amlodipine (Norvasc®), Nifedipine, Felodipine	Hypertensie, angina pectoris	104
7	Glycemieverlagende middelen	Biguaniden (Metformine), Sulfonylureumderivaten (Gliclazide, Tolbutamide)	Diabetes mellitus	92
8	Angiotensine II-antagonisten	Losartan, Valsartan	Hartfalen, hypertensie	80
9	Vitamine A en D	Vitamine A (Retinol), Vitamine D (coleciferol Divisun®)	Osteoporose, vitaminegebrek	77
10	Diuretica	Furosemide (Lasix®), Bumetanide	Oedemen, hypertensie	73
Totaal aantal gebruikers 65+ polyfarmacie: 1.022.222				



Afbeelding 5: Bij hyposalie gerelateerd aan medicamentgebruik blijft vaak veel debris achter in de mond als gevolg van een verminderd zelfreinigend vermogen.

nesynthetaseremmers (NSAIDs) of protonpompremmers. De prevalentie wordt geschat op 0,1-0,7% onder de gebruikers van ACE-remmers.^{20,22, 23} In de meeste gevallen is de zwelling, mits het gebruik van het oorzakelijke medicament direct wordt gestaakt, ongevaarlijk en verdwijnt deze vanzelf. Wanneer het angio-oedeem de luchtweg bedreigt, is snel optreden essentieel en kan zelfs intubatie nodig zijn.²⁴

Gingivahyperplasie

Hyperplasie van de gingiva wordt onder andere gezien bij gebruik van calcium-antagonisten (tabel 2, afb. 3). Er is sprake van gingiva-overgroei zonder een beeld van ontsteking zoals typerend is voor gingivitis. Een goede mondhygiëne kan het proces afremmen, maar niet altijd voorkomen. Na het staken van medicamenten en het verbeteren van de mondhygiëne verdwijnt de hyperplasie veelal niet vanzelf en kan chirurgische correctie van de gingiva gewenst zijn om de mondhygiëne makkelijker te maken en plaqueretentie beter te voorkomen. Deze correctie is alleen zinvol wanneer de mondhygiëne goed is.²⁵

Lichenoïde reactie

Een lichenoïde reactie van het orale slijmvlies lijkt klinisch op een unilateraal beeld van lichen planus met karakteristieke witte striae. NSAIDs en ACE-remmers worden het meest gelinkt aan het ontwikkelen van deze reactie, maar ook bij gebruik

Tabel 3: Meest voorkomende orale bijwerkingen ten gevolge van door ouderen veelgebruikte medicamenten.

Oorzakelijke factor	Orale bijwerkingen	Therapie
ACE-remmers	Droge mond Angio-oedeem Lichenoïde reactie	Speekselsubstituten Adrenaline toevoegen en spoedarts regelen Applicatie corticosteroid zalf of verwijzing kaakchirurg
	Smaakstoornis	Geen therapie mogelijk, behoudens medicament staken
Angiotensine II-antagonisten	Angio-oedeem	Adrenaline toevoegen en spoedarts regelen
Anti-angiogene en antiresorptieve medicatie	MRONJ (medicament gerelateerde osteonecrose van de kaak)	Verwijzen naar kaakchirurg ten behoeve van HBO (hyperbare zuurstof therapie) en wegnabbelen necrotisch bot en herbedekken met slijmvlies indien mogelijk
Antibiotica	Candidiasis	Applicatie fungicide creme en spoelen chloorhexidine
	Lichenoïde reactie	Applicatie corticosteroid zalf of verwijzing kaakchirurg
	Smaakstoornis	Geen therapie mogelijk, behoudens medicament staken
β-blokkers	Lichenoïde reactie	Applicatie corticosteroid zalf of verwijzing kaakchirurg
Calciumantagonisten	Gingivahyperplasie	Gingivectomie indien wenselijk
Diuretica	Droge mond,	Speekselsubstituten
Inhalatie-corticosteroiden	Candidiasis	Applicatie fungicide creme en spoelen chloorhexidine
	Cariës	Voorlichting en cariës preventie
NSAID	Angio-oedeem Lichenoïde reactie	Adrenaline toevoegen en spoedarts regelen Applicatie corticosteroid zalf of verwijzing kaakchirurg
Orale glycemieverlagende middelen	Lichenoïde reactie	Applicatie corticosteroid zalf of verwijzing kaakchirurg
Protonpompremmer	Droge mond Angio-oedeem	Speekselsubstituten Adrenaline toevoegen en spoedarts regelen
Zwavel- of jodiumbevattende medicamenten	Smaakstoornis	Geen therapie mogelijk, behoudens medicament staken
Polyfarmacie	Droge mond	Speekselsubstituten
Gevolg droge mond	Halitose	Spoelen met Halita, tong, dentitie en mond reinigen, speekselsubstituten
	Smaakstoornis	Geen therapie mogelijk, behoudens medicament staken



Afbeelding 6: De kans op het ontwikkelen van cariës is sterk vergroot bij een medicamentgerelateerde hyposialie, vooral cervicaal en op de gladde gebitsvlakken.

van antibiotica, β-blokkers en orale glycemieverlagende middelen wordt deze bijwerking gemeld.^{26,27} Op basis van het klinische beeld is niet direct vast te stellen of dit het gevolg is van medicamentgebruik. Pas wanneer na staken van het medicament de reactie verdwijnt en recidiveert wanneer het medicament weer wordt gestart, kan er met zekerheid worden gesproken van een medicamentgerelateerde reactie.²⁷ De etiologie van de lichenoïde reactie blijft onduidelijk, maar lijkt verband te houden met een lokale cellulaire immuunrespons.²⁶

Smaakstoornis

Medicamenten die invloed hebben op de aanwezigheid van koper, nikkel en zink kunnen leiden tot een smaakstoornis. Dit wordt het vaakst gemeld bij het gebruik van ACE-remmers (tabel 2). ACE-remmers vormen een binding met zink in smaakreceptoren en beïnvloeden hiermee smaakgevoel.²⁸ Ook bij gebruik van antibiotica, protonpompremmers, orale glycemieverlagende medicamenten en medicamenten die de speekselsecretie verminderen, wordt deze bijwerking beschreven.²⁹ In veel gevallen is het mechanisme onduidelijk. Wanneer de smaakstoornis als erg hinderlijk wordt ervaren, kunnen alternatieve medicamenten worden overwogen, maar dit is in de meeste gevallen niet mogelijk.



Afbeelding 7: Candidose kan ontstaan wanneer de samenstelling van de orale flora wordt beïnvloed, bijvoorbeeld door antibiotica of inhalatiecorticosteroiden.

