# Oral health-related quality of life, tooth loss and utilization of dental services among older people in Norway and Sweden

A prospective and comparative perspective

**Ferda Gülcan**

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Author:    Ferda Gülcan

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*Dedicated to my mother, Müesser Salman*

# Scientific environment

Department of Clinical Dentistry

Faculty of Medicine and Dentistry

University of Bergen

Bergen, Norway

*Collaborators*

Örebro Läns Landsting

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# Abbreviations

| | |
|---|---|
| CI | Confidence Interval |
| DALYs | Disability Adjusted Life Years |
| GEE | Generalised Estimating Equations |
| GOHAI | Geriatric Oral Health Assessment Index |
| HRS | Health and Retirement Study |
| ICC | Intra-cluster correlation |
| IPW | Inverse Probability Weighting |
| OHIP | Oral Health Impact Profile |
| OHRQoL | Oral Health-Related Quality of Life |
| OIDP | Oral Impacts on Daily Performances |
| OR | Odds Ratio |
| PDS | Public Dental Service |
| RIM | Random Intercept Model |
| SDA | Shortened Dental Arches |
| SHARE | Survey of Health, Ageing and Retirement in Europe |
| UN | United Nations |
| WHO | World Health Organization |

# Abstract

**Background:** Globally, the proportion of older people is increasing. There is a need to address issues related to oral health and oral health-related quality of life of elderly. There is scarce information on how oral health and dental care utilization as well as the social distribution of those oral indicators develop across time and by ageing in Norway and Sweden. The overall aim was to provide new information about oral health, dental care utilization and associated life-course factors among older people using comparative data generated by Norwegian and Swedish 1942 birth cohorts of elderly.

**Methods:** The thesis is based on data from two cohort studies. All persons born in 1942 in three counties of Norway and two counties of Sweden were defined as the study cohorts. The 2007 and 2012 waves were used in the present thesis. In Norway, the response rates were 58.0% (n=4211) in 2007 and 54.5% (n=3733) in 2012. A total of 2947 (follow-up rate of 70.0%) participated in both waves. The corresponding rates in Sweden were 73.1% (n=6078) and 72.2% (n=5697), respectively. A total of 4862 (follow-up rate of 80.0%) participated in 2007 and 2012. Data were collected using self-administered questionnaire and analysed separately by country.

**Results:** The prevalence of reporting any oral impacts (OIDP>0) was 29.0% in 2007 and 28.4% in 2012 in Norway, whereas corresponding figures in Sweden were 27.3% in 2007 and 20.4% in 2012. Altogether, 63.6% of the Norwegian and 68.1% of the Swedish participants reported no change regarding OIDP (Oral Impacts on Daily Performances) scores across time. The percentage of persons reporting tooth loss (defined as extensive tooth loss or being edentulous) increased from 21.8% to 23.2% in Norway and from 25.9% to 27.3% in Sweden. Less frequent dental attendance decreased from 14.5% to 12.2% in Norway and from 13.6% to 12.9% in Sweden. Early and later life social conditions contributed independently on tooth loss and OIDP. Participants in socially disadvantaged groups were more likely to report oral impacts (OIDP), tooth loss and less frequent dental attendance. Marginal and random intercept models were applied to take account into clustered structure of data due to repeated observations. Using Andersen's behavioural model, predisposing, enabling, and need related factors and dental care utilization indicators were associated with OIDP.

**Conclusions:** The OIDP frequency inventory demonstrated acceptable longitudinal validity, reproducibility and responsiveness. OIDP (reporting any oral impacts) and less frequent dental attendance declined while tooth loss increased from age 65 to 70 in both countries investigated. Social inequalities were confirmed and shown to be persistent in Norwegian and Swedish older people from age 65 to 70 years. Support for the latent effect life-course model was obtained. This thesis provides support to Andersen's model as a satisfactory model to explain oral health in older people.

# Sammendrag

**Bakgrunn:** Andelen av eldre øker på verdensbasis. Det er behov for å ta opp spørsmål knyttet til oral helse og oral helse-relatert livskvalitet for eldre. Det er lite informasjon om hvordan oral helse og bruk av tannhelsetjenester samt den sosiale fordelingen av disse indikatorer forandrer seg over tid og ved aldring i Norge og Sverige. Det overordnede målet var å skaffe ny informasjon om oral helse, bruk av tannhelsetjenester og tilhørende livsløpsfaktorer blant eldre mennesker ved hjelp av å bruke komparative data i norske og svenske 1942 fødselskohorter av eldre.

**Metoder:** Denne avhandlingen er basert på data fra to kohortstudier. Alle personer født i 1942 i tre fylker i Norge og to fylker i Sverige ble definert som studiekohorter. Data fra 2007 og 2012 ble brukt. I Norge var responsraten 58,0 % (n = 4211) i 2007 og 54,5 % (n = 3733) i 2012. I alt 2947 (oppfølging rate 70,0 %) deltok i begge årene. De tilsvarende tallene i Sverige var henholdsvis 73,1 % (n = 6078) og 72,2 % (n = 5697). Totalt 4862 (oppfølging rate 80,0 %) deltok i 2007 og 2012. Data ble samlet inn ved hjelp av selvadministrert spørreskjema og analysene ble gjort separat på hvert land.

**Resultater:** Forekomsten av redusert livskvalitet (OIDP>0) var 29,0 % i 2007 og 28,4 % i 2012 i Norge, mens tilsvarende tall i Sverige var 27,3 % i 2007 og 20,4 % i 2012. Til sammen 63,6 % av norske og 68,1 % av svenske deltakere rapporterte ingen endring av OIDP (Oral Impacts on Daily Performances) skår over tid. Andelen av personer som rapporterte tanntap (definert som omfattende tanntap eller å være tannløs) økte fra 21,8 % til 23,2 % i Norge og fra 25,9 % til 27,3 % i Sverige. Sjeldent bruk av tannhelsetjenester ble redusert fra 14,5 % til 12,2 % i Norge og fra 13,6 % til 12,9 % i Sverige. Livsløpsperspektiv modellen (the latent effect life-course model) ble bekreftet at tidlige og senere livsløpsfaktorer hadde en uavhengig effekt på tanntap og OIDP. Deltakere med minst sosiale ressurser var mer sannsynlig å rapportere redusert livskvalitet (OIDP), tanntap og sjeldnere bruk av tannhelsetjenester. Ulike statistiske metoder ble anvendt for å ta hensyn til den «cluster» strukturen av data på grunn av repeterte målinger. Ved hjelp av Andersens atferds modell, disponerende-, muliggjørende-, og behovs- relaterte faktorer og bruk av tannhelsetjenester var assosiert med OIDP.

**Konklusjon:** OIDP instrument demonstrerte akseptabelt longitudinell validitet, reproduserbarhet og respons. Redusert livskvalitet og sjeldnere bruk av tannhelsetjenester ble redusert mens tanntap økte fra 65 år til 70 i begge landene. Sosiale ulikheter ble bekreftet og viste seg å være vedvarende hos den norske og svenske eldre populasjonen fra alderen 65 til 70 år. Denne avhandlingen gir støtte til Andersens modell som en tilfredsstillende modell for å forklare oral helse hos eldre. Støtte for den livsløpsperspektiv modellen ble også oppnådd.

# List of publications

I.  **Gulcan F**, Nasir E, Ekback G, Ordell S, Astrom AN. Change in Oral Impacts on Daily Performances (OIDP) with increasing age: testing the evaluative properties of the OIDP frequency inventory using prospective data from Norway and Sweden. BMC Oral Health 2014, 14:59.

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II.  **Gulcan F**, Ekback G, Ordell S, Lie SA, Astrom AN. Inequality in oral health related to early and later life social conditions: a study of elderly in Norway and Sweden. BMC Oral Health 2015, 15:20.

III.  **Gulcan F**, Ekback G, Ordell S, Lie SA, Astrom AN. Social predictors of less frequent dental attendance over time among older people: population-averaged and person-specific estimates. Community Dent Oral Epidemiol 2016, 44(3):263-273.

IV.  **Gulcan F**, Ekback G, Ordell S, Klock KS, Lie SA, Astrom AN. Exploring associations of dental care utilization on oral impacts on daily performances using Andersen's behavioural model − a prospective cohort study of older people in Norway and Sweden. Manuscript for submission.

# Contents

# 1. INTRODUCTION

## 1.1 Preface

This thesis, entitled "Oral health-related quality of life, tooth loss and utilization of dental services among older people in Norway and Sweden a prospective and comparative perspective" emanates from 1942 cohort studies in Norway and Sweden and focuses non-institutionalized community-dwelling older people from age 65 to 70 years. The overall aim of the thesis is to provide new information about the development of oral health and associated life-course factors among ageing people in Norway and Sweden. The Swedish cohort has been tracked since 1992 at age 50, whereas the Norwegian cohort was initiated in 2007 at age 65 years. This thesis extends previous studies based solely on the Swedish cohort by; 1) covering an extended period from age 65 (2007) to age 70 (2012), 2) including comparative Norwegian cohort data and cross-country analyses and 3) expanding methodological aspects by introducing advanced multilevel statistical methods to take into account the clustered structure of repeated data. The thesis presented includes; longitudinal validation of OIDP across the Norwegian and Swedish cohorts, testing of early life-course hypotheses in relation to oral health and its social disparities across time and cohorts, assessment of population-averaged and person-specific estimates of social predictors of less frequent dental attendance in older people, and examination of the relationship between oral health-related quality of life and dental care utilization using Andersen's behavioural model as a theoretical framework. For the purpose of this thesis, older people has been defined as "a population with health care conditions and need which differs significantly from those of younger people and which are often complicated by physical, social and behavioural changes associated with ageing, including people 60 years and above"[1].

Oral health, quality of life and their importance for oral health care are concerns of the health and welfare policy in all Nordic countries [2]. Increased research activity is necessary to be able to satisfy the political ambitions of equal access to oral health care and maintenance of good oral health for older people [2-4]. The present

thesis has relevance according to national strategic documents, as well as to individual users of the oral health care systems [3, 4]. Broad research areas and questions have motivated both the content and design of the 2007 and 2012 waves of the Norwegian and Swedish 1942 cohort studies [5, 6]. In subsequent waves, new topics will enter to be in accordance with the development of the current policy contexts.

## 1.2  Population ageing

Ageing is a dynamic process, and defining old age can vary across societies [7]. In a later report, the United Nations (UN) agreed that a cut-off 60+ years should refer to older people [7]. In contrast, most developed countries have accepted the age of 65 as the beginning of old age since it is roughly equivalent with time of retirement [8].

Population ageing entails an increasing share of older people and is taking place in nearly all regions in the world following decreased fertility and increased life expectancy [7]. The extent and speed, however, vary in different countries. Worldwide, the proportion of people aged 60 years and above increased from 9.2% in 1990 to 11.7% in 2013 and will reach 21.1% by 2050. Globally, the share of the "oldest old" (80 years and above) within the older population was 14% in 2013. This share will increase to 19% in 2050 [7].

In Norway, just over one in nine people are aged 70 years and above in 2016 [9]. By 2060, every fifth person will be aged 70 years and above [9]. In Sweden more than one million will be aged 80 years or above in 2045 [10]. In 1960, the remaining life expectancy at age 65 years was 13.7 years for men and 15.3 years for women. The corresponding figures in 2014 were 18.9 and 21.5 years. Following a continued decline in mortality rates, the remaining life expectancy at age 65 is estimated to be 23.7 years for men and 25.4 years for women by 2060 [10]. Similar demographic changes are not limited to Norway and Sweden. During the period 2005-50, the median age of the European Union's population is projected to rise from 38 to 48

years [11]. In 2005, the age group 65 years and above was 79 million. By 2025 it will increase to 107 million and subsequently to 133 million in 2050 [11].

Population ageing presents both opportunities and challenges [12, 13]. It has public health implications, as increasing age is associated with increased chronic diseases and disability [13, 14]. According to the Global Burden of Disease 2010 Study, disability adjusted life years (DALYs) due to oral conditions, increased by 20.8% up to 15 million DALYs between 1990 and 2010 because of population growth and ageing [15]. Although during the late 1960s, improvement in oral health occurred in industrialized countries, mostly due to widespread availability of fluoridated toothpaste [16, 17], people born before the introduction of fluoride suffered from high levels of dental caries [16]. More teeth with restorative requirements in ageing populations imply that older people will be in greater need for dental health care services. It is anticipated that a "bulge of restored teeth" will create considerable demands for the provision of oral health care [16, 18].

## 1.3 Epidemiology of tooth loss, oral health-related quality of life and utilization of dental services in older people

### 1.3.1 Tooth loss

Oral health is an integral part of general health and essential for quality of life and well-being [19]. Good oral health implies being free from chronic orofacial pain, oral and pharyngeal (throat) cancer, oral tissue lesions, birth defects such as cleft lip and palate, and other diseases and disorders that affect oral, dental and craniofacial tissues [19]. It is evident that poor oral health persists among older people in terms of tooth loss, dental caries experience, periodontal disease, xerostomia, oral cancer and impaired quality of life [14, 15, 18, 20, 21].

Tooth loss is an outcome that reflects an individual's history of dental disease and its treatment over the life-course [22]. Tooth loss is monitored in many countries since it is considered as an effective marker of the population oral health situation [22]. Globally, a reduction in the prevalence of edentulism (loss of all teeth) as well

as in the prevalence and incidence of tooth loss has occurred in many countries [23-25]. According to a recent systematic review, a significant reduction in the global burden of severe tooth loss (having fewer than 9 remaining teeth) was observed between 1990 and 2010 [22]. During that period, the global age-standardized prevalence of edentate people decreased from 4.4% to 2.4% [22].

During the 1990s, the prevalence of edentulism among 75 year olds was 27% and 58% in Sweden and Finland, respectively [26]. Hugoson et al. [24] reported a change in the prevalence of edentulism of 40-70- year- old Swedes from 16% in 1973, to 1% in 2003, and further to 0.3% in 2013 [27]. Ekornrud et al. [28] reported a prevalence of edentulism among 65-74 year olds amounting to 2% in Sweden in 2011 and 7% in Norway in 2008. Corresponding figures in Denmark and Iceland were 10% (in 2010) and 33% (in 2007). Despite these observed declining trends in edentulism, the mean number of lost teeth increases with increasing age and substantial proportions of the current older generations experience tooth loss [14, 25, 29, 30]. Muller et al. [25] in a review of edentulism and tooth loss in Europe, notified a lack of epidemiological studies, and the quality of data varied considerably in the incidence studies. Across countries and survey years the prevalence of edentulism has varied being; 0.3% in Sweden in 2013, 18.6% in the USA in 2012, 48.0% in Turkey in 2005, and 58.0% in the UK in 1998 [27, 30-32]. The sequential cross-sectional Adult Dental Health Survey in UK has shown a decline in the prevalence of edentulism in the general adult population from 28% in 1978 to 6% in 2009, whereas the proportions having more than 21 teeth increased from 73% in 1978 to 86% in 2009 [30, 33]. Incidence studies with follow-up periods ranging from 12 months to 10 years have shown that the incidence of tooth loss has varied from 6.5% in Norway to 96.0% in China [29, 34]. Table 1 presents an overview of international studies, published between 1996 and 2016, considering the prevalence/incidence of tooth loss (self-reported and clinically assessed), mean number of remaining teeth and prevalence/incidence of edentulism in community-dwelling older people aged 60 years and above.