Halitose

Een slechte adem (halitose, foetor ex ore) is voornamelijk het gevolg van tongbeslag, hetgeen vooral bij ouderen die niet goed meer kunnen slikken (dysfagie) en/of een droge mond hebben met enige regelmaat wordt gezien. Medicamenten die zwavel of jodium bevatten, zoals het diureticum hydrochloorthiazide (tabel 2), worden ook gelinkt aan het ontwikkelen van halitose. Een zuivere medicamentgeïnduceerde halitose is echter zeldzaam. Vaker komt voor dat halitose een indirect gevolg is van de bijwerking van medicamenten, in het bijzonder van medicamenten die worden gelinkt aan xerostomie. Door de droge mond blijven voedselresten en debris en daarmee ook veel bacteriën langer in de mondholte aanwezig en kunnen op deze wijze leiden tot halitose.^{16,25} Het is geen uitzondering dat daarbij een beslag op de tong wordt gezien. De patiënt moet dan worden aangeraden om een tongschraper te gebruiken en te spoelen met middelen die speciaal voor het tegengaan van halitose op de markt zijn gebracht.

MRONJ

Antiresorptieve en antiangiogene medicamenten (bijvoorbeeld bisfosfonaten en denosumab) worden voorgeschreven om de schadelijke gevolgen van postmenopauzale osteoporose tegen te gaan. Daarnaast worden deze medicamenten gebruikt als behandeling van kanker waarbij beenmerg is betrokken (bijvoorbeeld het multipole myeloom ofwel de ziekte van Kahler) of wanneer er zich metastasen bevinden in het skelet (bijvoorbeeld van mamma- en prostaattumoren). Deze medicamenten remmen het proces van botafbraak door het induceren van apoptose

(interfase celdood, het fysiologische proces van celdood) van osteoclasten en/of het remmen van vorming van nieuwe osteoclasten. Bij osteoporose worden voornamelijk orale bisfosfonaten voorgeschreven, bij de behandeling van tumoren vaak een intraveneuze variant. Ook kunnen in dit kader antiangiogene medicamenten worden gebruikt. Deze medicamenten gaan de vorming van bloedvaten tegen. Wanneer een patiënt antiresorptieve en/of antiangiogene medicamenten (heeft) gebruikt, is na invasieve behandelingen, zoals extracties of dentoalveolaire chirurgie, of bij een drukulcus onder een gebitsprothese, de kans op het ontwikkelen van MRONJ (medication-related osteonecrosis of the jaw) vergroot.

MRONJ wordt gekenmerkt door geëxposeerd bot of een langer dan 8 weken bestaande fistel, zonder een voorgeschiedenis van radiotherapie of een metastase in dit gebied.³⁰ Vooral de intraveneuze bisfosfonaten zijn berucht en geven een sterk verhoogde kans op MRONJ, terwijl bij het gebruik van orale bisfosfonaten deze complicatie relatief zelden wordt gezien. Dit wordt veroorzaakt door het feit dat intraveneus toegediende bisfosfonaten voor 70% opgenomen worden in het bot, in tegenstelling tot de orale bisfosfonaten waarbij per gift slechts 1% door het bot wordt opgenomen. Bovendien zijn de bisfosfonaten die intraveneus toegediend worden vele malen potenter dan de oraal toegediende. De kans op het ontwikkelen van MRONJ is groter als in de periode van wondgenezing na een extractie eveneens inhalatiecorticosteroiden worden gebruikt.³¹ Omdat de halfwaardetijd van deze antiresorptieve medicamenten circa vijf jaar is, heeft het geen zin om de medicamenten te staken en moet men ook beducht zijn op situaties waarin het gebruik van de medicamenten al enkele jaren geleden is geëindigd. Na het staken van bisfosfonaten blijft het effect van deze medicamenten nog lang aanwezig en blijft dus de kans op het ontwikkelen van MRONJ vergroot.³²

Om dit risico goed te kunnen beoordelen, is een goede anamnese is van groot belang. De ervaring leert dat veel mensen het gebruik van bisfosfonaten of denosumab vergeten te melden omdat zij dit bijvoorbeeld één keer per week gebruiken of een aantal keren per jaar gebruiken en dit dus niet zien als reguliere medicamenten. Nog groter is de kans dat het gebruik van bisfosfonaten niet wordt gemeld als deze medicatie is gestopt. Echter, vanwege de lange halfwaardetijd kan het medicament nog wel actief zijn. Mocht uit de anamnese naar voren komen dat de kans bestaat dat de patiënt een dergelijk medicament heeft gebruikt, bijvoorbeeld als de patiënt is behandeld voor een mamma- of een prostaattumor, dan moet hier actief naar worden gevraagd. Het wordt aanbevolen om voor de start van antiresorptieve of antiangiogene medicamenten patiënten focusvrij te maken, vooral als de patiënt start met het gebruik van intraveneuze

medicamenten. Tijdens en na de medicatie moeten extractie en dentoalveolaire chirurgie zoveel mogelijk worden voorkomen. Wanneer een extractie eigenlijk onvermijdelijk is, gaat de voorkeur toch uit naar een endodontische behandeling en eventueel decapitatie.³³ Als dit niet tot de mogelijkheden behoort, is de aanbeveling om de patiënt te verwijzen naar een afdeling Mondziekten-, Kaak- en Aangezichtschirurgie van een medisch centrum. Het kan dan noodzakelijk zijn om extra maatregelen te treffen. Zie ook de openbare richtlijn 'Medicatie gerelateerde osteonecrose van de kaak' van de Nederlandse Vereniging voor Mondziekten, Kaak- en Aangezichtschirurgie.³⁴

Conclusie

Ouderen gebruiken doorgaans veel medicamenten. Het gebruik van medicamenten kan verschillende orale bijwerkingen hebben, variërend van het gevoel van een droge mond of een veranderde smaak tot angio-oedeem en MRONJ. Een goede kennis van de werking en de mogelijke (orale) bijwerkingen van door ouderen veel gebruikte medicamenten en het in het patiëntendossier actueel houden van het medicamentgebruik door de patiënt zullen bijdragen aan het tijdig onderkennen van de (orale) bijwerkingen van medicamenten en – indien nodig – het treffen van de juiste maatregelen.

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Chapter 8

Summary

Summary

Worldwide, the population aged 65 and over is increasing rapidly. The increasing number of elderly will have a great impact on the healthcare system, as these elderly are in need of more – and often complex – healthcare. Over the last 50 years, not only the number elderly has increased, but also the number of elderly who are able to retain their natural dentition until high age. This increase in number of elderly with a natural dentition is probably due to a better dental awareness and improved dental care. For edentulous elderly, the option of being provided with an implant retained overdenture (IOD) has solved the frequently reported retention problems of the conventional full denture. This has resulted in an elderly population with differing oral status, viz. elderly with a natural dentition, elderly with a conventional denture and elderly provided with an IOD. Subdividing elderly into these three categories based on oral status has clinical relevance as there are studies indicating that maintaining a natural dentition until high age may have a favorable impact on oral functioning, social wellbeing and general health. Therefore, the general aim of the studies described in this PhD thesis was to assess the association between oral status (natural dentition, conventional denture, IOD) and general health, frailty, quality of life, nutritional status, oral pain complaints and dental care utilization of elderly (aged ≥ 75 years). In addition, it was assessed whether placement of dental implants to retain an overdenture, which treatment is known to improve oral function and quality of life, has a positive effect on general health and whether this dental concept remains to be successful on the long run (≥ 20 years) in a population with increasing frailty (Chapter 1).

Oral status and general health, health care use and healthcare costs

Cross-sectional studies have shown that elderly with a natural dentition have better general health than edentulous elderly, but this has not been confirmed in studies with longitudinal design. Therefore, a big data follow-up study was performed in close collaboration with Vektis (Chapter 2). Vektis is an organization that warehouses the data on all health care declarations in the Netherlands. Based on the Vektis data, three cohorts of elderly (aged ≥ 75 years) were formed in 2009 consisting of 143 199 elderly with a natural dentition, 24 923 elderly with conventional dentures and with 6 503 IODs. These cohorts were followed for eight years, i.e., from 2009 up to 2016. During the follow-up, the following variables were assessed annually and analyzed: visits to medical professionals, health-

care costs per healthcare profession, type of medication received, total number of medication received and presence of chronic conditions as well as admission to a nursing home (only data from 2012 were available). Additionally, dental and healthcare costs were assessed.

In general, elderly with a natural dentition were healthier than edentulous elderly. Cardiac disease and diabetes were more prevalent among elderly with conventional dentures as well as that they had the highest medication use (polypharmacy). At baseline (2009), elderly with an IOD showed prevalence of cardiac disease and diabetes similar to elderly with a natural dentition, but over time prevalence increased to the level comparable to elderly with conventional dentures.

With regard to healthcare use, the three groups of elderly with differing oral status showed some similarities. The general practitioner is visited at least once a year by more than 90% of all elderly and visits to the medical specialists between 85–95%. No differences are seen between elderly with a natural dentition, conventional denture or IOD. This is in great contrast to dental care use: over a period of eight years dental care use of elderly with a natural dentition drops from 100% at baseline to 67%. Elderly with a conventional denture visit the dentist in 10% of the cases and elderly with an IOD in 26% of the cases. Especially the decrease in dental care use by the elderly with an IOD is interesting as the guidelines for aftercare for IODs state that yearly check-ups are recommended to prevent peri-implantitis.

With regard to dental care costs, elderly with a natural dentition had the lowest and most stable dental care costs compared to elderly with an IOD or conventional denture. Especially elderly who received an IOD had high dental care costs at baseline. Compared with elderly with a natural dentition, the fabrication costs of an IOD were 10 times the costs of preserving a natural dentition. Even in the period after implant placement and fabrication of the IOD, dental costs for this group of elderly remained high.

IODs and general health

Previous research suggested that elderly with IODs have better general health (less frailty, better physical condition) than elderly with conventional dentures. These studies, however, had a cross-sectional study design. It is unknown whether the advantageous health status was already present when the elderly in those studies (aged ≥ 75 years) received an IOD. Therefore, we performed a cross-sectional big data study, in collaboration with Vektis, aimed to determine general

health status of elderly with a natural dentition and elderly who received an IOD or a conventional denture (Chapter 3) in 2009 and in 2017. Information concerning medical conditions, medication use and socioeconomic status (SES) were assessed and compared to the three groups of elderly (aged ≥ 75 years) with differing oral status. In order to assess whether the outcomes of elderly with IODs in 2009 and 2017 were not coincidental, health status of elderly receiving IODs in the period 2010 – 2016 was assessed as well.

For the year 2009 we could include 143 199 elderly with a natural dentition, 18 420 with a conventional denture and 6 503 with an IOD. For the year 2017 these numbers were 237 450 elderly with a natural dentition, 17 787 with a conventional denture and 4 631 IOD. No clinically relevant differences were found between the years 2009 and 2017. Between the three groups of elderly we found significant differences for SES and age. With regard to chronic conditions, elderly with conventional dentures had a higher prevalence of cardiac disease, hypertension and diabetes. Also, polypharmacy, use of antithrombotic and antihypertensive drugs was the highest in elderly with conventional dentures. When focusing on elderly with IODs in the period 2009–2017, it became clear that implants were mostly placed in elderly aged 75–85 years (90%).

This study showed that general health of elderly with an IOD and elderly with a natural dentition was on average better than the general health of elderly wearing conventional dentures, with lower prevalence of diabetes, cardiac disease and hypertension. These differences are already present when elderly receive an IOD or conventional denture.

Implant-retained overdentures in frail elderly

Thus far, most research on treatment outcomes of IODs has been conducted in a relatively young and healthy population. An IOD is considered as a safe and reliable treatment modality. To determine whether this treatment modality is also a reliable option in an ageing and increasingly becoming frail population, a long-term study (≥ 20 years follow-up) on IODs in an elderly population was conducted (Chapter 4). In total 53 edentulous elderly (aged 60 years or older) were included. These patients had received an IOD between 1990 and 1999. At baseline all 53 elderly had received either two Brånemark, IMZ or ITI implants in the mandible and three months later a new IOD was made. For the maxilla a conventional denture was fabricated. Of the 53 elderly at baseline, 15 were available for evaluation at 20-years follow-up. The high number of drop-outs after 20 years was mainly due

to decrease as most of the participants were aged ≥ 85 years at the 20 years follow-up. During the 20 years of follow-up the following clinical parameters were scored every 5 year: implant loss, plaque index, calculus index, gingival index, bleeding index and pocket depth. Bone level was analyzed using radiographs. At the 20-years follow-up the following patient-reported outcomes were scored additionally: frailty (Groningen Frailty Indicator, GFI), health-related quality of life (EuroQoL EQ-5D, EQ VAS) and questions on dental visits, oral hygiene and patient satisfaction.