Table 1. Prevalence/incidence of tooth loss, mean number of teeth and prevalence/incidence of edentulism in community-dwelling older people aged 60+.

| Authors/ Year | Country | Sample (n) | Year examined | Age (years) | % Tooth loss | % Edentulism |
|---|---|---|---|---|---|---|
| **Incidence Studies** | | | | | | |
| Slade et al., 1997[35] | South Australia | 693 | 1991/92 1993/94 | 60+ | 19.5 | 0.7 |
| Fure & Zickert 1997[36] | Sweden | 148 | 1987 1992 | 60, 70, 80 | 40.0 | |
| Baelum et al., 1997[29] | China | 86 | 1984 1994 | 60+ | 96.0 | |
| Warren et al., 2002[37] | USA | 73 | 1983/88 1996/98 | 65+ | 62.0 | 4.1 |
| Fure S. 2003[38] | Sweden | 102 | 1987 1997 | 65, 75, 85 | 13.0[a] | |
| Haugejorden et al., 2003[34] | Norway | 2520 | 1999 2000 | 20-79 | 6.5 5.7 (67-79) | |
| De Marchi et al., 2012[39] | Brazil | 273 | 2004 2008 | 60+ | 67.8 | 12.5 |
| Koyama et al., 2016[40] | Japan | 51280 | 2010 2013 | 65+ | 8.2 | |
| **Prevalence Studies** | | | | | | |
| Suominen-Taipale et al., (1999)[41] | Finland | 5037 3516 | 1978 1997 | 15-64 | | 14.0 6.0 |
| Steele et al., 2000[30] | UK | 3817 | 1998 | 16+ | 24.8[b] | 13.0 (overall) 58.0 (75+) |
| Henriksen et al., 2003*[42] | Norway | 582 | 1996/99 | 67+ | | 31.6 |
| Petersen et al, 2004[43] | Denmark | 3818 | 2000 | 16+ | | 8.0 (overall) 36.0 (65+) |
| Shah et al., 2004[44] | India | 1240 | | 60+ | | 15.2 |
| Pallegedara & Ekanayake, 2005[45] | Sri Lanka | 630 | | 60+ | 98.0 | 17.0 |
| Hugoson et al., 2005[24] | Sweden | 987 | 2003 | 3-80 | 20.7[b](70) | 1.0 (40-70) |
| Osterberg et al., 2006[46] | Sweden | 484 | 2000/01 | 70 | 20.9[b] | 7.0 |
| Hugo et al., 2007[47] | Brazil | 5349 | 2002/03 | 65-74 | | 54.8 |
| Holst & Skau, 2010[48] | Norway | 1859 | 2008 | 20+ | | 1.9 (overall) 2.9 (60-69) 14.5 (80+) |
| Steele et al., 2012[33] | UK | 6469 | 2009 | 16+ | 25.7[b] | 6.0 (overall) 47.0 (85+) |
| Dogan & Gokalp, 2012[32] | Turkey | 1545 | 2004/05 | 65-74 | | 48.0 |
| Northridge et al., 2012[49] | USA | 729 | 2006/09 | 65+ | | 19.5 |
| Dye et al., 2015[31] | USA | (NHANES) | 2011/12 | 65+ | | 18.6 |
| Ramsay et al., 2015[14] | UK | 1660 | 2010/12 | 71-92 (men) | | 20.0 |
| Nordreryd et al., 2015[27] | Sweden | 1010 | 2013 | 3-80 | 22.5[b](70) | 0.3 (40-70) |
| Han et al., 2015[50] | Korea | 8814 | 2007/12 | 65+ | | 11.0 |
| Ren et al., 2016[51] | China | 17167 | 2011/12 | 45+ | | 8.6 |
| Laguzzi et al., 2016[52] | Uruguay | 341 | 2010/11 | 65-74 | 75.0 | 28.2 |

Specific age group(s) is given in parentheses. NHANES (National Health and Nutrition Examination Survey)

*Both institutionalised and community-dwelling

a) Lost more than 2 teeth

b) Mean number of teeth

## 1.3.2  Oral health-related quality of life

Clinical indicators of the oral condition fail to consider the functional and psychosocial aspects of oral health [53-55]. Clinical measures need to be supplemented by subjective measures when assessing oral health and evaluating treatment outcomes. Subjective oral health indicators, initially designed as socio-dental indicators, refer to measures of oral health-related quality of life (OHRQoL) [55]. OHRQoL is a multidimensional construct, encompassing physical, social and psychological impacts of oral problems [54, 56].

Since Cohen & Jago (1976) first advocated use of socio-dental indicators, different inventories have been developed [54, 57]. Specification of measurement goals as descriptive, predictive, discriminative or evaluative are prerequisites in order to choose an appropriate measure of OHRQoL [58, 59]. Descriptive measures are used in population based cross- sectional surveys to document the prevalence of OHRQoL; predictive measures are used to predict patient's health status with respect to current or future "gold standard" measures; discriminative measures distinguish between groups that differ in clinical condition; and evaluative measures assess within-individual change occurring naturally or as an effect of an intervention [59]. Ideally, both the cross-sectional and longitudinal psychometric properties of an instrument should be established in every context under consideration [59]. Longitudinal validity, reproducibility, responsiveness and interpretability are the key properties of evaluative measures [59, 60]. While longitudinal validity refers relationship between changes in instrument and other measures over time, reproducibility of the instrument indicates ability to yield consistent results over time in stable subjects [58, 59]. Responsiveness represents a measure's ability to detect change in oral health status, whereas interpretability refers to whether these changes are clinically significant or meaningful to a person experiencing change [61]. Yet, few studies have reported on the longitudinal validity and responsiveness of OHRQoL instruments [59, 62-66].

A variety of OHRQoL instruments has been applied in older populations, including the Oral Health Impact Profile (OHIP) [54, 67-70], the Geriatric Oral Health Assessment Index (GOHAI) [71-74] and the Oral Impacts on Daily Performances (OIDP) [75-79]. The original OIDP scale contained nine items [80]. However, for the purpose of cultural adaptation, modifications of the number of OIDP items have been implemented [75, 81]. The OIDP has demonstrated appropriate psychometric properties in terms of validity and reliability when applied in cross–sectional surveys of older people in Norway, Sweden, Greece and the UK, as well as in studies emanating from middle- and low income countries [77, 79, 81-83]. Thus, the prevalence of OIDP (OIDP>0) has been reported to range from 12.3% in Great Britain to 62.9% in Korea [76, 78], amounting to 39.7% among Swedish people aged 20-86 years [82] and to 18.3% among 16-74 year old Norwegians [77]. According to a recent survey of older English men, about 70% reported oral problems (oral impacts, problems with gums and teeth) [14]. Few studies, most of them focusing effects of interventions, have evaluated the responsiveness and interpretability of the OIDP inventory [63, 64, 66, 79, 84, 85]. Table 2 presents an overview of international studies, published between 1996 and 2016, considering the prevalence of OIDP in populations including older people.

Table 2. Studies published between 1996 and 2016 including older people and focusing on the prevalence of oral impacts (OIDP>0).

| Authors/ Year | Country | Sample (n) | Age (years) | % Prevalence of oral impacts (OIDP>0) | Frequently reported impacts |
|---|---|---|---|---|---|
| Tsakos et al., 2001[76] | Great Britain Greece | 753 (Great Britain) 681 (Greece) | 65+ | 12.3 (British-D) 39.0 (Greek- D) | Eating |
| Sheiham et al., 2001[86] | Great Britain | 753 (F) 202 (I) | 65+ | 13.7 (F-D) 31.8 (I- D) | Eating |
| Srisilapanan & Sheiham, 2001[87] | Thailand | 623 | 60-74 | 52.8 | Eating |
| Astrom et al., 2005[77] | Norway | 1309 | 16-79 | 18.3 18.4* | Eating Cleaning |
| Kida et al., 2006[83] | Tanzania | 1031 | 50+ | 51.2(urban) 62.1(rural) | Eating |
| Ostberg et al., 2008[82] | Sweden | 204 | 20-86 | 39.7 | Eating and cleaning |
| Jung et al., 2008[78] | Korea | 668 | 65+ | 62.9 | Eating |
| Zeng et al., 2010[88] | China | 1196 | 55+ | 60.0 | Eating and cleaning |
| Hwang et al., 2012[89] | Korea | 634 | 60+ | 39.3 | Eating and speaking |
| Eric et al., 2012[90] | Bosnia and Herzegovina | 261 | 65+ | 55.2 | Eating |
| Nair et al., 2015[91] | Singapore | 202 | 65+ | 18.8 | Eating |
| Abegg et al., 2015[92] | Brazil | 200 | 50-74 | 58.0 | Smiling and eating |
| Ilha et al., 2016[93] | Brazil | 720 | 50-74 | 57.8 | |

*Age (67-79). F-Free living, I- Institutionalised, D- Dentate

### 1.3.3 Utilization of dental services

Regular use of dental care with recommended attendance rate once a year has been reported to be 87% and 81% among Danish and Swedish people in 1999 [94], 78% in Norwegians in 2004 [95] and 44% among older people in Finland in 1997 [96]. In a recent nation-wide population based study from Sweden, almost 90% of adults between 16 and 84 years reported regular dental attendance, whereas 7% men and 4% women reported that they rarely or never visited a dentist [97]. The third Nord-Trøndelag Health Survey carried out from 2006 to 2008 and focusing adults above 20 years, revealed a prevalence of dental care utilization of 77.1% [98]. In a nationwide study of Norwegian adults aged 20 years and above, the prevalence of dental care utilization amounted to 80 % [99]. Nationwide repeated cross- sectional surveys in Sweden have shown increase in the prevalence of dental care utilization across time in older age groups between 1968 and 2002 [100].

In the UK, the Adult Dental Health surveys revealed that the proportions of regular dental attendees increased from 43% in 1978 to 59% in 1998 [101]. The Japanese Study of Ageing and Retirement, second wave from 2009, revealed a prevalence of 47.9% of dental health care utilization in the past year [102]. Surveys conducted between 1994 and 2008 in Australia have shown that the prevalence of dental attendance within last year increased from 54.9% to 59.9%, being higher in older compared with younger adults [103]. A recent study based on data from the Survey of Health and Ageing and Retirement in Europe (SHARE) (2006/07) and the Health and Retirement Study (HRS) (2004/06) in the USA including people aged 51 years and above revealed variation of dental attendance across countries from 23.1% in Poland to 81.9% in Sweden [104]. Listl [105], reported regular dental attendance to vary across 13 European countries from 41.7% in Greece to 95.4% in Sweden. Few studies considering the development of dental attendance across time have utilized prospective longitudinal study designs [106-108]. Notably, assessing developmental trends in tooth loss, OHRQoL and dental care utilization among older people is difficult due to a general lack of longitudinal studies focusing intra-individual change in segments of the older populations. Table 3 presents an overview of international

studies including older people, published between 1996 and 2016, considering the prevalence of utilization of dental services.

Table 3. Studies published between 1996 and 2016 focusing on the prevalence of utilization of dental services and including older people.

| Authors/ Year | Country | Sample (n) | Year examined | Age (years) | % Prevalence* | Comments |
|---|---|---|---|---|---|---|
| Manski & Goldfarb, 1996[109] | USA | 5327 | | 55-75 | 52.0 | |
| Osterberg et al., 1998[110] | Sweden | 14964 13309 | 1980/81 1988/89 | 16+ | 36.0 (65-74) 59.0 (65-74) | 25.0 (75-84) 39.0 (75-84) |
| Millar & Locker, 1999[111] | Canada | 70884 | 1996/97 | 15+ | 59.0 | 51.0% of 55-64-year-olds 40.0% of 65+ |
| Nuttall et al., 2001[101] | UK | 6204 | 1998 | 16+ | 59.0 66.0 (55+) | Dental attendance was assessed asking whether participants go to dentist for regular dental check-up |
| Suominen-Taipale et al., 2001[96] | Finland | 1500 | 1997 | 65-74 | 44.0 | |
| Bagewitz et al., 2002[112] | Sweden | 1974 | 1998 | 50-75 | 12.0 | Attendance less than once a year |
| Kronstrom et al., 2002[94] | Sweden Denmark | 1001 1175 | 1999 | 55-79 (Sweden) 45-69 (Denmark) | 81.0 (Sweden) 87.0(Denmark) | |
| Holst et al., 2005[95] | Norway | 2471 | 2004 | 20+ | 78.0 88.0 (66-69) | 87.0% reported dental attendance within last two years |
| Seirawan H., 2008[113] | USA | 39300 | 2003 | 18+ | 71.6 | The lowest percentage of dental attendance was in Nevada (64%) and the highest in New Hampshire (76%) |
| Harford et al., 2011[103] | Australia | 5580 5939 5727 5418 12392 6017 | 1994 1996 1999 2002 2005 2008 | 18+ | 60.2 (65+) 63.7 (65+) 59.5 (65+) 61.8 (65+) 66.9 (65+) 62.5 (65+) | Between 1994 and 2008 the proportion in general with dental attendance within last year increased from 54.9% to 59.2% |
| Vikum et al. 2012[98] | Norway | 17136 men 21414 women | 2006/08 | 20+ | 77.1 | 76.5 (65+)men 76.9 (65+)women |
| Grytten et al., 2012[99] | Norway | 1861 | 2008 | 20+ | 80.0 | |
| Listl et al., 2012[114] | 14 European countries | | 2006/07 2008/09 | 50+ | 81.5(Sweden) 23.7(Poland) | Survey of Health, Ageing and Retirement in Europe (SHARE) wave 2 and 3 |
| Palencia et al., 2014[115] | 11 European countries | 12364 men 14692 women | 2006 | 50+ | 55.5 | SHARE wave 2 |
| Molarius et al., 2014[97] | Sweden | 5999 | 2012 | 16-84 | 89.0 90.0 (65-84) | Dental visit less than three years ago defined as regular attendees |
| Sgan-Cohen et al., 2015[116] | Israel | 2441 | 2009/10 | 50+ | 43.1 | SHARE Israel wave 2 |
| Murakami & Hashimoto, 2016[102] | Japan | 2581 | 2009 | 50+ | 47.9 | The Japanese Study of Aging and Retirement |
| Manski et al., 2016[104] | USA and 14 European countries | 29680 (SHARE) 16911 (HRS) | SHARE 2006/07 HRS 2004/06 | ≥ 51 | 66.0 (USA) 73.2(Germany) 79.8(Denmark) 81.9(Sweden) 23.1(Poland) | SHARE- dental attendance within last 12 months HRS (Health and Retirement Study)- dental attendance last 2 years |

Specific age group(s) is given in parentheses. *Attendance within last year

## 1.4 Social inequalities in tooth loss, oral health-related quality of life and utilization of dental services

### 1.4.1 Inequalities in tooth loss

Tooth loss and edentulism occur as final outcomes of a multifactorial process including, not only disease related factors (dental caries and periodontitis), but also socio-economic factors, oral health behaviours, patient preferences and professional interventions [39, 47, 117-121]. Despite improvements in oral health, social inequalities persist both between and within regions and societies, which are similar to that in general health [122, 123].

Also, social inequalities in dentition status and access to dental care persist among adults even in countries with generous redistributive oral health policies [19, 120, 121, 124-129]. The Adult Dental Health Survey in England, Wales and Northern Ireland concluded that social gradients in tooth loss persisted through the two decades studied despite marked improvements in tooth retention [130]. Persistence of income inequalities has been confirmed among adults in Brazil, Australia and USA [131]. A recent systematic review and meta-analysis demonstrated a positive association between low income and tooth loss in adults [132]. Using repeated cross-sectional studies, Liu et al. [133] reported that disparities in dentition status associated with ethnicity, education and income persisted among adults in the USA despite the overall improvement in oral health.

### 1.4.2 Inequalities in oral health-related quality of life

Socio-economic inequalities have been demonstrated for various indicators of oral health mostly clinical and disease related, whereas few studies have focused on inequalities in subjective oral health measures and even fewer having focused older adults [125]. According to the Swedish 1942 cohort study covering the period between 1992 and 2007, disadvantaged social condition at age 50 years as well as deterioration of social circumstances across time had a detrimental effect on OHRQoL at age 65 [134]. A nationwide cross-sectional study revealed a modest

prevalence of OIDP in Norwegian adults that did not vary with increasing age but confirmed the social gradient reported in other studies [135, 136]. Significant educational gradients in the prevalence of oral impacts across different welfare regimes have also been confirmed based on data from 21 European countries [137]. Other studies have confirmed on educational gradients in broad measures of self-reported oral health, suggesting that the lower the educational level the worse the self-reported oral health and oral quality of life [125, 138]. A representative sample of Brazilian community-dwelling older adults showed that poor socioeconomic characteristics predicted worse clinical dental status and worse OHRQoL [139].

## 1.4.3 Inequalities in utilization of dental services

Regular dental attendance has been shown to have a positive impact on oral health and to be more prevalent at the upper compared to the lower end of the socio-economic scale [95, 105, 140-144]. Based on data from the Survey of Health, Ageing and retirement (SHARE) in 14 European countries, Listl [142] reported considerable income related inequality in dental care utilization among Europeans aged 50+, whereby people in the highest income group had more frequent access to dental care than their counterparts in the lowest income group. In subsequent studies, Listl [105] reported income inequalities throughout the life-course and identified reasons for dental non-attendance across various European countries [145]. In a nationwide Norwegian survey, economy figured as the most prevalent reported reason for non-dental attendance in older people [146]. Manski et al. [104] reported that income and education were more strongly associated with dental care utilization than dental insurance aspects across European countries. Astrom et al. [106] identified perceived oral problems to be as important for regular use of dental care as indicators of social position, notifying that dental care system related factors omitted from their analyses, could have been important variables to consider. Although some evidence suggests that social disparity in oral health might be partly attributable to dental attendance patterns, and that dental attendance patterns are one pathway through which oral health disparities emerge, there is still disagreement considering the explanation of the social position gradient in oral health [147, 148]. Most previous studies of oral

health and dental care utilization conducted among older people have relied on cross-sectional design and very few longitudinal studies have been reported [105, 114, 125, 149, 150]. Few surveys of older people have addressed inevitable methodological caveats, such as survivor biases and biases due to non-responses. Despite its relevance in guiding decision makers of dental services, there is little longitudinal and comparative evidence regarding the social distribution of oral health and dental health care utilization in older people across Scandinavian countries.

### 1.4.4  Relationship between tooth loss and oral health-related quality of life - modifying factors

Several studies have confirmed expected positive associations between tooth loss and oral impacts as well as the modification of those relationships by personal, socio-demographic and health care service related factors [for review see 151, 152]. In a recent review of the literature considering the relationship between tooth retention and OHRQoL covering the period 2004-2015, the following main findings were reported; a significant association between reduced number of teeth and poor OHRQoL was shown by most studies after adjusting for potential confounding factors, the number of occluding pairs and the location of remaining teeth impacted on OHRQoL, and people with shortened dental arches (SDAs) did not show more impaired OHRQoL than people with more natural teeth after adjustment for socio-demographic factors in the analyses [153]. The authors concluded that retention of teeth is associated with better OHRQoL [153]. Also in accordance with a previous study of Brazilian middle aged people, the authors concluded that people with SDAs maintain an acceptable level of OHRQoL [153, 154].

## 1.5  Oral health care systems in Norway and Sweden

Norway and Sweden are ethnically and culturally similar and share a common history which explains their similar approach to welfare policies [155]. In all Nordic countries, the welfare state model is characterised by universalism and comparatively generous social transfers [156]. Typical features are the availability of public services to the whole population (health and education), social welfare services covering

people at all ages, equity between men and women and eligibility based on citizenship rights. The concept of common access to health care derives from the idea that all citizens are entitled to care on equal terms and according to people needs [2, 156-158].

The Nordic oral health care system is typically characterized by a large public dental service (PDS) with salaried personnel financed by income taxes [157, 158] and a private sector partly financed by patient charges and partly by national, individual and private health insurance systems [157]. In all Nordic countries, the majority of the adult populations obtain their dental care from private practitioners, whereas the PDS provides some care for adults although the extent of this varies between the countries. Despite country variation in the rates of reimbursement, adults' demand for oral health care services has been high in Norway and Sweden [157].

### 1.5.1 The Norwegian oral health care system

Oral health care in Norway is divided into a public and private sector [158-160]. The school dental service was formalised in 1917 due to an alarming situation of high level of dental caries in children [157]. In 1949, Law on Folketannrøkta (public dental care system) was adopted which later was unified with school dental services under one organization with the new law enacted in 1983 [3]. According to the Oral Health Service Act of 1983, the PDS, organized and funded by 19 counties, is responsible to provide dental services to the following groups in priority order; children aged 0–18 years, mentally disabled persons both living in institutions and at home, groups of elderly and long-term care patients living in institutions or receiving care at home, young people aged 19 and 20 and other groups that the county gives priority. Dental services for the groups specified above are provided free of charge, except for those aged 19 and 20 years who pay 25% of their expenses out of pocket [160, 161]. Nearly all dental service for the general adult population is provided by the private dental health care financed by patient charges without any general reimbursement of the costs from public funds. The only exception to this rule is some reimbursements by the national health insurance system for patients with certain

disorders and diseases (e.g. rare medical disorders, oral cancer, periodontal treatment and rehabilitation, allergy to dental restorative materials etc.) [157, 160]. As there is no public regulation of dental fees in the private sector, there might be variation in how much patients have to pay out of pocket when a disease releases reimbursement from the national insurance system [160]. Since the reimbursement is based on fixed prices set by the health authorities that generally are lower than the fees applied by the dentists, the patient is left by a gap between the reimbursed sum and the actual price [160]. Except for the financial support from the social welfare system, the out of pocket payment system for adults has remained in Norway. Thus, for the general Norwegian adult population, dental services are organized according to market mechanisms with no regulation of prices and with dental fees determined by supply and demand [162]. Norway is claimed to be the only country among the advanced welfare states that are not providing basic dental services for adults through a public policy [163].

## 1.5.2 The Swedish oral health care system

In Sweden, oral health care is provided by the PDS and by private care providers [164]. County councils are responsible for the provision of the PDS, founded in 1938 [160]. Since 1960, the PDS has offered free dental care for all children up to 19 years of age. Although the county council (Landstinget) is responsible for provision of free regular and comprehensive dental services for children and adolescents, those groups have, in contrast to their counterparts in Norway, free choice of provider; the PDS or private practitioners [160, 165]. For specific groups of patients, for instance elderly people living either in nursing homes or their own homes receiving social and nursing support, there are special arrangements for both the provision and funding of oral health care supposed to be provided free of charge [160]. Since 1999, the free outreach system seeks out those with highest need for oral health care [159, 160]. In 2013, special dental care allowance was introduced, aimed at people who have diseases or disabilities that increase the risk of deteriorated oral health [166]. Also in Sweden, supplementary social benefits can be claimed if the patient has difficulties paying the treatment cost.

As in Norway, the traditional patient financial system for the general adult population is fee for service. In addition to the social security and welfare benefits by which particular sub-groups have their dental care expenses refunded, benefit schemes of a more universal nature are offered in Sweden. In the PDS, an alternative subscription care system exists by which the patient enters a contract for a fixed period of time and pays a set fee annually based on the individual patient's risk classification. Since 1974, people 20 years and older has been covered by a third party payment system, the national dental health insurance system, covering a proportion of adult's dental treatment costs [165]. In 2008, a new state dental care financial support system was introduced for people above 20 years, consisting of a dental voucher (Allmänt tandvårdsbidrag) and a high-cost protection scheme [160]. The dental care voucher is issued every year and can be used as part payment for a dental care check-up or as a part-payment for subscription dental care at any dentist or dental hygienist [160]. The value of the dental voucher varies with age: for individuals 20-29 years of age 300 SEK, for individuals 30-74 years of age 150 SEK and for individuals 75 years of age and older 300 SEK [160]. High-cost protection scheme (Högkostnadsskydd) designed to prevent large expenditures, does not reimburse costs below SEK 3000 [167]. Cost between SEK 3000 and SEK 15 000 are refunded by 50% and above that sum by 85% [160].

## 1.6 Conceptual frameworks

### 1.6.1 A life-course approach in oral health research

Life-course epidemiology is a theoretical framework, defined as "the study of long-term effects on chronic disease risk of physical and social exposures during gestation, childhood, adolescence, young adulthood and later adult life" [168, 169]. Thus, in a life-course perspective, the notion of time is important. Within this approach, there are different conceptual models which may operate simultaneously; the latent effect model or critical period model, the social mobility or trajectories model and the cumulative life-course model [168, 170]. *The latent effect model* or *critical model* builds on the biological programing concept and, advocates that an exposure in a critical period results in subsequent permanent and irreversible damage or disease [168]. It is hypothesized that there are key periods in people's lives during which changes in circumstances can put them onto a trajectory towards either health or disease [170]. *The accumulation model* considers that advantages and disadvantages accumulate gradually over the life-course, increasing or decreasing the likelihood of having good health [168]. *The social mobility* or *trajectories model* is a special case of the accumulation model and refers to chains of risk by which one negative exposure increases the subsequent risk of another negative exposure [168]. The life-course approach has been applied extensively to capture risk factors on chronic systemic diseases such as cardiovascular disease, diabetes, breast cancer, and chronic obstructive pulmonary disease [171]. It is recognized that life-course approach is well-suited in the field of dental research [172, 173].

## 1.6.2 Andersen's behavioural model

Andersen's behavioural model is one of the well-known models of health care utilization, initially developed in the late 1960s to understand families' use of health care services [174]. The model evolved over time according to issues related to health policy and health services delivery [175]. According to this model people's use of health services is determined by *predisposing, enabling* and *need-related factors. Predisposing factors* including demographic characteristics such as age and gender represent biological imperatives, social structure such as education, occupation and ethnicity, and health belief such as attitudes, values and knowledge related to health and health services [174]. *Enabling factors* are based on the financing and organizational factors such as income, health insurance, source of care, travel and waiting times whereas *need-related factors* refer to perceived and clinically evaluated need. It was hypothesized that predisposing, enabling and need-related factors have differential ability to explain use, depending on the type of services examined. The interrelationship between predisposing, enabling and need-related factors determine the likelihood of personal health practices and use of services which in turn influence health outcome and satisfaction with care [174, 176].

Andersen's behavioural model has been applied to research considering a broad range of health service sectors and diseases [177]. However, there has been variation in relation to the operationalization of the model constructs and the selection and categorization of variables [177]. The model allows a flexible approach for the selection of the variables related to the researchers' hypothesis and area of interest [178]. This model has been applied only to a limited extent in research considering oral health and dental care utilization in older people [106, 176, 178-180].

## 1.7  Justification of the study

The proportion of elderly is growing and the proportion of dentate people over 65 years increases rapidly in all industrialized countries [25]. Studies suggest that older people have more oral disease than the rest of the adult population and social disparities persist in spite of the governmental efforts to eliminate it [20, 120, 124, 127, 142]. People in their late 60s- and 70s experience exit from the labour force, increasing probability of chronic diseases, loss of social networks and lower income. These events my complicate their oral health conditions and increase their need for oral health care.

To address poor oral health in community-dwelling older adults, it is imperative to understand the extent, distribution and development of their oral problems and patterns of dental health care utilization. In the Nordic countries, there is scarce information on how oral health and dental care utilization as well as the social distribution of those oral indicators develop across time and by ageing. Cross-national and comparable data on the oral health situation of older people is also generally missing. Most evidence emanates from sequential small scale cross-sectional epidemiological studies or from representative population based samples that are not specific to older adults or do not include issues related to oral health, specifically. The Survey of Health Ageing and Retirement in Europe (SHARE) [181] considers general health, oral health and dental attendance patterns in older European populations, but Norway is not included in this surveillance. Comparing the oral health impact of social position across countries with different welfare regimens seems relevant to get information that facilitates planning of public health strategies for current and future cohorts of older people [104]. In this respect, the Norwegian and Swedish 1942 cohort studies represent a response to an urgent need to document oral health of older people, comparing two culturally similar Scandinavian countries with slightly different organization and financing of their oral health care systems.

# 2.  AIMS

The overall aim of the thesis was to provide new information about oral health, dental care utilization and associated life-course factors among older people comparing the Norwegian and Swedish 1942 birth cohort study between the ages of 65 and 70 years. Specifically, this thesis aimed to investigate the development of the oral health indicators and its social distribution across a 5-year-follow-up period and to test hypotheses about how social and behavioural factors adopted throughout the life-course influence dentition status, oral health-related quality of life and utilization of dental services at later life stages.

The specific objectives were:

*Paper I*

- To assess reproducibility, longitudinal validity and responsiveness of the OIDP frequency score
- To assess whether the temporal relationship between tooth loss and OIDP varied according to country of residence

*Paper II*

- To assess the influence of early and later life social conditions on tooth loss and OIDP
- To examine whether social inequalities in tooth loss and OIDP change during the 5-year follow-up period

*Paper III*

- To describe the patterns of less frequent dental attendance (less than once a year) over time from the age of 65–70 in Norwegian and Swedish 1942 cohorts

- To estimate the influence on less frequent dental attendance across time from predisposing, enabling and need related social predictors using marginal and random intercept models
- To compare the estimates of associations between social predictors and less frequent dental attendance derived from marginal and random intercept models

*Paper IV*

- To explore impacts of predisposing, enabling, and need related- factors and dental health care utilization on oral impacts on daily performances (OIDP) in older adults between age 65 and 70

# 3.   MATERIAL AND METHODS

This thesis is based on two cohort studies conducted in Norway and Sweden. The Swedish cohort was initiated in 1992 focusing individuals born in 1942. As a companion to the ongoing Swedish cohort study and in order to build up cross-national research, the Norwegian 1942 cohort was initiated in 2007 as a "sister study". In both countries, the study populations were defined by continuously updated version of the 1942 census every 5th year and information was collected by self-administered questionnaire. Data collections from 2007 and 2012 were used in this thesis.

## 3.1  Study areas in Norway

Norway has 19 counties and 428 municipalities with a total population of 5,236,256 (per 01.07.2016) [182, 183]. The study population comprised of residents born in 1942 in Hordaland, Sogn og Fjordane and Nordland. Hordaland is located in the south-western part of Norway, comprising 9.9% of the total population of the country [184]. It is the third largest county including 33 municipalities. The largest relative growth is expected to come among 60-74 year olds (44%) and those over 75 years. It is therefore expected doubling of the elderly over 75 years by the year 2040 [184]. Sogn og Fjordane is a neighbouring county of Hordaland, and is the second smallest county in population including 26 municipalities [185]. It is among the three counties which have had the weakest population growth in Norway during the period from 2000 and 2015 [185]. Nordland is located in northern part of Norway. It is divided into 44 municipalities with approximately 242,000 inhabitants [186].