At the 20-years follow-up, the median age was 85.5 years old and nine elderly were frail according to the GFI. Generally, they were satisfied with their IOD (mean VAS score: 7 on a scale from 1–10) and had a good quality of life (mean EQ-5D score was 0.79 on a scale of 0–1, mean EQ VAS score was 68.2 on a scale 0–100). The overall survival of the implants was high (92.5% after 23 years) and the marginal bone loss around the implants low (mean 1.14 mm, \pm 0.85 mm). Clinical parameters of the implants (calculus, gingival index, bleeding index and probing depth) remained stable during the last part of the follow up (in the period 10 to 20 years). Of all measured parameters, only plaque index showed a remarkable increase at the 20-years follow-up and was in most patients at the 20-years follow-up clearly visible, while in the first 10 years plaque scores were low. This increase in plaque was associated with age.

In short, most patients became increasingly frail over a period of 20 years, yet this did not affect peri-implant health in this group. There was an increase in plaque index, but other clinical parameters remained stable. Despite the frailty and deteriorated oral hygiene of the participants, this study shows that the IOD is a durable treatment option that it contributes to a high quality of life when aftercare is guaranteed.

Oral pain and dental care use

When elderly become old and frail they often become more care-dependent and the performance of daily activities, such as performing personal (oral) hygiene and visiting the dentist, becomes a challenge. These restrictions in maintaining a proper self-care pose a risk for maintaining a good oral health and oral function. Oral pathologies, such as tooth loss and oral pain, can therefore frequently occur in these elderly. Thus far, it is unclear how many community-dwelling elderly are suffering from oral pain complaints, whether they have easy and proper access to dental care and whether they have the ability to manage their dental care needs

by themselves. We studied a large group of community-dwelling elderly aged ≥ 75 years with increasing frailty and complex care needs ($n=1622$) (Chapter 5). Between July 2017 and February 2018 these elderly were asked to complete questionnaires on frailty (Groningen Frailty Indicator, GFI) and complex care needs (INTERMED for the Elderly Self-Assessment) as well as that they were asked to complete questions regarding their dental visits and oral health problems in the previous three months (oral pain, chewing problems, swallowing problems, dry mouth, feeling of insecurity regarding their oral status).

In total 100 elderly (6.2%) reported to have experienced oral pain and 190 (11.7%) reported to have a dry mouth, which were the most commonly reported complaints. Chewing problems (5.7%), an insecure feeling regarding oral status (4.7%) and swallowing problems (2.2%) were less frequently reported. The elderly who reported oral pain in the questionnaires were contacted by telephone to further investigate their oral pain complaint and whether they were able to manage their dental care needs by themselves. Among these elderly 61% was robust, 10% frail and 29% had complex care needs. Most of these elderly were registered at a local dental office and were able to go there when needed (84.3%) with or without the aid of informal caretakers. In general, dental visits amongst elderly differed: robust elderly visited the dentist independently (87%), but frail (44%) and complex (46%) elderly more often required assistance. Most of the elderly that did not visit the dentist any more on regularly basis, reported that they did not feel the need to visit the dentist or had other (health) problems that required more attention.

This study showed that the prevalence of oral pain among community-dwelling elderly is rather low (6%) and that community-dwelling elderly who reported oral pain and were in need of dental care, were often able to organize their dental care needs. Elderly with increased frailty and complex care needs experienced more problems with visiting the dentist. These frail elderly are therefore at risk for developing poor oral health. It is advisable to safeguard dental visits for this group of elderly.

Oral status and malnutrition

The risk of becoming malnourished increases when the population is ageing. In this study it was assessed whether oral status had an impact on the nutritional status. Malnutrition was defined as a BMI of $< 20 \text{ kg/m}^2$ or unintentional weight loss over 1 month ($> 5\%$) or 6 months ($> 10\%$) (Chapter 6). In total 1041 community-dwelling

elderly aged ≥ 75 years participated in this study. Questionnaires on frailty (GFI) and complex care needs (INTERMED) were completed, along with questionnaires on activities of daily living (Katz-15) and health-related quality of life (EQ-5D), next to questions regarding oral status and oral health problems (such as chewing problems, eating problems).

The results of this study revealed that oral status (natural dentition, conventional denture, IOD) was not associated with malnutrition, while frailty and complex care needs were: malnutrition occurred more often in frail elderly (4.5%) and elderly with complex care needs (10%) compared with robust elderly (2.9%). The malnourished elderly reported more chewing and eating problems, but these factors were not significantly associated with malnutrition in a multivariate analysis. Only health-related quality of life (HRQoL) showed a significant association with malnutrition. It is possible that the combination of various oral health-related problems (chewing and eating problems) affected the HRQoL, and thereby the association with malnutrition, but this requires further research.

Elderly with a natural dentition have the best general health outcomes, the lowest medication use, fewest comorbidities, the lowest admittance to a nursing home, the lowest healthcare use and the lowest healthcare costs compared with edentulous elderly. Elderly with an IOD have general health outcomes comparable to elderly with a natural dentition when they receive an overdenture, but over time their general health profile deteriorates to the level of elderly with a conventional denture. These observations as well as the impact of oral status on nutritional status and peri-implant health in elderly are discussed in a broader perspective in the general discussion (Chapter 7).

Chapter 9

Nederlandse samenvatting

Nederlandse samenvatting

Het aantal personen ouder dan 65 jaar neemt wereldwijd in hoog tempo toe. De toename van de oudere bevolking heeft direct gevolgen voor de gezondheidszorg. Immers, hoe ouder mensen worden, hoe groter de kans is op het ontwikkelen van een of meerdere chronische aandoeningen, waardoor er een groter beroep op de gezondheidszorg wordt gedaan.

Binnen de tandheelkunde is ook een verandering in zorgvraag waar te nemen. De afgelopen 50 jaar is het aantal edentate ouderen met een gebitsprothese sterk afgenomen. Redenen daarvoor zijn onder andere de toenemende aandacht voor goede mondgezondheid en de verbeterde tandheelkundige zorg. Het gevolg hiervan is dat veel meer mensen tot op hoge leeftijd een eigen dentitie kunnen behouden. In het geval iemand toch edentat wordt en een gebitsprothese gaat dragen, dan kunnen eventuele retentieproblemen van de gebitsprothese veelal worden verholpen door het plaatsen van implantaten ter ondersteuning van deze prothese. Dit heeft ertoe geleid dat op basis van de orale status drie groepen ouderen kunnen worden onderscheiden: ouderen met een eigen dentitie, ouderen met een conventionele gebitsprothese en ouderen met een implantaatgedragen overkappingsprothese.