## 3.2 Study areas in Sweden

Sweden is divided into 21 counties and 290 municipalities with a total population of 9,938,648 (per 31.08.2016) [187]. The study started as a collaborative project between counties of Örebro and Östergötland which were chosen conveniently. Örebro and Östergötland are two neighbouring counties located in south part of Sweden. Örebro is divided in 12 municipalities, where of Örebro is the main city with about 142 000 inhabitants [188]. The proportion of elderly 65+ is 21.2% of the total population in the county [189]. Östergötland is a county with a total population of 445, 661 in 2015 [190]. Östergötland is Sweden's fourth largest county including 13 municipalities [191].

## 3.3 Selection procedure and study profile- the Norwegian 1942 cohort

In 2007, a census of non-institutionalised persons born in 1942 (65 years old) and residing in the three selected counties of Norway were invited to participate in a prospective questionnaire survey. The three counties were chosen not only to represent rural and urban parts of Norway, but also due to known variability in oral conditions and the dental service provided [146, 192]. Names and addresses were obtained from public population records of Statistics Norway. The study took place between June and August 2007 and the final response rate was 58.0% (n=4211 of the net population, n=7248). In 2012, the questionnaires were sent again to all persons born in 1942 (70 years old) in the three counties. The final response rate was 54.5% (n=3733 of the net population of n= 6841). Of the cohort members who completed the 2007 wave, 70.0% (n=2947) participated in 2012, leaving 1264 drop outs. Table 4 depicts details of the Norwegian survey characteristics and the cross-sectional and longitudinal response rates.

## 3.4 Selection procedure and study profile- the Swedish 1942 cohort

In 1992, (the baseline at age 50 years), a census of persons born in 1942 in two selected counties of Sweden, were invited to participate in a prospective questionnaire survey. Of the total population of 8888 people, 6346 (71.4%) participated. In 1997 (age 55 years), 2002 (age 60 years), 2007 (age 65 years) and 2012 (age 70 years), the corresponding cross-sectional participation rates (defined as the number of respondents divided with the number eligible participants) were 74.3% (6513/8764), 75.0% (6372/8500), 73.1% (6078/8313) and 72.2% (5697/7889). Of the 6346 participants who completed the 1992 survey, 3585 participated in all five waves, leaving 2761 drop outs at the postal follow-ups after baseline. This provides a longitudinal response rate of 56.5% (3585/6346). Percentage of baseline respondents have also been computed for the other waves; 5364 (85.5% of baseline responders) participated in 1992 and 1997, 4736 (74.6% of baseline responders) participated in 1992, 1997 and 2002, 4143 (65.0% of baseline responders) participated 1992, 1997, 2002 and 2007.

To provide directly comparable data with the Norwegian 1942 cohort study, only data from the 2007 and 2012 waves were used in this thesis. In 2007, a total of 6078 (6078/8313, response rate 73.1%) participated in the study. A total of 4862 (80.0%) participated in both waves, leaving 1216 drop-outs at the postal follow-up after 2007. Table 4 depicts details of the Swedish survey characteristics and the cross-sectional and longitudinal response rates.

Table 4. Number of invited and participating individuals (%) by survey year and gender at each data collection wave and follow-up rate (n).

| | Survey year | Age | Invited | Responded n (%) | | | Follow-up rate % (n) |
|---|---|---|---|---|---|---|---|
| | | | | Female | Male | Total | |
| **Sweden** | | | | | | | |
| | 1992 | 50 | 8888 | 3184 (50.2) | 3162 (49.8) | 6346 (71.4) | |
| | 1997 | 55 | 8764 | 3324 (51.0) | 3189 (49.0) | 6513 (74.3) | |
| | 2002 | 60 | 8500 | 3264 (51.2) | 3108 (48.8) | 6372 (75.0) | |
| | 2007 | 65 | 8313 | 3080 (50.7) | 2998 (49.3) | 6078 (73.1) | |
| | 2012 | 70 | 7889 | 2896 (50.8) | 2801 (49.2) | 5697 (72.2) | |
| *Cohort by survey year* | | | | | | | |
| | 1992-2012 | 50/70 | | 1707 (52.4) | 1878 (47.6) | | 56.5 (3585) |
| | 2007-2012 | 65/70 | | 2489 (51.2) | 2373 (48.8) | | 80.0 (4862) |
| | | | | | | | |
| **Norway** | | | | | | | |
| | 2007 | 65 | 7248 | 2015 (49.6) | 2047 (50.4) | 4211 (58.0) | |
| | 2012 | 70 | 6841 | 1746 (48.4) | 1860 (51.6) | 3733 (54.5) | |
| *Cohort by survey year* | | | | | | | |
| | 2007-2012 | 65/70 | | 1415 (48.8) | 1486 (51.2) | | 70.0 (2947) |

## 3.5 Questionnaires and variables

With few modifications, the same basic questionnaire has been used at all waves with 128 questions, mostly collected on Likert scales (Appendix I). The Swedish questionnaire from 2007 is available at www.lio.se/tandrapp. The Swedish questionnaire was translated into Norwegian and back translated by academic university staff knowable in both languages. In constructing the questionnaires, efforts have been made to ensure that the questions are not in conflict with local values and norms. When data contain information that can lead to the identification of individuals (as in longitudinal cohort studies) confidentiality must be guaranteed. Researchers will not have access to information about the participants that might lead to individual identification. Statistics Norway performs the surveys in Norway and keep the list of names and addresses corresponding to identification numbers,

separately in a secret place. In Sweden, the codes for the participants are kept in a password protected database which can only be accessed by the respective principle investigator. Both the Norwegian and Swedish cohort studies have achieved governmental financial support, can be linked to financial and health registry data and not at least include measurements not commonly assessed in other studies of older people. Thus, these cohort studies focus entirely and broadly on aspects of oral health and related life-course factors. The broad set of oral health and socio-economic and socio-behavioural indicators measured allows an exploration of economic and psychosocial pathways in relation to aspects of oral health and oral health inequalities. The eight-item OIDP frequency inventory was added to the questionnaire in 2007.

### 3.5.1 Outcome variables

The eight-item OIDP frequency inventory [75] was applied by asking "During the past six months, how often have problems with your mouth and teeth caused you any difficulty with: eating and enjoying food; speaking and pronouncing clearly; cleaning teeth; sleeping and relaxing; smiling and showing teeth without embarrassment; maintaining usual emotional state; enjoying contact with people and carrying out major work?" with response categories; (1) never affected, (2) less than once a month, (3) once or twice a month, (4) once or twice a week and (5) every/nearly every day. Subscale scores of each item and sum scores (OIDP frequency SC and OIDP frequency ADD) were constructed for the purpose of analysis. The OIDP frequency ADD score (8-40) was computed adding the eight item scores whereas the OIDP frequency SC (0-8) was constructed by dichotomized subscale scores; greater sum scores represent greater impacts. The psychometric properties of the OIDP inventory were tested previously in Norway and Sweden [77, 82].

Tooth loss (self-reported) was assessed by asking "How many of your own teeth do you still have (excluding baby teeth)?" The response categories were; (1) all (28-32 teeth), (2) missing few teeth, (3) missing quite many teeth, (4) almost no teeth left and (5) edentulous. The variable was dichotomized into (0) all/almost all teeth

(categories 1 and 2) and (1) lost teeth (categories 3, 4 and 5). Previous studies have shown a close agreement between self-reported and clinically measured dentition status [193, 194]. A sub-study with a sample of 26 people aged 65 and over, was carried out to validate the question regarding dentition status in Norway. The study showed close agreement between the question and clinically measured dentition status. The weighted kappa score was 0.69 [195].

Frequency of dental attendance was measured using the question "Roughly, how often do you visit a dentist?" with response options (1) twice or more yearly, (2) once year, (3) every second year and (4) more seldom than every second year. The question was later recoded into (0) frequent dental attendance and (1) less frequent dental attendance. The variable is concerning only the frequency of dental attendance, not considering the reason in terms of being problem-oriented or preventively oriented.

### 3.5.2 Independent variables

Independent variables in the papers were identified based on theoretical and conceptual frameworks and previous research. Overview of the variables and type of statistical analysis applied are given in Table 5.

Table 5. Overview of outcome and independent variables and statistical methods applied in *Paper I-IV*.

| | Paper I | Paper II | Paper III | Paper IV |
|---|---|---|---|---|
| Outcome variable(s) | OIDP | OIDP and tooth loss | Frequency of dental attendance | OIDP |
| Independent variables | • Gender<br>• Marital status<br>• Country of birth<br>• Satisfaction with oral health<br>• Satisfaction with tooth appearance<br>• Tooth loss | • Gender<br>• Country of birth<br>• Education<br>• Working status<br>• Marital status<br>• Social network | • Gender<br>• Country of birth<br>• Education<br>• Working status<br>• Marital status<br>• Social network<br>• Smoking status<br>• Perceived health | • Gender<br>• Marital status<br>• Education<br>• Social network<br>• Belief of keeping teeth for life<br>• Frightening experiences of dental care during childhood and adolescence<br>• Type of dental services<br>• Satisfaction with services<br>• Avoiding care due to cost<br>• Tooth loss<br>• Tooth brushing<br>• Smoking status<br>• Frequency of dental attendance<br>• Regularity of dental attendance<br>• Initiative of last visit |
| Statistical test/methods | Cronbach's alpha, Chi-square test, Cochrane's Q, One-Way ANOVA, Bonferroni post hoc test, GLM for repeated measures, Wilcoxon Matched pair signed test, Logistic regression | Chi-square test, Cochrane's Q, Logistic regression, GEE | Chi-square test, Cochrane's Q, Logistic regression, Robust variance estimation, Random Intercept Model (RIM) | Chi-square test, Cochrane's Q, Logistic regression, Robust variance estimation |

## 3.6 Data analysis and statistical methods

Data were analysed by country using two different statistical programs: IBM SPSS Statistics version 20 (IBM Corporation, NY, USA) and STATA version 13.1 (Stata Corporation, College Station, TX, USA). The level of statistical significance was set at 5%. Table 5 depicts an overview of statistical methods applied in papers (*I-IV*).

### 3.6.1 Missing data

Analyses in *Paper I* and bivariate analyses (Cochrane's Q and cross tabulation with chi-square test) in *Paper II-IV* were performed with the intact cohorts, based on individuals with complete data or those who were followed-up in the Norwegian and Swedish cohorts between 2007 and 2012. In Norway, statistically significant differences ($p < 0.05$) were observed between the groups who were (n=2947) and were not (n=1264) successfully followed-up with respect to a number of socio-demographic characteristics assessed at baseline in 2007. In the Swedish cohort, there were also statistically significant differences between those who were followed-up (n=4862) and those who were lost to follow-up (n=1216) regarding socio-demographic characteristics assessed in 2007.

Inverse probability weighting (IPW) was carried out (*Paper II-IV*) to adjust estimates for missing responses and loss to follow-up [196]. According to the IPW approach, participants are weighted by the inverse of their probability of being followed-up. The underlying idea is to base estimation on the observed responses but weight them to account for the probability of remaining in the study [196, 197]. As a first step, the baseline characteristics of participants who remained in the study and those who were lost to follow-up were compared by fitting a logistic regression model. Secondly, probabilities were calculated for each participant based on the estimated model. Inverse of the probabilities was applied as probability weights in the analyses [196].

### 3.6.2 Clustered data

Research considering oral health, quality of life and use of health care services often includes hierarchical data structures where cluster effects arise. This thesis with its prospective longitudinal design comprised repeated observations over time for each survey participant [198] to allow assessment of within individual changes [197]. Thus, the present data has a multilevel structure, with repeated observations (level 1) nested within individuals (level 2). Figure 1 illustrates how repeated measures obtained at different measurement occasions are clustered within the same individual

across time, with the lowest level of observation in the hierarchy being the observations at different occasions, level 1, and the group/ cluster/ individual, level 2.

When individuals form groups or clusters, it is expected that two randomly selected individuals from the same group will tend to be more alike and thus less independent than two individuals from different groups. By the same reasoning, measurements taken from the same individual at different occasions across time will tend to be higher correlated than two measures from different individuals. If the observations are not independent because they are clustered, for instance within families, schools, dentists, work places, counties etc., or alternatively within the same individual across time, the dependency has to be accounted for when calculating the sample size and when analysing the data [197, 199]. Ignoring clustering in the data has the implication that the standard errors of the estimates (e.g. regression coefficients) will generally be underestimated [200]. Consequently, the confidence interval will be to narrow and p-values to small. This may lead us to believe that a predictor has an effect on the outcome when this effect in fact could be attributed to chance [201].

A number of strategies are available for analysis of repeated data and data with hierarchical structures. One is to allow for grouping of data by including a set of dummy variables for clusters/groups, called a fixed effect model [199]. This approach is obviously unpractical when the number of clusters/groups is large. Another disadvantage is that the target of inference is restricted to the groups being present in the sample –not the population of groups. Yet another strategy is to fit a single level model with group level predictors, i.e. to include explanatory variables that measure group characteristics believed to influence the individual outcome. In contrast to the approaches mentioned above, multilevel modelling provides an efficient means of allowing for the between cluster variance and obtain correct standard errors [199]. If the aim is to just control for clustering as a nuisance in the data, marginal models (population-averaged models) can be fitted in which the dependency is modelled directly. With this approach it is not possible however to model the between cluster variance. If the aim is both correct standard errors and estimates of the between

cluster variance, multilevel modelling with random intercepts and random coefficients (slopes) can be applied [199].

*Level 2* Individuals

| Person1 | | Person2 |

| Occasion1 | Occasion2 | | Occasion1 | Occasion2 |

*Level 1* Repeated observations
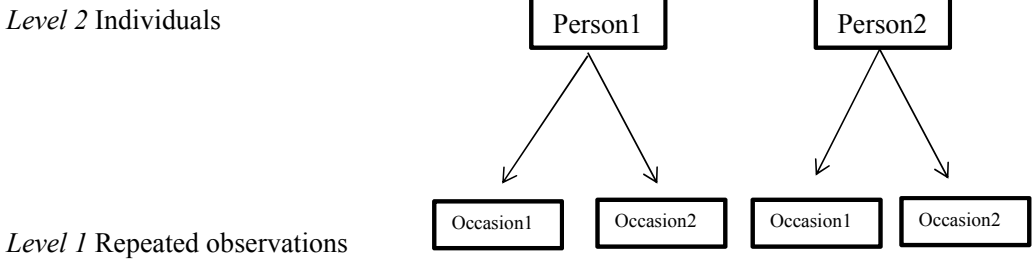
Figure 1. Illustration of multilevel structure in longitudinal data.

This thesis applied two common statistical approaches, marginal models (population averaged models) and mixed effects models to account for the cluster structure of the repeated data. For both methods, reshaping data from wide to long format is essential. In the long format there will be one row of data per occasion for each person and for each time. The regression models applied contained time variant and time invariant variables, which respectively vary and do not vary across time.

*Robust variance estimation* (sandwich estimators) was applied in *Paper III* and *IV* using the option "cluster (id)" to obtain robust standard errors. By fitting a logistic regression model with robust variance estimation, the between cluster variance was taken into account and treated as a nuisance [199]. In *Paper III*, the implication of ignoring clustering was examined by calculating design effects (D= ($se_{\text{robust variance estimation regression}}$/$se_{\text{ordinary logistic regression}}$)$^2$) [201]. A value of D<1 indicates over- and a value of D> 1 under estimation of the variance revealed by ordinary logistic regression analyses relative to the model with robust variance estimation.