Dat steeds meer ouderen hun eigen dentitie tot op hoge leeftijd kunnen behouden is een gunstige ontwikkeling, omdat er aanwijzingen zijn dat het behoud van een eigen dentitie tot op hoge leeftijd samengaat met een betere orale functie, een gelukkiger en gezonder leven. Een verbeterde orale functie en groter kauwcomfort wordt ook bij ouderen met een implantaatgedragen overkappingsprothese gezien. Maar er is tot op heden weinig onderzoek gedaan naar algemene gezondheid en orale status bij ouderen. Daarom is het doel van dit proefschrift om te onderzoeken welk verband er is tussen orale status (eigen dentitie, conventionele gebitsprothese, implantaatgedragen overkappingsprothese) en de algemene gezondheid, kwetsbaarheid, kwaliteit van leven, ondervoeding, orale pijnklachten en tandartsbezoek van ouderen in Nederland (≥ 75 jaar). Dit proefschrift richt zich met name op ouderen boven de 75 jaar, omdat in deze categorie de kans op gezondheidsproblemen groter is dan bij ouderen tussen 65 en 75 jaar. Daarnaast is onderzocht of het plaatsen van implantaten ten behoeve van een implantaatgedragen overkappingsprothese een positief effect heeft op de algemene gezondheid en of deze behandeling ook succesvol is op de lange termijn (≥ 20 jaar) in een ouder wordende, kwetsbare populatie (hoofdstuk 1).

Orale status en algemene gezondheid, zorggebruik en zorgkosten

Er was nog geen longitudinaal onderzoek uitgevoerd naar het verband tussen orale status en algemene gezondheid, terwijl er aanwijzingen zijn dat er verschillen zijn in algemene gezondheid tussen ouderen met een verschillende orale status. Om dit te onderzoeken werd een zogeheten big data onderzoek opgezet met Vektis (hoofdstuk 2), een organisatie die alle data over gedeclareerde zorg in Nederland beheert. De term big data onderzoek houdt in dit geval in dat er met een grote hoeveelheid gegevens wordt gewerkt, in dit geval gegevens van een grote groep ouderen in Nederland. In het jaar 2009 werden drie cohorten van ouderen (≥ 75 jaar) gevormd op basis van hun orale status: 143.199 ouderen met een eigen dentitie, 24.923 ouderen met een conventionele prothese en 6.503 ouderen met een implantaatgedragen overkappingsprothese. Vervolgens werden deze drie cohorten acht jaar lang gevolgd (periode 2009–2016) waarbij jaarlijks de volgende variabelen werden gemeten: bezoek aan zorgverleners, zorgkosten, voorgeschreven medicatie, totaal aantal medicijnen en aanwezigheid van chronische ziekten. Ook werd onderzocht hoeveel ouderen van elk cohort werd opgenomen in een verpleeghuis (data beschikbaar vanaf 2012). Van alle drie cohorten waren de gemaakte tandheelkundige kosten en overige zorgkosten voor de gehele periode beschikbaar.

Gemiddeld genomen bleken ouderen met een eigen dentitie gezonder te zijn dan edentate ouderen. Hartaandoeningen en diabetes kwamen vaker voor bij ouderen met een conventionele prothese. Deze groep ouderen gebruikte ook meer medicijnen (polyfarmacie), met name antitrombotische medicatie. In 2009 kwam de prevalentie van hartaandoeningen en diabetes bij ouderen met een implantaatgedragen overkappingsprothese overeen met die van ouderen met een eigen dentitie, maar in de jaren daarna verslechterde de gezondheid van de groep ouderen met een overkappingsprothese op implantaten sneller dan die van ouderen met een eigen dentitie. Aan het eind van de onderzoeksperiode was het niveau van de algemene gezondheid van de overkappingsprothesedragers zelfs vergelijkbaar met die van ouderen met een conventionele prothese.

Als we het zorggebruik van deze drie groepen ouderen met elkaar vergelijken, dan vallen een aantal overeenkomsten op. Vrijwel alle ouderen bezochten minstens een keer per jaar de huisarts (90% van de ouderen) en een medisch specialist (tussen de 85–95%). Wanneer gekeken wordt naar het gebruik van tandheelkundige zorg, dan wordt een heel ander beeld gezien gedurende de onderzoeksperiode. Er is een dalende lijn zichtbaar met betrekking tot tandarts-

bezoek bij ouderen met een eigen dentitie: in 2010 kwam nog 90% minstens een keer per jaar bij de tandarts, in 2016 was dit afgenomen tot 67%. Ouderen met een conventionele prothese bezochten nog maar in 10% van de gevallen de tandarts in de periode 2010-2016, en onder ouderen met een implantaatgedragen overkappingsprothese was dit percentage in dezelfde periode ongeveer 30%. Met name de afname van tandartsbezoek onder ouderen met een overkappingsprothese is opvallend, omdat de richtlijnen voor nazorg bij implantaat-gedragen overkappingsprothesen aangeven dat dragers van dergelijke prothesen minstens één keer per jaar voor controle de tandarts moeten bezoeken.

Wanneer er gekeken wordt naar de tandheelkundige kosten over de hele onderzoeksperiode, dan hebben ouderen met een eigen dentitie constante en relatief lage tandheelkundige kosten in vergelijking met beide andere groepen. Vooral ouderen met een implantaatgedragen overkappingsprothese maken, zoals was te verwachten, hoge kosten in het jaar dat deze prothese werd vervaardigd, maar in vergelijking met ouderen met een eigen dentitie blijven deze kosten ook na plaatsing van de overkappingsprothese relatief hoog.

Implantaatgedragen overkappingsprothesen en algemene gezondheid

Uit eerder onderzoek is naar voren gekomen dat ouderen met een implantaatgedragen overkappingsprothese in het algemeen beschikken over een betere gezondheid (minder kwetsbaar, betere fysieke conditie) dan ouderen met een conventionele prothese. Onduidelijk was of deze betere gezondheidsstatus al aanwezig was op het moment dat ze voorzien werden van een implantaatgedragen overkappingsprothese. Om dit nader te bestuderen werd een cross-sectieel big data onderzoek opgezet met Vektis (hoofdstuk 3) onder ouderen (≥ 75 jaar) die een implantaatgedragen overkappingsprothese hebben ontvangen in de periode 2009-2017. Voor de jaren 2009 en 2017 zijn tevens de algemene gezondheid van ouderen met een eigen dentitie en conventionele prothese geïnventariseerd om na te gaan of de eventuele verschillen in algemene gezondheid tussen de drie groepen die werden gezien in 2009 nog steeds aanwezig waren in 2017.

In het jaar 2009 werden 143.199 ouderen met een eigen dentitie, 18.420 ouderen met een conventionele prothese en 6.503 ouderen met een implantaatgedragen overkappingsprothese geïncludeerd. In 2017 waren dit respectievelijk 237.450 ouderen met een eigen dentitie, 17.787 ouderen met een conventionele prothese en 4.631 ouderen met een implantaatgedragen overkappingsprothesen. Ouderen die werden voorzien van een conventionele prothese hadden de hoogste preva-

lentie van hartaandoeningen, hypertensie en diabetes, en gebruikten de meeste medicatie (polyfarmacie). Opmerkelijk was dat over de gehele periode 2009-2017 het plaatsen van implantaten ten behoeve van de overkappingsprothese voornamelijk werd uitgevoerd bij ouderen tussen de 75-85 jaar (90%) en zelden boven de 85 jaar. Het lijkt erop dat onder tandartsen de voorkeur voor behandeling uit gaat naar de relatief jongere en gezondere groep binnen de oudere populatie.

Implantaatgedragen overkappingsprothese bij kwetsbare ouderen

De meeste onderzoeken naar de uitkomsten van een behandeling met implantaten en overkappingsprothesen zijn uitgevoerd in een jonge en gezonde populatie. Om uit te zoeken of deze behandeling ook nog succesvol is in een oudere, meer kwetsbare populatie, werd een onderzoek uitgevoerd naar de lange termijnresultaten (≥ 20 jaar) van de implantaatgedragen overkappingsprothese in een populatie die inmiddels ouder is dan 80 jaar (hoofdstuk 4). Tussen 1990 en 1999 waren 53 ouderen (≥ 60 jaar) voorzien van een implantaatgedragen overkappingsprothese. Er werden twee Brånemark, IMZ of ITI implantaten geplaatst in de onderkaak, en na drie maanden werd een overkappingsprothese in de onderkaak en een nieuwe conventionele prothese in de bovenkaak gemaakt. Voor de 20-jaars resultaten waren nog 15 ouderen beschikbaar. Het hoge aantal uitvallers was vooral te wijten aan het overlijden van patiënten, aangezien de meesten boven de 85 jaar zouden zijn geweest op moment van het vervolgonderzoek. Gedurende de afgelopen 20 jaar werden elke vijf jaar de volgende klinische parameters onderzocht: verlies van implantaat, plaque index, tandsteen index, gingiva index, bloedingsindex en pocketdiepte. Tevens werden röntgenfoto's vervaardigd. Aan de hand van die foto's kon het botniveau worden beoordeeld. Bij de 20-jaars follow-up werd aan de ouderen gevraagd om tevens een aantal patiënt gerelateerde vragenlijsten in te vullen met betrekking tot de kwetsbaarheid (Groningen Frailty Indicator: GFI), de kwaliteit van leven (EuroQoL EQ-5D, EQ VAS), het tandartsbezoek, de mondhygiëne en de tevredenheid met de prothese.

De mediane leeftijd was 85.5 jaar op het moment van de 20-jaars follow-up. Negen ouderen bleken kwetsbaar volgens de GFI. In het algemeen waren de ouderen erg tevreden met hun overkappingsprothese (score 7 op een schaal van 1-10) en hadden ze een goede kwaliteit van leven (gemiddelde EQ-5D waarde was 0,79 op een schaal van 0-1 en EQ VAS score 68,2 op een schaal 0-100). De lange termijn overleving van de implantaten was hoog (95,5%). Het peri-implantaire botverlies was zeer gering (gemiddeld $1,14 \pm 0,85$ mm). De scores van de klinische uitkomsten (tandsteen, gingiva index, bloedingsindex en pocketdiepte) waren

constant en lieten de gehele periode goede uitkomsten zien. De plaque index vertoonde echter een opmerkelijke toename: de hoeveelheid plaque rondom implantaten was hoog bij de 20-jaars follow-up, in tegenstelling tot de eerdere resultaten waarbij nauwelijks plaque aanwezig was.

Samenvattend, de meeste patiënten waren gedurende deze 20 jaar in meer of mindere mate kwetsbaar geworden, maar de peri-implantaire gezondheid bleef op een goed niveau en de ouderen waren tevreden met hun prothese. Met andere woorden: ook in een oudere, kwetsbaar wordende populatie is een implantaatgedragen overkappingsprothese een duurzame behandeloptie. In ieder geval indien er sprake is geweest van voldoende nazorg, zoals bij deze onderzoekspopulatie.

Orale pijnklachten en gebruik tandheelkundige zorg

Op het moment dat de algemene gezondheid van ouderen achteruit gaat en zij meer zorgafhankelijk worden, bestaat het risico dat bepaalde alledaagse activiteiten, zoals een goede (mond)hygiëne en tandartsbezoek, worden overgeslagen. Dit kan gevolg hebben dat de mondgezondheid snel achteruit gaat, waardoor cariës en parodontitis kunnen zorgen voor verlies van tanden en kiezen en het ontstaan van pijnklachten. Het was onduidelijk in welke mate thuiswonende ouderen (≥75 jaar) in Nederland hinder ondervinden van pijnklachten in de mond. Het was ook onduidelijk of de ouderen met pijn wel bij de tandarts kunnen komen als zij dit zouden willen, en of zij de mogelijkheid hebben om dit te organiseren. Voor dit onderzoek werden 1625 thuiswonende ouderen geïncludeerd (hoofdstuk 5). Deze ouderen werden verzocht om vragenlijsten in te vullen over kwetsbaarheid (GFI) en hun behoefte aan complexe zorg (INTERMED for the Elderly Self Assessment). Voorts werden vragen gesteld over het tandartsbezoek en de mondgezondheidsproblemen gedurende de afgelopen drie maanden (pijnklacht, kauwproblemen, slikklachten, droge mond, onzeker over het eigen gebit).

In totaal meldden 100 van de 1625 geïncludeerde ouderen (6,2%) dat zij de laatste drie maanden pijnklachten hebben gehad. Een droge mond werd door 190 ouderen (11,7%) gemeld. Kauwproblemen (5,7%), onzekerheid (4,7%) en slikklachten (2,2%) werden minder vaak gerapporteerd. De ouderen met pijnklachten werden telefonisch benaderd om hun klacht nader te specificeren en of zij de tandarts hadden bezocht. De ouderen met pijnklachten waren vaak robuuste ouderen (61%), 10% was kwetsbaar en 29% had een complexe zorgbehoefte. Binnen deze groep hadden meeste ouderen een eigen tandarts en konden hier naartoe wan-

neer zij dat zelf wilden (84%). De robuuste ouderen konden vaak zelfstandig naar de praktijk toe (87%), de andere groepen ouderen hadden regelmatig hulp nodig.