*Generalized Estimating Equations* (GEE), commonly used in longitudinal data analyses where the clustering is due to multiple observations over time on the same individual was applied in *Paper II*. The GEE approach is based on the concept of "estimating equations" and provides a very general and unified approach for analysing correlated responses that can be discrete or continuous [197]. The binomial logit function and unstructured correlation structure were employed and the results were presented as ORs and 95% CIs in *Paper II*.

Mixed-effect models, including group level random effects in terms of random intercepts and random slopes thus allowing for unobserved group level variables, are widely used for analysis of longitudinal data since they are quite robust to missing data and can easily handle time variant and time invariant covariates [202]. The basic idea of these models is the inclusion of random subject effect to account for the influence of subjects on their repeated observations [202]. The coefficients based on mixed effect logistic regression models are interpreted differently from the marginal population averaged models as the former models provide cluster specific (person-specific) estimates. A *random intercept model* (RIM) was fitted using generalized linear latent and mixed models (gllamm) [203]. In RIM, the intercept of the group regression lines is allowed to vary randomly across clusters (individuals). This model consists of a fixed part with fixed parameters that can be extended by adding predictors  and a random part with random parameters that can be extended by allowing the effect of predictors to vary across groups (in a random intercept-random slope model). RIM is the simplest form of the mixed models where intercept vary between clusters [204]. Intra-cluster correlation (ICC) was calculated which measures the amount of dependency in the data due to clustering [202, 204]. When the ICC is 0, there is no variation between clusters/persons. A likelihood-ratio test was employed to test the null hypothesis that there is no variation between clusters/persons. Rejection of the null hypothesis implies that model accounting for a multilevel structure of data is appropriate [199].

## 3.7  Ethical considerations

The ethical considerations were in accordance with the Declaration of Helsinki. Participation is voluntary, based on written informed consent, and all participants are allowed to withdraw from the study without giving any reason and without the withdrawal having any negative impact for the individual. In Sweden, the study was approved by the ethic committee in Örebro and Östergötland in 1992. The Ethics Committee of Uppsala approved the studies in 2007 and 2012 (Appendix II). In Norway, the studies were approved by the Ethics Committee of the Norwegian Social Science Services (NSD) and the Regional Committees for Medical and Health Research Ethics (REK) in 2007 and 2012, respectively (Appendix III, IV).

# 4. SUMMARY OF RESULTS

## 4.1 Paper I

***Change in Oral Impacts on Daily Performances (OIDP) with increasing age: testing the evaluative properties of the OIDP frequency inventory using prospective data from Norway and Sweden***

Totals of 29.0% and 28.4% of the Norwegian cohort participants reported at least one impact (OIDP>0) in 2007 and 2012, respectively. The corresponding figures among the Swedish cohort participants were 27.3% and 20.4%. In Norway, the mean OIDP frequency score were 9.5 (sd=3.9) in 2007 and 9.4 (sd=3.8) in 2012.In Sweden the mean OIDP declined significantly from 9.7 (sd=4.5) to 9.0 (sd=3.4) between 2007 and 2012. Eating and smiling were the impacts most frequently reported in both countries. Altogether, 63.6% of the Norwegian and 68.1% of the Swedish participants reported no change regarding OIDP scores across time. Reproducibility of the OIDP in terms of intra-class correlation coefficient was 0.73 in Norway and 0.77 in Sweden. In both countries, the mean change scores in the OIDP total- and subscale scores were negative among those who worsened and positive among those who improved change scores in the reference variables (satisfaction with oral health, satisfaction with tooth appearance and tooth loss). The effect sizes ranged from 0.0 to 0.5 in Norway and from 0.1 to 0.4 in Sweden. Multivariable logistic regression analysis revealed that all reference variables contributed to the improvement and worsening of OIDP, with tooth loss being the strongest covariate. The two-way interaction between country and tooth loss upon worsening and improvement in OIDP scores was not statistically significant. The evaluative properties of the OIDP frequency score were found to be promising in terms of acceptable longitudinal validity, reproducibility and responsiveness among older people in Norway and Sweden.

## 4.2  Paper II

*Inequality in oral health related to early and later life social conditions: a study of elderly in Norway and Sweden*

In Norway, the percentages of tooth loss, defined as extensive tooth loss or being edentulous, were 21.8% and 23.2% in 2007 and 2012, respectively. The corresponding figures in Sweden were 25.9% in 2007 and 27.3% in 2012. Early-life social conditions were measured in terms of time invariant characteristics of gender, education and country of birth. Later-life social conditions were assessed in terms of time variant characteristics such as working status, marital status and social network. In Norway, tooth loss was more likely to occur among males (OR=1.3, 95% CI 1.1-1.6), lower educated (OR=2.7, 95% CI 2.2-3.3), unemployed (OR=1.5, 95% CI 1.2-1.8) and single (OR=1.5, 95% CI 1.2-1.8) participants in 2007. Males (OR=1.6, 95% CI 1.3-2.0), lower educated (OR=2.5, 95% CI 1.9-3.3), single participants (OR=1.6, 95% CI 1.2-2.0) and people with narrow social network (OR=1.7, 95% CI 1.3-2.3) were more likely than their counterparts to report tooth loss in 2012. GEE analyses revealed significant interaction between social network and survey year on tooth loss. In Sweden, tooth loss was more likely to occur among participants with foreign country of birth, lower educated, single participants and people with narrow social network in both survey years. There was significant interaction between survey year and marital status on tooth loss, OR=0.8 (95% CI 0.7-0.9).

In Norway, males (OR=1.3, 95% CI 1.1-1.5) and people with narrow social network (OR=1.3, 95% CI 1.1-1.5) were more likely than their counterparts to report oral impacts (OIDP>0) in 2007. Oral impacts were significantly associated with gender, education level and marital status in 2012. In Sweden, country of birth and marital status were the strongest predictors in both survey years. GEE revealed no statistically significant interaction between time and social conditions on OIDP in either country.

Early and later life social conditions contributed independently on tooth loss and OIDP among older people in Norway and Sweden, in which the latent effect life-

course model was supported. With few exceptions, social inequalities in tooth loss and OIDP remained stable across the survey years in both countries. Inequalities in tooth loss related to social network increased in Norway, while marital status related inequalities in tooth loss decreased with increasing age in Sweden.

## 4.3  Paper III

*Social predictors of less frequent dental attendance over time among older people: population-averaged and person-specific estimates*

Less frequent dental attendance (attendance less than once a year) decreased from 14.5% to 12.2% (p<0.001) in Norway and from 13.6% to 12.9% (n.s) in Sweden. Robust variance estimation and random intercept models were used for population-averaged and subject (person)-specific estimates, respectively. Time-invariant (gender, country of birth and education) and time-variant (working status, marital status, social network, smoking status and perceived health) social predictors contributed to less frequent dental attendance in both countries. In Norway, the population-averaged estimates from robust variance estimation varied from 1.3 (95% CI 1.1-1.6) to 2.0 (95% CI 1.1-3.4) whereas person-specific estimates from random intercept model (RIM) varied from 2.7 (95% CI 1.4-4.9) to 7.9 (95% CI 1.4-44.5). Using ordinary logistic regression (not taking account of the clustered structure in data) would provide underestimated predictors by a factor varying from 12% to 47% as indicated by design effects. The intra-cluster correlation coefficient (ICC) was 0.90, implying that 90% of the variance was between individuals after having accounted for all predictors. In Sweden, the population-averaged ORs varied from 1.2 (95% CI 1.0-1.5) (lower education) to 1.8 (95% CI 1.6-2.1) (single marital status). The respective person-specific ORs were 1.6 (95% CI 1.0-2.6) and 3.9 (95% CI 2.6-5.9) for lower education and single marital status. The design effects indicated that standard errors would be underestimated for all predictors by a factor varying from 5% to 39% if applying ordinary logistic regression. The ICC was 0.85. The social predictors coincide with Andersen's behavioural model featuring predisposing (country of birth, education, marital status, smoking and working status), enabling

(social network) and need (perceived health) factors in the explanation of health care service utilization. Both at population-averaged and person-specific levels, being advantaged on social aspects protects against less frequent dental attendance after 65 years of age in Norwegian and Swedish older people. The study suggests that the robust variance estimation and RIM are appropriate methods for the analyses of less frequent dental attendance in the cohorts investigated.

## 4.4 Paper IV

*Exploring associations of dental care utilization on oral impacts on daily performances using Andersen's behavioural model – a prospective cohort study of older people in Norway and Sweden*

Andersen's behavioural model guided the selection of predictor variables used in the analyses. In both cohorts, predisposing, enabling, need-related factors and dental care utilization were associated with OIDP across time. In Norway, fully adjusted model showed that oral impacts were more likely among those who reported, frightening experience of dental care during childhood/adolescence, dissatisfied with dental services, tooth loss, avoidance dental care due to cost and those who took initiative themselves for last dental visit. The corresponding ORs were 1.5, 2.7, 4.1, 3.1 and 1.8, respectively. The model explained 20% of the variance in OIDP. In Sweden, the probability of oral impacts increased if reporting frightening experiences, dissatisfaction with dental services, tooth loss, avoidance care due to cost, patient taken initiative of last visit and irregular dental attendance. The strongest predictors in fully adjusted model were dissatisfaction with dental services, tooth loss and dental care avoidance due to cost. The corresponding ORs were 2.9 (95% CI 2.1-3.9), 2.6 (95% CI 2.2-3.0) and 2.4 (95% CI 1.9-3.1), respectively. The model explained 17% of the variance in OIDP. No statistically significant two-way interactions were observed between predictor variables and time on the OIDP in either country. Disparity in OIDP related to marital status was not maintained after adjustment for need- related factors.  Overall, the variables explained a small part of the total

variance in oral impacts. Andersen's behavioural model was supported as a tool to identify predictors of oral impacts in older people.

# 5.  DISCUSSION

## 5.1  Comments on the main findings

Development of appropriate oral health care policy and programs for the older population should be informed by evidence of high quality. Prospective cohort studies, like the present one, are appropriate to generate quality evidence about the development of oral health indicators and their social distribution during older ages. Moreover, comparing oral health and patterns of dental attendance across countries with different oral health care systems seems relevant to get information that facilitates planning of public health strategies for current and future cohorts of older people [104, 127, 181].

The studies presented in this thesis are among the first to comprehensively assess the development of various oral health indicators (tooth loss, OHRQoL and less frequent dental attendance) as well as the development of their social distribution prospectively, in above 65 year olds and across two Scandinavian cohorts.  Also this study evaluates for the first time in a cross-national perspective the longitudinal validity of OIDP and the extent to which OIDP is attributable to dental care utilization whilst at the same time adjusting for differences in socio-demographic position and dentition status.

In the following section research findings of this thesis will be discussed in light of the conceptual frameworks used and the organization and financing of the oral health care systems that is implemented in Norway and Sweden. The findings will also be evaluated with reference to methodological challenges associated with a prospective cohort design.

## 5.1.1 Longitudinal validity of OIDP across cohorts of older people

Longitudinal validity, reproducibility and responsiveness are the necessary evaluative psychometric properties of OHRQoL measures [59]. The findings presented in *Paper I* showed that the OIDP frequency score had acceptable longitudinal validity, responsiveness and reproducibility among older people belonging to the Norwegian and Swedish 1942 cohorts. Change scores is one approach to measure change in health status and is commonly used in the literature [205]. A large proportion of the participants reported no change in OIDP scores which is consistent with a previous study considering changes in self-perceived oral health over a three year period [205]. In contrast, de Andrade et al. [206] found that almost half of the older Brazilians investigated in their study experienced deterioration in OHRQoL during a five-year follow-up period. As shown in *Paper I*, acceptable longitudinal construct validity of OIDP was indicated since those reporting deterioration in the reference variables had negative mean change OIDP scores and those who reported improvement in the reference variables had positive mean change OIDP scores. It is important to acknowledge the shortcomings of changes scores [61]. Slade [207] reported important methodological problems when measuring change in OHRQoL, with comparisons of scores between sub-groups being masked by effects of regression to the mean. Nevertheless, there is no golden standard when assessing change and using different methods as recommended by Locker [205] increased the strength of the present validation study.

*Paper I* demonstrated that a generic measure of the OIDP frequency scale was responsive to change in self-reported and clinical oral health indicators (tooth loss) occurring naturally among community-dwelling older people. Given that change scores are important, benchmarks for their interpretation are also needed [65]. The effect sizes used to assess minimally important differences in this study indicated small to moderate change [61]. The main caveat of using effect sizes is that they are sample dependent and can be affected by the dispersion of observations [61]. However, few studies have reported upon the evaluative properties of the OIDP instrument and most of them have assessed score changes in response to an

intervention [63, 64, 66, 84]. Thus, it is difficult to compare the evaluative properties revealed in *Paper I* with those presented in previous studies. One of the strengths of the study presented in *Paper I* was the utilization of a cross-national perspective which might help to explore the cultural dimension of the development of OHRQoL [208]. According to the findings, responsiveness to change of the OIDP was independent of the study site.

## 5.1.2  Developmet of oral health indicators across time and cohorts

*Paper I* revealed that the prevalence of oral impacts and dissatisfaction with oral health in the Norwegian cohort amounted to 29.0% and 21.8% at age 65 and 28.4% and 18.8% at age 70. In Sweden, the corresponding figures were 27.3% and 21.4% at age 65 and 20.4% and 17.9% at age 70. Thus, the prevalence of poor self-reported oral health declined with increasing age and across time. Moreover, small proportions reported improvement in oral health-related quality of life, amounting to 18.7% and 20.4% in Norway and Sweden, respectively. Across both cohorts, the prevalence of OIDP were below those observed elsewhere; in Thailand (52.8%), Tanzania (51.2%), Korea (62.9%), Bosnia and Herzegovina (55.2%), Brazil (58.0%) and previously in a representative sample of Swedish adults (39.7%) [78, 82, 83, 87, 90, 92] but larger than those observed in Great Britain (12.3%), Norway (18.4%) and Singapore (18.8%) [76, 77, 91]. Comparisons should, however, be done with caution since different age ranges and various versions of the OIDP inventory (eight and nine items) were included in the various studies.

According to *Paper II*, the prevalence of tooth loss (defined as extensive tooth loss or being edentulous) increased marginally from 21.8% to 23.2% in the Norwegian cohort and from 25.9% to 27.3% in Swedish one. Country differences observed in tooth loss prevalence across time might be attributed not only to variation in individuals' dental disease history, but also to differences in individuals' and dentists' attitudes and behaviours, access and utilization of dental services and prevailing philosophy of dental care [209]. Notably, the definition of tooth loss applied in this study (the cut-off point used to define the variable) limits the

possibility to compare the present findings with those of other studies. However, in general, previous studies have reported low prevalence of edentulism and that this prevalence has increased with age in the Nordic countries [24, 27, 41, 43, 48]. Based on a representative sample of Norwegian adults above 20 years of age, Holst & Skau [48] reported an overall prevalence of edentulism of 1.9%, increasing to 4.5% and 14.5% in the age groups 60-69 and 85 years and above. According to the findings in *Paper III*, the prevalence of less frequent dental attendance was low in both cohorts and declined (about 2%) across the survey period, whereas annual dental attendance increased marginally from 85.5% to 87.8% in Norway and from 86.4% to 87.1% in Sweden (*Paper IV*). High proportions of annual dental attendance have been observed in Scandinavian countries, amounting to yield above 80% of the older adult populations in Denmark and Sweden [104].

Strictly speaking the development of oral health indicators may be examined by three survey designs. A single cross-sectional survey indicates changes due to age effects or cohort effects – with a cohort referring to a group of people sharing social and cultural circumstances for instance throughout childhood and adolescence [210]. Repeated cross-sectional studies of time trends indicate both period effects (influences during a time period that affects all age groups simultaneously) and cohort effects. Longitudinal analyses follow single cohorts over time indicating age- and period effects [100, 210]. Repeated cross-sectional studies of the Swedish adult population have demonstrated increase in the prevalence of dental care utilization from 1974 to 1991, whereas the period from 1992 to 2002 was characterized by less change [100]. It has been recognized that the observed patterns during the period 1992 to 2002 coincide with the occurrence of economic cut backs and increases of user charges in Sweden [211]. Nevertheless, repeated cross-sectional studies demonstrating age specific prevalence figures across time reveal overall trends at the population level and disguise intra-cohort changes at the individual level. In addition, time trends confound cohort effects which imply that changes may be misinterpreted as originating during a particular period rather than reflecting historical change. Previous studies in Sweden, Norway and Spain have inferred that changes over time

in oral health and utilization of dental care have been mainly a consequence of cohort rather than period effects [100, 212, 213].

Notably, this thesis focusing single 1942 cohorts in Norway and Sweden cannot distinguish between period and age effects and the development in oral health indicators observed during the study period might be attributed to ageing, time or to a common history of the cohorts investigated [113]. Through the national Swedish dental health insurance system initiated in 1974 and the high cost protection program for people above 65years, the Swedish cohort has received cost reductions from the age of 32 years. In contrast, the Norwegian cohort has received no general reimbursement of the costs of dental care by public funds from young adulthood, although particular groups might have been refunded through social security and welfare benefit schemes. From this perspective, the cross-country differences in oral health indicators as observed in this study seem surprisingly small. However, variation regarding accessibility to oral health care does not automatically translate into variation in dental care utilization given that people with access might exercise their rights not to use the services available to them. According to Listl et al. [114], comparing dental service utilization across European countries among people aged 50 years and above, there was a tendency towards more frequent and preventive dental treatment in Scandinavia compared with other European regions. These differences were only partially attributable to country differences in accessibility of dental care.

## 5.1.3 Social inequalities in oral health indicators across time and cohorts

Social inequalities in various oral health indicators have been documented extensively across age-groups and countries [104, 120, 127, 129, 138, 140, 214]. However, few previous studies have focused older age groups specifically, utilizing a prospective design and a cross-national comparative perspective [125, 215-217].

Findings presented in *Paper II* and *III* suggested significant associations between various social factors and tooth loss, OIDP and less frequent dental attendance across survey years and the 1942 cohorts investigated. Thus, social

inequalities in oral health indicators seem to persist in Norway and Sweden despite general improvements in oral health and governmental efforts to reduce or eliminate them. Specifically, similar disparities in tooth loss, OIDP and less frequent dental attendance (*Paper II*, *III*) were identified in unadjusted and adjusted analyses across the survey years with respect to early life social conditions or time invariant factors, such as gender, country of origin and education level as well as later life social conditions or time variant factors, such as working, marital and social network status. Disparities in less frequent dental attendance were also identified according to smoking and perceived health status. These findings agree broadly with previous studies using cross-sectional survey designs [97, 127, 137, 142, 218]. Tsakos et al. [125] found consistent social gradients in oral health indicators among community-dwelling people aged 50 years and above. Based on a recent systematic review, Seerig et al. [132] confirmed income disparities in tooth loss among adults aged 18 to 60 years.

Whether social inequalities change with increasing age or across time is still a question to be answered, specifically in older age groups [12, 130]. As shown in *Paper II*, social inequalities in tooth loss according to marital status declined in Sweden whereas inequalities in tooth loss according to social network increased in the Norwegian cohort. Previous studies regarding whether or not social inequalities in health narrow, widen or persist have revealed contradictory findings [219]. Some studies indicate that inequalities in health peak in late middle age and decline thereafter [219, 220], others have suggested that inequalities are persistent or widen across time into older ages [5, 221, 222]. Among dentate British adults, absolute and relative inequalities in number of teeth and in the proportions of people with functional dentition remained unchanged over time [130]. Holst [218] reported that having a functional dentition was less equally distributed among older people in Norway in 2002 compared to 1975. Consistent with previous studies, the present one by and large confirmed persistent inequalities between age 65 and 70 in both cohorts. These findings observed across two countries sharing a common historical and cultural heritage but having different oral health care systems are attention-grabbing.

A number of theoretical models have been established that describe the linkage of life-course factors to later oral health conditions, postulating that exposures during a specific time window has an irreversible influence on later oral health conditions [223]. Although it would be premature to interpret the findings of this thesis as evidence in support or against the life-course hypotheses, the findings in *Paper II* suggest that for both cohorts early- and later life social conditions had independent influence on oral health in old ages. More specifically, the findings may provide support for the latent effect life-course model. Previous research supports the critical period or latent effect life-course model where early life conditions have shown enduring effect on oral health in adulthood [223-226]. Studies in the oral health literature adopting a life-course perspective have been steadily increasing, specifically focusing on critical period (the latent effect) and accumulation of risk models [227]. Although a prospective cohort study is the most desirable design to study life-course influences [172], such studies considering oral health data are very rare [227] since they are expensive and difficult to conduct.

### 5.1.4 Andersen's behavioural model applied to study the influence of dental care utilization on oral health-related quality of life

Using different indicators of utilization of dental services in the context of Andersen's conceptual health behaviour model, *Paper IV* identified dental care utilization related predictors of OIDP in Norwegian and Swedish community-dwelling older adults. Andersen's behavioural model assumes that the interrelationship between predisposing, enabling and need related factors determine use of dental services which in turn influence oral health outcomes and satisfaction with care [174]. According to the findings presented in *Paper IV*, predisposing, enabling and need related factors and indicators of dental care utilization were independently associated with OIDP in both countries, suggesting this model to be an appropriate tool to identify predictors of oral impacts in older adults. Using structural equation modelling Baker [176] provided stronger support for Andersen's model applied to understand key determinants of dental service use and perceived oral health outcomes as well as the interrelationships of those determinants.

It seems important to assess the role of dental attendance as a predictor of OHRQoL to better understand the oral health benefits of attendance patterns and possible pathways of oral health inequalities. Satisfaction with services, tooth loss and dental care avoidance due to cost were found to be the strongest predictors of oral impacts in both cohorts. Those who reported irregular dental attendance were more likely to report oral impacts, whereas those who reported less frequent dental attendance (less than once a year) were less likely to report oral impacts. These relationships were statistically significant in the Swedish cohort, only. Nevertheless, previous research findings are inconsistent, with some studies reporting a positive association between dental attendance and oral health conditions and others not [108, 144, 228]. This study adds to the literature in that the influence of frequency and regularity of dental attendance on OHRQoL were opposite among older people. Consistent with previous studies, the findings in *Paper IV* suggested that social inequalities in OHRQoL persisted after having included need related variables and dental care utilization into the statistical models [134, 135, 137]. Donaldson et al. [147] found a socio-economic gradient in the number of sound teeth which was partially explained by dental attendance. Also a study based on a representative sample of Australian adults reported a significant decrease in the socioeconomic gradient in OHIP-14 after having accounted for dental visiting [229]. Small cross-country variations in the utilization of dental care, OIDP and tooth loss as well as in the social distribution of those oral health indicators over time are striking considering the difference in the financing of dental services for older adults between Norway and Sweden.

## 5.2  Methodological issues

### 5.2.1  Comments on the study design

Among the strengths of the studies presented in this thesis is the time dimension of the prospective cohort design utilized with repeated observations obtained from the same individual across a 5-year follow-up period. Using a life-course perspective as a theoretical framework, the notion of time becomes important as the rationale for longitudinally designed studies include examination of phenomena in their time related constancy and change [230-232]. Longitudinal studies are hence critical to understand issues associated with ageing and fit well within the life-course theoretical perspective since the issue of what comes first and last is usually not a concern [231]. Notably, however, a single cohort design was utilized in this thesis, in which a census of 65-year-olds in Norway and Sweden was recruited at one point in time (age 65) and followed-up at subsequent 5-year- intervals. With this simple longitudinal design where all cohort participants are of the same age; age-, cohort- and time of measurement effects are confounded and cannot easily be distinguished [126, 210, 231]. Moreover, the single cohort design with complete data analysed (those who participated at both survey occasions) is also resource demanding and may be relatively slow at producing long-term later life-course outcomes which in turn may limit its relevance for policy and practice [231]. Nevertheless, in spite of this weakness as well as the use of only two measurement-points, thus limiting the possibility to construct trajectories, utilizing longitudinal rather than cross –sectional data has advantages when studying changes in oral health related phenomena. Observing two individuals of different ages at the same time using cross-sectional designs cannot substitute for observing the same individual across time because two persons of different ages observed simultaneously belong to various cohorts [233]. Cross-sectional research does not allow for information regarding intra-individual change and inter-individual differences in intra individual change which are among the primary objectives for prospective cohort studies [231]. *Paper III* assessed intra-individual changes by demonstrating person specific odds ratio estimates of less frequent dental attendance. This was obtained by multilevel random intercept logistic

regression models. Although prospective panel data makes important steps towards determining causality which is not possible with a single wave cross-sectional design [234], the person specific odds ratio estimates for less frequent dental attendance were not purely based on within individual information and thus may suffer from omitted variable bias [199]. The random intercept approach utilized contrasts to a fixed effects model where the individual serves as its own control and where only within individual (level 1), or time varying covariates are analysed thus generating estimates that are not confounded with level 2 covariates. Nevertheless, a fixed effect approach is data inefficient and larger study groups than those included in this thesis would have been necessary to achieve satisfactory statistical power in conditional logistic regression analysis and thus improve the possibility to disentangle causal relationships [199].

### 5.2.2 Comments on validity and reliability

A threat to the internal validity of the longitudinal studies comprising this thesis is the presence of non-response and attrition of participants that were present in both cohorts investigated [232, 235]. By the time of the follow-up data collection in 2012, only 2947 and 4862 of the initial 2007 participants in respectively, Norway and Sweden remained in the studies. Moreover, differential loss to follow-up was observed, implying that the Norwegian and Swedish participants lost to follow-up and those who were retained across the survey years, differed on social characteristics assessed at baseline at age 65. This increases the possibility of non-response and selection bias in the findings presented. Loss to follow-up does not occur randomly and to account for selection bias inverse probability weighting (IPW) was used by which participants were weighted by the inverse of their probability of being followed-up [196, 236]. Thus, the study participants account in the analysis for those with similar characteristics that were not followed-up [237]. Nevertheless, in spite of use of IPW to restore incomplete data, differential survival of sub groups of the participants could have challenged the present findings.

Selection bias in cohort studies also arises from unwillingness to participate [235]. Nevertheless, the non-institutionalised older aged people comprising the present study population are recognized to be more demographically stable compared with younger cohorts, thus limiting losses to follow-up. Compared to institutionalized elderly, non -institutionalised older people may also limit attrition from being unwilling or unable to participate. Although exclusion of institutionalized elderly limits investigation in the domain of the most disabled part of the older populations and makes a threat to the external validity of the findings, this bias is marginal, as institutionalized people constitutes only a small part of the Norwegian and Swedish 1942 cohorts at age 65 and 70 years.

Another major limitation of the present study design, is residual confounding that may have created spurious associations [235]. The multifactorial nature of the oral health indicators measured in *Paper I-IV* implies that confounding biases needed to be addressed. However, in spite of efforts to limit confounding bias, inadequate adjustment of variables associated with both the exposures and the outcome remains an alternative explanation for the relationships observed. Although survey based data as utilized in this thesis is prone to measurement bias, recall bias and social desirability bias, self-reports have provided reasonably valid estimates as for instance regarding number of remaining teeth [193].

Yet another methodological challenge is the cluster effect arising due to aggregation of repeated measures across time [199]. The 1942 prospective cohorts include multilevel or clustered data with several measurement occasions clustered within the same individual, thus violating the assumption of independent measurements made for ordinary regression models. In the most recent analyses of the cohort data in *Paper II, III* and *IV* marginal and random effect models have been utilized to accommodate the structure of the clustered data providing both population-averaged and person-specific estimates of oral health. Further analyses of the cohort data will use multilevel analyses more extensively than what have hitherto been the case. However, using multilevel analyses in combination with weighting procedures

for missing data have so far constituted a challenge with respect to choice of statistical packages.

A major strength of the papers presented lies in the use of a unique and large scale data set that is harmonized across two Scandinavian countries, thus allowing consistent evaluation of the development of oral health indicators and related social disparities across the Norwegian and Swedish cohorts investigated. In spite of the comparative perspective, the cross-country comparison of oral health indicators was made by eye balling only and generally without using statistical testing. Moreover, in light of the cross-country variation in oral health indicators observed, one may question whether the differences can be taken at face value. When 65 year olds in Norway were more likely than their Swedish counterparts to report oral impacts (*Paper I*), does that mean that they are more burdened by oral problems than their counterparts in Sweden? Individuals with the same oral health status may have different reference levels against which they judge their oral health which casts doubt on comparison of such measures across groups of individuals. Thus, in spite of cultural similarities between Norway and Sweden, response categories may have different connotations in the two countries due to habitual language.

# 6.  CONCLUSIONS

Using prospective and comparative data, the present thesis provides useful information on oral health-related quality of life, tooth loss and utilization of dental services in community-dwelling older people in Norway and Sweden. According to the present findings, the 1942 cohorts in Norway and Sweden present with good oral health and have satisfactory dental attendance patterns. Also social disparities remain unchanged across the survey period. In all oral health indicators, changes between age 65 and 70 were limited. The following conclusions were drawn:

- The eight-item OIDP frequency inventory showed acceptable evaluative properties in terms of longitudinal validity, responsiveness and reproducibility between age 65 and 70 in the Norwegian and Swedish 1942 cohorts.
- There were no significant interactions between country and tooth loss upon worsening and improvement in the OIDP inventory, suggesting that responsiveness of the OIDP did not depend on country of residence.
- OIDP (reporting any oral impacts) and less frequent dental attendance declined while tooth loss (extensive tooth loss or being edentulous) increased from age 65 to 70 in both countries investigated.
- Social inequalities in OIDP and tooth loss remained, by and large, unchanged during the 5 year study period. Independent of later life-course factors, early life-course factors influenced all oral health indicators investigated suggesting support for the critical period hypothesis.
- Being advantaged on social aspects protects against less frequent dental attendance both at population and person-specific levels.
- Predisposing, enabling and need related factors and indicators of dental care utilization were associated with OIDP in Norwegian and Swedish elderly.
- Andersen's behavioural model was found to be useful tool to identify predictors of OIDP in elderly.

# 7.  FUTURE PERSPECTIVES

This thesis presented development of oral health indicators and the social distribution of those indicators across time in Norwegian and Swedish 1942 cohorts. A relatively short follow-up period of 5 years limits the policy implications that can be drawn from this research. Thus, extension of the follow-up period and further studies are needed to establish trajectories in oral health indicators and to identify possible causes of differences in oral health care indicators between the cohorts investigated. In the future, additional waves of the Norwegian and Swedish 1942 cohort studies will enable to better investigate individual change in oral health and use of dental health care services across time and cohorts.