Dit onderzoek liet zien dat de prevalentie van pijnklachten in de mond onder thuiswonende ouderen laag is (6%) en dat zij meestal zelfstandig hun tandarts kunnen bezoeken of in ieder geval hun tandartsbezoek kunnen organiseren. Kwetsbare ouderen en ouderen met complexe zorgbehoeften hadden vaker hulp van anderen hierbij nodig. De laatste twee groepen ouderen lopen daardoor een hoger risico op het ontwikkelen van een slechte mondgezondheid. Het is aan te raden dat deze ouderen regelmatig door de tandarts gezien blijven worden.

Orale status en ondervoeding

Het risico om ondervoed te raken neemt toe met ouder worden. In dit onderzoek werd gekeken of een verband bestaat tussen de orale status en ondervoeding. Ondervoeding werd gedefinieerd als een BMI <20 kg/m² of onbedoeld gewichtsverlies >5% in 1 maand of >10% in 6 maanden (hoofdstuk 6). In totaal werden 1041 thuiswonende ouderen (≥75 jaar) in deze studie geïncludeerd. De ouderen werden verzocht om vragenlijsten over kwetsbaarheid (GFI), complexe zorgbehoefte (INTERMED), dagelijkse activiteiten (Katz-15), gezondheid gerelateerde kwaliteit van leven (EQ-5D), hun orale status en orale problemen in te vullen.

De resultaten lieten zien dat orale status (eigen dentitie, conventionele prothese en implantaatgedragen prothese) niet geassocieerd zijn met ondervoeding, in tegenstelling tot kwetsbaarheid en complexe zorgbehoefte. Ondervoeding kwam vaker voor onder kwetsbare ouderen (4,5%) en ouderen met complexe zorg (10%) dan onder robuuste ouderen (2,9%). Ondervoede ouderen meldden ook vaker kauwproblemen en problemen met eten, maar dit bleek niet significant geassocieerd te zijn met ondervoeding in een multivariate analyse. Alleen gezondheidgerelateerde kwaliteit van leven bleef in het multivariate model geassocieerd met ondervoeding. Het is mogelijk dat de combinatie van mondproblemen (kauwen en eten) een effect heeft op de gezondheid-gerelateerde kwaliteit van leven, en daarmee verband houdt met ondervoeding, maar hiervoor is meer onderzoek nodig.

Concluderend kan worden gesteld dat ouderen met een eigen dentitie over het algemeen een betere algemene gezondheid, een lager medicatiegebruik, minder chronische aandoeningen, een lager aantal verpleeghuisopnames, een lager zorggebruik en lagere zorgkosten hebben dan edentate ouderen. Ouderen met

een implantaatgedragen overkappingsprothese lijken in eerste instantie qua algemene gezondheid meer op ouderen met een eigen dentitie, maar na verloop van tijd lijkt hun gezondheid steeds meer op dat van ouderen met een conventionele prothese. Deze bevindingen, samen met de uitkomsten over orale status en ondervoeding, tandartsbezoek en peri-implantaire gezondheid bij kwetsbare ouderen, worden in een breder kader toegelicht in de overkoepelende discussie in hoofdstuk 7.

Dankwoord

Dankwoord

Prof. dr. A. Visser, hooggeleerde eerste promotor, beste Anita. Ik vind het heel bijzonder dat je binnen de tijd van dit onderzoek bent gepromoveerd van co-promotor naar eerste promotor: een plek die je naar mijn inzien ook meer dan verdient. Met bewondering zie ik hoe ondernemend je bent en met hoeveel enthousiasme je de geriatische tandheelkunde op de kaart zet. Is het niet door een gero-kliniek te openen, dan wel door professor in de gerodontologie worden of teleconsulten uitvoeren, en daarnaast ook nog altijd beschikbaar te zijn voor overleg. Heel veel dank voor de afgelopen jaren, opdat er nog veel onderzoeks-jaren samen zullen volgen.

Prof. dr. A. Vissink, hooggeleerde promotor, beste Arjan. Ogenschijnlijk eenvoudig weet je de juiste vragen te stellen in mijn geschreven stukken. Regelmatig voorzie ik de discussie van speculatie of probeer ik lastige onderwerpen te vermijden, maar dan krijg ik altijd terug: 'dit heb je niet onderzocht', 'wat bedoel je hiermee?' of 'dit kan allemaal weg'. Jouw input heeft mijn onderzoek flink verbeterd (en opgeschoond) en daarvoor ben ik je erg dankbaar. Dank voor je bijdrage aan dit onderzoek.

Prof. dr. G.M. Raghoobar, hooggeleerde promotor, beste Gerry. Je hebt altijd een eenvoudige oplossing voor moeilijke problemen, of het nu gaat om een oude patiëntpopulatie (80+) te overtuigen van controle van hun implantaten in het UMCG of bij het maken van keuzes over Vektis data. Helaas is een congres in Suriname tot op heden nog niet gelukt, maar ik hou me zeker aanbevolen voor de toekomst. Dank voor je bijdrage aan mijn onderzoek.

Prof. dr. F.K.L. Spijkervet, beste Fred, afdelingshoofd MKA-chirurgie. Ik wil je bedanken voor de mogelijkheid die ik heb gekregen om mijn promotieonderzoek te doen binnen de afdeling MKA-chirurgie van het UMCG.

Hooggeleerde leden van de beoordelingscommissie, geachte prof. dr. M.S. Cune, prof. dr. F.R. Rozema en prof. dr. H. de Bruyn. Ik wil u bedanken voor de tijd die u heeft genomen om dit proefschrift te beoordelen.

Prof. dr. H.J.A. Meijer, beste Henny. Dankzij jouw inspanningen (in dit geval: op de tafel klimmen om oude archiefdozen door te spitten) kon er een artikel geschreven worden over de 20-jarige overleving van de overkappingsprothese bij ouderen. Dank voor je inzet bij dit onderzoek.

Dr. A. Hoeksema, beste Arie. Jouw proefschrift gold als inspiratiebron voor mijn onderzoek. Dank voor je inbreng, vooral wat betreft de onderzoeken met Vektis.

Dr. K. Wynia †, dr. S.L.W. Spoorenberg, beste Klaske en Sophie. Met jullie inzet hebben we twee mooie onderzoeken onder thuiswonende ouderen kunnen uitvoeren. Het is erg spijtig dat Klaske de afronding van het proefschrift niet mee heeft mogen maken.

Dr. L.L. Peters, beste Lilian. Dank voor je statistische advies en feedback op de onderzoeken met Vektis.

Medewerkers van Vektis, in het bijzonder Tijs van Gorp. Dank voor jullie inzet om de juiste data boven water te krijgen, dankzij jullie konden we op grote schaal kijken naar algemene gezondheid en orale status bij ouderen.

Mw. S. de Vries, beste Saar. Dank voor alle tijd en energie die je hebt besteed aan dit proefschrift. Dankzij jouw inspanningen ligt hier nu een prachtig proefschrift.

Beste dames van het secretariaat, beste Nienke en Lisa. Dank voor jullie ondersteuning bij het onderzoek en het bieden van een luisterend oor. Tevens gewillig aanschouwers van nieuwe aankopen.

Collega-onderzoekers van de afdeling MKA, dank voor alle koffie- en lunchmomenten en interesse in mijn onderzoek. Ik wens jullie veel succes in het afronden van jullie onderzoeken.

Team van de Zevenster in Coevorden, beste Laurent, Monica, Kostas, Esther, Sabine, Annemie, Sjaran, Inge, Marian, Joke, Jacqueline, Ineke, Anita en Rolinda. Een aantal van jullie kent mij vanaf jongs af aan en hebben mij zien opgroeien tot een heuse dr. Bakker ;-). Ik ben er trots op deel te mogen zijn van dit team en ik hoop dat we nog lang zo door kunnen gaan.

Lieve Chapeau, lieve Karen, Bibi, Judith, Natalie, Stephanie, Frédérique, Pauline, Susanne en Jocelyne. Jullie zijn een van de weinigen die de weg naar Groningen niet langer vinden dan de weg van Groningen naar Amsterdam of Utrecht. Inmiddels is een clubweekend Groningen een standaarduitje geworden, naast carnaval en Tilburg en het (ooit te organiseren) datediner. Dank voor jullie gezelligheid, goede verhalen en Brabantse/lange nachten.

Dr. M.J. de Smit, lieve Menke. Je bent een echte aanvulling op de gero-Gro-groep. Altijd beschikbaar voor een koffie (of twee) of een rondje hardlopen. Je positieve houding en enthousiasme zijn altijd erg welkom op onderzoeksdagen.

Daarnaast is er ook altijd een eindeloze hoeveelheid foto's van honden en boten beschikbaar, dus saai wordt het nooit. Dank voor je enthousiasme en altijd positieve feedback.

E.A. Selier, MSc, lieve Eva. Hoewel we niet meer in aangrenzende kamers slapen, zullen we toch altijd Mieva blijven. Of er nu een weekenddienst in Suriname is of we missen de laatste lift op de piste: er kan altijd gekeet worden. En zelfs nu we ouder (en saaier) worden, blijft er genoeg over om ons te vermaken. Een draak van een patiënt of een verdwaalde snorhaar: sommige momenten blijven je altijd bij. Ik ben heel blij voor je dat je je plek hebt gevonden in het CBT en weet zeker dat je een goede angststandarts zal worden. Ik wil je bedanken voor alle support en vermaak de afgelopen jaren.

Lieve Loes, Josien en Gijs, lieve broer en zussen. Uiteindelijk zijn we niet vaak allemaal op dezelfde plek, maar gelukkig zijn de woonplaatsen van Gijs altijd een goede reden om met z'n allen op reis te gaan. Kerst in Ghana, wintersport met z'n vijftien of 's nachts in de Gobi-woestijn op zoek naar de juiste *ger* zijn momenten die ik niet zal vergeten. Ook jullie hulp in noodgevallen wordt gewaardeerd: dankzij jullie hulp zaten pap en ik niet Seven years in Tibet tijdens de corona-crisis. Dank voor jullie nuchtere advies en gezelligheid.

Lieve pap en mam. Lange tijd leek het erop dat er geen tandarts Bakker bij zou komen. Na de niet-medische studies van Loes, Josien en Gijs en mijn keus voor Biomedische Wetenschappen leken de kansen klein. Maar mijn twijfel over het werken in een lab en de mogelijkheid om een zij-instroom opleiding te volgen resulteerden in het beste van beide: zowel onderzoek doen als tandarts zijn. Pap, ik vind het heel bijzonder dat we zij aan zij als tandarts aan het werk zijn. Voor patiënten is het ook altijd makkelijk om mezelf voor te stellen: nog steeds tandarts Bakker, maar dan zonder snor. Dat je na 40 jaar nog plezier heb in het werk is iets dat ik ook hoop te bereiken. Maar dit draait natuurlijk niet zo soepel zonder de organisatie van mam. Mam, je bent een ster in het organiseren van zaken, van het regelen van verjaardagscadeaus tot voedselpakketten voor een vakantie met de VW-bus en patiënten achterna zitten. Samen vormen jullie een gouden team, hoewel er soms wat wrijving is. Maar goed, anders ook geen glans natuurlijk ;-)
Dank voor jullie support, praktische kijk op zaken en broodjes tussen de middag.

Lieve Gijs, binnen de familie sta je misschien bekend als Gijs A, maar voor mij ben je gewoon Gijs. Samen met jou in villa Kakelbont, met bezoek van buurkatten, vliegt de tijd voorbij. Of we nu op de racefiets in het Zwarte Woud afzien of van de online kaart afdwalen in Servië: er is altijd iets te beleven. Je wijst me vaak

op het belang van voldoende ontspanning en niet te lang en te hard werken: ik beloof hierbij plechtig dat er na deze promotie relaxte (vakantie)weken zullen volgen. Misschien binnenkort een zomer door Engeland toeren? Dank dat je er altijd voor me bent.

Curriculum Vitae

Curriculum Vitae

Mieke Bakker

Mieke Bakker werd geboren op 14 september 1991 in Coevorden. Na het behalen van haar VWO diploma ging ze Biomedische Wetenschappen studeren in Utrecht. In 2012 behaalde ze haar bachelor diploma, waarna zij overstapte naar de opleiding tandheelkunde aan de Rijksuniversiteit in Groningen. Hier heeft zij het verkorte opleidingsprogramma voor zij-instromers gevolgd en studeerde in 2016 af als tandarts. Vanaf 2016 heeft zij zich verbonden als tandarts aan het Tandheelkundig Centrum de Zevenster in Coevorden en daarnaast als PhD student binnen de onderzoekslijn mondgezondheid voor ouderen onder leiding van prof. dr. A. Visser, prof. dr. A. Vissink en prof. dr. G.M. Raghoobar aan de Rijksuniversiteit Groningen binnen de afdeling MKA-chirurgie van het UMCG.

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Printing of this thesis was kindly supported by:

Drukken van dit proefschrift werd mede mogelijk gemaakt door:



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