Although the findings presented in *Paper I* suggest that a generic version of the OIDP frequency score has promising evaluative properties in terms of longitudinal validity, responsiveness and reproducibility, further studies seem warranted. As the OIDP inventory can be used both as a generic and a condition specific inventory, future studies should use the OIDP inventory to assess condition specific impacts attributed to tooth loss, periodontal disease and caries in older adults. Moreover, to determine whether a change in OIDP reflects a real change or not only measurement error, the ability of OIDP to detect minimally important differences, the smallest change in the OIDP score that is important and meaningful, should be further examined in future studies [66].

Persistent social inequalities as observed in both cohorts point to a need for future research to inform policies aimed at tackling such inequalities in older people. Future studies should also use both absolute and relative measures of social inequality in oral health and explore inequalities using a variety of social indicators over longer periods of time. While recognizing the limitations of the present thesis, the findings presented in *Paper I-IV* suggest that, independent of later life-course social factors, those social factors suggested to be established in early life contributed to inequalities in tooth loss, oral health-related quality of life and dental health care utilization across the cohorts investigated. If early life-course factors are dominating contributors to

social inequalities in older ages, early life preventive measures of oral health in addition to contemporaneous policy interventions among older people should be emphasized.

The present thesis revealed that predisposing, enabling and need related factors and indicators of dental care utilization were independently associated with OIDP in both cohorts. The findings suggest that Andersen's model is an appropriate tool to identify predictors of oral health in older adults. Future research should examine more carefully the role of dental attendance as a predictor of OHRQoL to better understand the oral health benefits of attendance patterns and possible pathways of oral health inequalities. Using structural equation modelling would provide strong support for Andersen's model in the context of older peoples' oral health.

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# 9. PAPERS I-IV

BMC
Oral Health

# Change in Oral Impacts on Daily Performances (OIDP) with increasing age: testing the evaluative properties of the OIDP frequency inventory using prospective data from Norway and Sweden

Ferda Gülcan[1*], Elwalid Nasir[1], Gunnar Ekbäck[2,3], Sven Ordell[4] and Anne Nordrehaug Åstrøm[1]

## Abstract

**Background:** Oral health-related quality of life, OHRQoL, among elderly is an important concern for the health and welfare policy in Norway and Sweden. The aim of the study was to assess reproducibility, longitudinal validity and responsiveness of the OIDP frequency score. Whether the temporal relationship between tooth loss and OIDP varied by country of residence was also investigated.

**Methods:** In 2007 and 2012, all inhabitants born in 1942 in three and two counties of Norway and Sweden were invited to participate in a self-administered questionnaire survey. In Norway the response rates were 58.0% (4211/7248) and 54.5% (3733/6841) in 2007 and 2012. Corresponding figures in Sweden were 73.1% (6078/8313) and 72.2% (5697/7889), respectively.

**Results:** Reproducibility of the OIDP in terms of intra-class correlation coefficient (ICC) was 0.73 in Norway and 0.77 in Sweden. The mean change scores for OIDP were predominantly negative among those who worsened, zero in those who did not change and positive in participants who improved change scores of the reference variables; self-reported oral health and tooth loss. General Linear Models (GLM) repeated measures revealed significant interactions between OIDP and change scores of the reference variables (p < 0.05). Stratified analysis revealed that the mean OIDP frequency score worsened in participants who became dissatisfied- and improved in participants who became satisfied with oral health. Compared to participants who maintained all teeth, those who lost teeth were more likely to experience improvement and worsening of OIDP across both countries. The two-way interaction between country and tooth loss was not statistically significant.

**Conclusions:** Changes in OIDP at the individual level were more pronounced than the percentage distribution of OIDP at each point in time would suggest. The OIDP frequency score showed promising evaluative properties in terms of acceptable longitudinal validity, responsiveness and reproducibility among older people in Norway and Sweden. This suggests that the OIDP instrument is able to detect change in the oral health status that occurred over the 5 year period investigated. Norwegian elderly were more likely to report worsening in OIDP than their Swedish counterparts. Disease prevention should be at focus when formulating the health policy for older people.

**Keywords:** Cohort, OIDP, Responsiveness, Aged, Norway, Sweden

* Correspondence: Ferda.Gulcan@iko.uib.no
[1]Department of Clinical Dentistry-Community Dentistry, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway
Full list of author information is available at the end of the article

## Background

Population ageing occurs globally and by 2050 people above 80 years will comprise 20% of the world's population [1]. As a consequence of living longer and retaining more natural teeth, the treatment decisions for elderly patients become more complex and their need for oral health care services increasingly prominent [2]. In light of changes in the population structure and epidemiology of oral diseases, it is important to address research issues that will inform delivery of oral health care services for the elderly [2-5]. Exploring and promoting ways in which oral health care can be improved and maintained on entering old age should be encouraged. Measures of OHRQoL may play an important role by identifying needs, selecting therapies and monitoring patient progress [5-7]. OHRQoL measures have been used increasingly in oral health surveys, clinical trials and evaluations of oral health care programs. However, few investigators have examined changes in perceived oral health of older populations across socio-cultural contexts [4,6,8,9]. This is an important omission considering the many benefits of using subjective oral health indicators in clinical- and oral health care services research.

In Norway and Sweden, the availability of oral health care services among non-institutionalized, community-dwelling elderly is good. However, evidence suggests that there has been country variation regarding the accessibility to oral health care [10-12] that might be attributed to their specific organization and financing of the health care services. In both countries the financing of oral health care for adults is primarily based on patients' payment. However, the division of labor between public and private sector, the financing of the services and the coverage of dentists differ. In Sweden, dental coverage systems were implemented for the adult population in 2008 to protect from high costs and to support oral examinations and preventive services [10-14]. A further interesting feature in Sweden is the free outreach system to actively seek out those with highest need for oral health care implemented since 1999. Although in Norway there are several social security- and welfare benefit schemes by which particular groups are refunded there is no general reimbursement of the costs of private dental care by public funds and Sweden has implemented benefit schemes for the total adult population that are of a more universal nature. Socio-cultural differences between countries regarding the provision of oral health care services to adult populations may influence dentition status and OHRQoL among the elderly.

The Oral Impacts on Daily Performance inventory (OIDP) is one of many self-reported inventories to assess OHRQoL in terms of adverse impacts that oral conditions can have on everyday life experiences [15]. The OIDP has been demonstrated to have appropriate psychometric properties when applied in population based cross-sectional surveys of elderly in Norway, Sweden, Greece and UK, just to mention a few as well as in middle- and low income countries [16-20]. Studies have shown that OIDP is associated in the expected direction with self-reported oral health and clinical indicators and that personal-, socio-demographic-, and health care service related factors modify those relationships [15,18,19,21-24]. Although OIDP has proven appropriate as a discriminative and descriptive measure in cross-sectional studies, there is less evidence on whether this inventory is suitable as an evaluative measure, to assess within individual change in oral health occurring naturally by ageing or as a consequence of interventions [8,9]. Longitudinal validity, responsiveness and ability to detect improvements and deteriorations in dentition status are necessary technical properties of an evaluative measure. Some evidence of the longitudinal validity of OHRQoL instruments generally have been provided in that substantial changes in quality of life scores have followed therapeutic regimens [9,25-28]. The longitudinal validity of the OIDP inventory and how its' evaluative properties may be influenced by country of residence has received little attention.

Following Norwegian and Swedish cohorts of non-institutionalized elderly from age 65- to 70 years, this study assessed reproducibility, longitudinal validity and responsiveness of the OIDP frequency score within each country using change scores of satisfaction with oral health, satisfaction with tooth appearance and tooth loss as references. This study also assessed whether the temporal relationship between tooth loss and OIDP varied according to country of residence.

## Methods

### Study population

In 2007, a self-administered questionnaire initially developed in Swedish and translated into Norwegian, was mailed by Statistics Norway to all persons born in 1942 residing in the counties: Hordaland (n = 3831), Sogn and Fjordane (n = 975) and Nordland (n = 2442). These counties were chosen not only as representing rural and urban parts, but also due to known variability in oral conditions [10]. Names and addresses were obtained from public population records of Statistics Norway in April 2007. The study took place from June to August 2007 and was approved by the Ethics Committee of the Norwegian Social Science Services (NSD) (Dnr15386). The final response rate was 58.0% (n = 4211of a net population N = 7248). In September/ November 2012, the questionnaire was mailed to all persons aged 70 (born in 1942) in the three counties. The final response rate was 54.5% (n = 3733 of a net population N = 6841). Of the cohort members who completed the 2007 survey (n = 4211), a total of 70.0% (n = 2947) also participated in 2012.The

2012 survey was approved by Regional Committees for Medical and Health Research Ethics (REK) (Dnr 2012/782).

In February/April 2007, an identical questionnaire was mailed to all persons born in 1942 and residing in two counties of Sweden: Örebro (n = 3377) and Östergötland (n = 4936). The final response rate was 73.1% (n = 6078 of the net population N = 8313). This study was part of a cohort study approved by the Ethics Committee in Örebro and Östergötland when it was initiated in 1992. In March/May 2012, the total population of 70-year-olds who were invited to participate in the questionnaire survey was N = 3201 in Örebro and N = 4688 in Östergötland. The response rate was 72.2% (n = 5697 of a net population N = 7889). A total of 4862 (80.0%) participated both in 2007 and 2012. The 2007 and 2012 studies were approved by the Ethics Committee of Uppsala, Sweden (Dnr 2006/251).

### Measures

To ensure comparability of data, identical questionnaires were used and administered in the same way at each data collection in Norway and Sweden. *Socio-economic status* was assessed in terms of country of birth, marital status and education. *Self-reported oral health status* was assessed by asking "Are you generally satisfied with your teeth?" and "Are you satisfied with appearance of your teeth?" recorded on a 4-point Likert scale from (1) very satisfied to (4) not satisfied at all. The variables were dichotomized into (0) satisfied with oral health/tooth appearance (including categories 1 and 2) and (1) dissatisfied oral health/tooth appearance (including categories 3 and 4). Change scores were calculated by subtracting 2012 scores from 2007 scores and then categorized with negative mean change scores indicating worsening; zero mean change scores no change (stability) and positive mean change scores indicating improvement across time. *Dentition status (tooth loss)* was assessed by asking "How many of your own teeth do you still have (excluding baby teeth)?" The variable was categorized as (1) all (28–32 teeth), (2) missing few teeth, (3) missing quite many teeth, (4) almost no teeth left and (5) edentulous. This variable was dichotomized into (0) all or almost all teeth (including categories 1 and 2) and (1) lost many teeth (including categories 3, 4 and 5). A trajectory score of tooth loss was constructed from dummy variables in 2007 and 2012 with the categories of (0) stable all teeth, (1) tooth loss and (2) stable tooth loss. A study of validation of the question about tooth loss was performed including 26 people aged 65+ in Norway. Participants were asked the question about tooth loss and counted their own teeth. In addition a clinical oral examination was performed whereby the number of teeth was counted. Kappa value was 0.69 between counted teeth and the question of tooth loss.

A method of self-administration was applied to assess oral health-related quality of life (OHRQoL). Two previous studies have shown high level of agreement between the self-administration and interview method administered Child-OIDP [29,30]. OHRQoL was assessed using the eight-item "Oral Impacts on Daily Performance" (OIDP) frequency inventory. "During the past 6 months, how often have problems with your mouth and teeth caused you any difficulty with: eating and enjoying food; speaking and pronouncing clearly: cleaning teeth; sleeping and relaxing; smiling and showing teeth without embarrassment; maintaining usual emotional state; enjoying contact with people and carrying out major work?" Each item was scored on a 5-point scale, as follows: (1) never affected, (2) less than once a month, (3) once or twice a month, (4) once or twice a week, (5) every/ nearly every day. For the purpose of analysis the items were dichotomized into (1) affected (including categories 2–5) and (0) never affected (the category 1). Sum scores OIDP frequency ADD (8–40) and OIDP frequency SC (0–8) were computed by adding the 8 performance scores as originally scored and the dichotomized performance scores, respectively. OIDP frequency SC score was dichotomized into (0) no daily performance affected (including score 0) and (1) at least one daily performance affected (including score 1 to 8). Change scores for the OIDP frequency ADD scores and the sub-scale scores were constructed by subtracting the 2012 from the 2007 scores. A positive mean change score indicated improvement, a negative mean change score indicated worsening and zero indicated stability or no change [7]. Minimal important difference (MID) or the smallest score of change considered important from the patients' and clinicians' point of view were calculated using the distribution based approach. Effect sizes were calculated by dividing the mean OIDP change scores by the standard deviation of the corresponding baseline scores [25].

### Statistical analysis

Data were analyzed using Statistical Package for Social Sciences 20 (SPSS Inc., Chicago, IL, USA). Internal consistency reliability was evaluated using Cronbach's alpha. Changes in prevalence of any impacts in OIDP and subscale scores were assessed using Cochrane's Q. Test-retest reliability was assessed using the intra-class correlation coefficient (ICC). Longitudinal validity was calculated by evaluating the association between OIDP change scores and categorical reference variables using One-Way ANOVA and Bonferroni post hoc test. General Linear Models (GLM) for repeated measures were used to assess the within individual change of OIDP ADD scores by categorical reference variables. Within group changes were assessed using Wilcoxon Matched pair signed test. To assess the independent contribution of

categorical reference variables to change in OIDP, multiple variable logistic regression analysis was performed with odd ratios (OR) and 95% confidence interval (CI) using worsening and improvements of OIDP as dependent variables (worsening versus all others and improved versus all others) and change scores of reference variables as independents, adjusting for sex and country of residence. Two-way interactions between country and reference variables upon OIDP were tested.

## Results
### Socio-demographic distribution and loss to follow-up
In Norway, there were statistically significant differences between the groups who were and were not successfully followed-up with respect to; satisfaction with oral health, satisfaction with tooth appearance, tooth loss and OIDP (Table 1). The 2947 Norwegian cohort members included in the analyses consisted of 48.8% women. Totals of 86.5% and 98.1% were married and native born in Norway, respectively. In Sweden, there were statistically significant differences between responders and non-responders with respect to socio-demographics, OIDP and the reference variables as measured at baseline (Table 1). The 4862

cohort members included in the analyses consisted of 51.2% women. Moreover, totals of 94.6% and 79.2% were native born and married in Sweden, respectively.

### Change in prevalence of OIDP and reference variables
According to Table 2, the prevalence of OIDP frequency score in Norway was 29.0% and 28.4% (n.s) in 2007 and 2012, respectively. Corresponding figures for the subscale OIDP frequency scores ranged from 21.1% versus 20.9% (eating) to 3.9% versus 3.5% (work relations) (n.s). The mean OIDP frequency ADD scores in 2007 and 2012 were 9.5 (sd = 3.9) and 9.4 (sd = 3.8) (n.s) (not in table). At both survey occasions, eating and smiling were the impacts most frequently reported (Table 2). In Sweden, the mean OIDP ADD score declined from 9.7 (sd = 4.5) to 9.0 (sd = 3.4) ($p < 0.001$) (not in table), whereas the prevalence of impacts declined from 27.3% in 2007 to 20.4% in 2012 ($p < 0.001$) (Table 2). The prevalence of OIDP subscale scores ranged from 19.0% versus 15.5% (eating) to 2.9% versus 2.0% (work relations) ($p < 0.001$). In 2007, eating and emotions were the impacts most frequently reported. Corresponding figures in 2012 were eating and smiling. The prevalence of tooth loss increased from 21.8% to

**Table 1 Socio-demographics and oral health status at baseline according to follow- up status in Norway and Sweden**

| | Norway | | | Sweden | | |
|---|---|---|---|---|---|---|
| | Lost to follow-up n = 1264 % (n) | Followed up n = 2947 % (n) | Baseline n = 4211 % (n) | Lost to follow-up n = 1216 % (n) | Followed up n = 4862 % (n) | Baseline n = 6078 % (n) |
| *Gender* | | | | | | |
| Males | 48.3(561) | 51.2(1486) | 50.4(2047) | 51.4(625) | 48.8(2373) | 49.3(2998) |
| Females | 51.7(600) | 48.8(1415) | 49.6(2015) | 48.6(591) | 51.2(2489) | 50.7(3080) |
| *Marital status* | | | | | | |
| Unmarried | 15.5(162) | 13.5(362) | 14.1(524) | 32.2(378) | 20.8(995) | 23.1(1373) |
| Married | 84.5(883) | 86.5(2314) | 85.9(3197) | 67.8(797) | 79.2(3781)** | 76.9(4578) |
| *Country of birth* | | | | | | |
| Native | 97.2(1120) | 98.1(2822) | 97.8(3942) | 90.1(1057) | 94.6(4520)** | 93.7(5577) |
| Foreign | 2.8 (32) | 1.9 (56) | 2.2 (88) | 9.9 (116) | 5.4 (259) | 6.3 (375) |
| *OIDP* | | | | | | |
| OIDP = 0 | 66.7(724) | 71.0(1975) | 69.8(2699) | 67.2(751) | 72.7(3375) | 71.6(4126) |
| OIDP > 0 | 33.3(361) | 29.0(806)* | 30.2(1167) | 32.8(367) | 27.3(1269)** | 28.4(1636) |
| *Satisfaction with oral health* | | | | | | |
| Satisfied | 72.2(824) | 78.2(2241)** | 76.5(3065) | 69.2(801) | 78.6(3748)** | 76.8(4549) |
| Dissatisfied | 27.8(318) | 21.8(625) | 23.5(943) | 30.8(356) | 21.4(1018) | 23.2(1374) |
| *Satisfaction with tooth appearance* | | | | | | |
| Satisfied | 75.4(859) | 80.3(2306)** | 78.9(3165) | 72.2(837) | 78.9(3768)** | 77.6(4605) |
| Dissatisfied | 24.6(280) | 19.7(567) | 21.1(847) | 27.8(323) | 21.1(1008) | 22.4(1331) |
| *Tooth loss* | | | | | | |
| All/Almost all teeth | 65.4(738) | 78.2(2224) | 74.6(2962) | 62.8(723) | 74.1(3515) | 71.9(4238) |
| Lost teeth | 34.6(390) | 21.8(619)** | 25.4(1009) | 37.2(428) | 25.9(1230)** | 28.1(1658) |

Chi Square test: *p < 0.05, **p < 0.001.

**Table 2 Prevalence% (n) of any impacts in OIDP and subscale scores, dissatisfaction with oral health, dissatisfaction with tooth appearance and tooth loss in 2007 and 2012 (The Norwegian cohort n = 2947) (The Swedish cohort n = 4862)**

|  | Norway | | Sweden | |
|  | 2007 | 2012 | 2007 | 2012 |
|---|---|---|---|---|
| OIDP | 29.0 (806) | 28.4 (796)ns | 27.3 (1269) | 20.4 (935)** |
| Eating | 21.1 (601) | 20.9 (604)ns | 19.0 (900) | 15.5 (728)** |
| Speaking | 7.8 (223) | 8.4 (243)ns | 5.2 (245) | 4.7 (223)ns |
| Cleaning | 11.7 (332) | 11.8 (341)ns | 8.0 (380) | 6.1 (286)** |
| Sleeping | 7.4 (211) | 7.0 (203)ns | 7.7 (363) | 6.1 (287)** |
| Smiling | 12.6 (357) | 11.7 (333)ns | 9.5 (448) | 6.9 (326)** |
| Emotion | 8.1 (229) | 8.3 (235)ns | 15.5 (732) | 6.2 (290)** |
| Social | 8.7 (247) | 8.2 (234)ns | 8.7 (410) | 5.5 (257)** |
| Work | 3.9 (111) | 3.5 (99)ns | 2.9 (139) | 2.0 (94)* |
| Dissatisfaction with oral health | 21.8 (625) | 18.8 (542)** | 21.4 (1018) | 17.9 (850)** |
| Dissatisfaction with tooth appearance | 19.7 (567) | 16.8 (485)** | 21.1 (1008) | 17.4 (829)** |
| Lost teeth | 21.8 (619) | 23.2 (655)** | 25.9 (1230) | 27.3 (1276)** |

Cochrane's Q test: *p < 0.05, **p < 0.001, ns- not statistically significant.

23.2% in Norway and from 25.9% to 27.3% in Sweden (p < 0.001) (Table 2).

**Change scores, longitudinal validity and responsiveness**
In Norway, 71.8%, 11.8% and 16.3% reported no change, worsening and improvement, regarding satisfaction with oral health. Corresponding figures for satisfaction with tooth appearance were 73.8%, 10.6% and 15.3%. Totals of 76.0% remained in the category having almost all teeth, 5.5% experienced tooth loss and 18.5% were stable with respect to reporting major tooth loss across the survey years. The majority of subjects who reported no change in the reference variable were reflected by the OIDP change scores. Totals of 63.6%, 17.7% and 18.7% reported no change, worsening and improvement, respectively. In Sweden, totals of 70.3%, 12.8% and 16.9% reported no change, worsening and improvement with respect to satisfaction to oral health. The corresponding rates for satisfaction with tooth appearance were 70.8%, 12.3% and 17.0%. Totals of 71.5%, 7.3% and 21.1% were stable with reporting all teeth, experienced tooth loss and were stable with reporting having major tooth loss. Totals of 68.1%, 11.5% 20.4% reported no change, worsening and improvement regarding OIDP scores (not shown in table).

Table 3 depicts the mean change OIDP scores by change scores in the categorical reference variables. Within each country, mean OIDP change scores (and the mean OIDP change subscale scores not shown in table) were negative (worsened) among those who reported worsened satisfaction with oral health and tooth appearance, about zero in subjects who were stable and positive (improved) in subjects reporting improvements in satisfaction with oral health and tooth appearance. Moreover, mean OIDP

change score (and the mean OIDP change subscale scores) were about zero for those who maintained almost all teeth and were stable with respect to reporting major tooth loss and negative with those who reported tooth loss between 2007 and 2012. Statistically significant gradients (p < 0.001) were observed according to all reference variables in both countries. Responsiveness was estimated by calculating effect sizes for the distribution of OIDP change scores according to the reference variables. In Norway and Sweden the effect sizes ranged from 0.0 to 0.5 and from 0.1 to 0.4, respectively (Table 3).

GLM repeated measures revealed statistically significant interactions between OIDP scores and change scores of categorical reference variables in both countries (Table 4). In Norway, statistically significant interactions occurred between OIDP scores and change scores of satisfaction with oral health (Wilk's λ = 0.946, p < 0.001), satisfaction with tooth appearance (Wilk's λ = 0.935, p < 0.001) and tooth loss (Wilk's λ = 0.997, p < 0.05). Estimated marginal means ranged from 9.9 (sd = 4.3) to 11.5 (sd = 5.8) and from 10.8 (sd = 5.4) to 9.5 (sd = 3.9) within the groups who worsened and improved their satisfaction with oral health and from 9.8 (sd = 3.6) to 10.6 (sd = 4.4) in those who reported tooth loss (Table 4). In Sweden, statistically significant interactions occurred between OIDP scores and change scores of satisfaction with oral health (Wilk's λ = 0.952, p < 0.001), satisfaction with tooth appearance (Wilk's λ = 0.963, p < 0.001) and tooth loss (Wilk's λ = 0.988, p < 0.001). The estimated marginal means ranged from 9.4 (sd = 3.9) to 9.9 (sd = 4.5) and from 10.9 (sd = 5.8) to 8.8 (sd = 2.9) within the groups who worsened and improved their satisfaction with oral health and from 9.4 (sd = 3.3) to 9.5 (sd = 3.7) in those who experienced tooth loss (Table 4).

**Table 3 Longitudinal validity: mean change OIDP scores (sd) and [effect sizes] by change scores of reference variables (Norwegian cohort n = 2947) (Swedish cohort n = 4862)**

| | Satisfaction with oral health | | | |
|---|---|---|---|---|
| | Worsened[a] | Stable[b] | Improved[c] | Total |
| *Norway* | | | | |
| OIDP change score | −1.60 (5.2) [0.4] | 0.02 (2.3)[0.0] | 1.28 (4.3)[0.2]** | 0.04 (3.3) [0.1] |
| *Sweden* | | | | |
| OIDP change score | −0.56 (4.1) [0.2] | 0.28 (2.7) [0.1] | 2.14 (5.4) [0.4]** | 0.49 (3.6) [0.1] |
| | Satisfaction with tooth appearance | | | |
| | Worsened[a] | Stable[b] | Improved[c] | Total |
| *Norway* | | | | |
| OIDP change score | −1.93 (5.4) [0.5] | 0.03 (2.5)[0.0] | 1.41 (3.9)[0.3]** | - |
| *Sweden* | | | | |
| OIDP change score | −0.59 (4.0)[0.2] | 0.34 (2.9)[0.1] | 1.88 (5.3) [0.3]** | - |
| | Tooth loss | | | |
| | Lost teeth[a] | Stable all teeth[b] | Stable tooth loss[c] | Total |
| *Norway* | | | | |
| OIDP change score | −0.72 (4.6)[0.4] | 0.01 (2.0)[0.0] | 0.21 (6.1)[0.3]* | - |
| *Sweden* | | | | - |
| OIDP change score | −0.14 (3.9) [0.4] | 0.25 (2.1)[0.1] | 1.13 (6.4) [0.2]** | - |

Data are given as mean (sd) [effect size].
One-way ANOVA: *$p < 0.05$, **$p < 0.001$.
Bonferroni post hoc analyses indicated the following ($p < 0.05$):
● Statistically significant differences in mean OIDP change by change score of satisfaction with oral health and change score of satisfaction with tooth appearance in *Norway* and *Sweden*: group a vs. group b, group a vs. group c and group b vs. group c.
● Statistically significant differences in mean OIDP change by change score of tooth loss in *Norway*: group a vs. group b, group a vs. group c.
● Statistically significant differences in mean OIDP change by change score of tooth loss in *Sweden*: group a vs. group c and group b vs. group c.

## Reliability

Internal consistency reliability of OIDP in terms of Cronbach's alpha in 2007 and 2012 were 0.89 in both countries. In Norway, the 1723 subjects who reported no change in satisfaction with oral health were used to assess test-retest reliability of the total OIDP score [8]. The intra-class correlation coefficient was 0.73 (95% CI 0.70-0.75). Corresponding figures in Sweden among 3294 who reported no change in satisfaction with oral health was 0.77 (95% CI 0.75-0.78) (not shown in table).

## Country variation in responsiveness to change

According to Table 5, multiple variable logistic regression analyses revealed that worsening of OIDP was less likely in Sweden than in Norway. All categorical reference variables contributed to the improvement and worsened of OIDP across the two countries, with change in tooth loss being the strongest covariate. Compared to subjects who maintained almost all teeth, subjects who lost teeth and were stable with reporting tooth loss across time were more likely to experience worsening in OIDP. The corresponding ORs were 3.3 (95% CI 2.6-4.2) and 3.5 (95% CI 2.9-4.2). Likewise, tooth loss was the strongest covariate of improvement in OIDP after adjusting for country- and other categorical

reference variables. Compared to those who maintained all teeth, those who reported tooth loss both in 2007 and 2012 were more likely to report improved OIDP. The corresponding ORs were 1.7 (95% CI 1.3-2.1) and 3.2 (95% CI 2.8-3.8). No two-way interactions between country and tooth loss upon worsening and improvement in OIDP were statistically significant, suggesting that the responsiveness to change of the OIDP inventory did not vary between countries.

## Discussion

This study presents one of very few undertaken to assess the evaluative properties of the OIDP frequency inventory, focusing non-institutionalized elderly in Norway and Sweden. Moreover, this study assessed the magnitude and direction of change in the OIDP frequency inventory to further understand the development of older peoples' OHRQoL by increasing age. The cross-sectional validity of the OIDP has been assessed previously in national samples of adults in Norway and Sweden [16,17]. According to Locker & Jakovic [6], Locker [7] and Locker & Jakovic [8], both cross-sectional and longitudinal psychometric properties of an OHRQoL inventory should ideally be established in every sample and context under consideration. Important steps in the process of psychometric

**Table 4 Responsiveness of OIDP: mean OIDP in 2007 and 2012 by change scores of reference variables in Norway (n = 2947) and Sweden (n = 4862)**

| Satisfaction with oral health | Worsened Mean (sd)[c] | Stable Mean (sd)[d] | Improved Mean (sd)[e] | Wilk's lamda p-value |
|---|---|---|---|---|
| **Norway** | | | | |
| OIDP 2007 | 9.9 (4.3) | 8.9 (3.1) | 10.8 (5.4) | |
| OIDP 2012 | 11.5 (5.8) | 8.9 (3.2) | 9.5 (3.9) | |
| 2007 versus 2012 | p = 0.001[a] | p = 0.792[a] | p = 0.001[a] | 0.946 p = 0.001[b] |
| **Sweden** | | | | |
| OIDP 2007 | 9.4 (3.9) | 9.2 (3.7) | 10.9 (5.8) | |
| OIDP 2012 | 9.9 (4.5) | 8.8 (3.0) | 8.8 (2.9) | |
| 2007 versus 2012 | p = 0.001[a] | p = 0.000[a] | p = 0.000[a] | 0.952 p = 0.001[b] |
| **Satisfaction with tooth appearance** | **Worsened Mean (sd)[c]** | **Stable Mean (sd)[d]** | **Improved Mean (sd)[e]** | |
| **Norway** | | | | |
| OIDP 2007 | 9.7 (3.9) | 9.1 (3.4) | 10.7 (5.1) | |
| OIDP 2012 | 11.6 (6.0) | 9.1 (3.4) | 9.3 (3.1) | |
| 2007 versus 2012 | p = 0.001[a] | p = 0.987[a] | p = 0.001[a] | 0.935 p = 0.001[b] |
| **Sweden** | | | | |
| OIDP 2007 | 9.2 (3.5) | 9.2 (3.6) | 10.8 (5.6) | |
| OIDP 2012 | 9.8 (4.6) | 8.8 (2.9) | 8.9 (3.1) | |
| 2007 versus 2012 | p = 0.002[a] | p = 0.000[a] | p = 0.000[a] | 0.963 p = 0.001[b] |
| **Tooth loss** | **Lost teeth Mean (sd)[c]** | **Stable all teeth Mean (sd)[d]** | **Stable tooth loss Mean (sd)[e]** | |
| **Norway** | | | | |
| OIDP 2007 | 9.8 (3.6) | 8.5 (1.8) | 12.8 (6.8) | |
| OIDP 2012 | 10.6 (4.4) | 8.5 (1.7) | 12.6 (6.9) | |
| 2007 versus 2012 | p = 0.032[a] | p = 0.916[a] | p = 0.243[a] | 0.997 p = 0.05[b] |
| **Sweden** | | | | |
| OIDP 2007 | 9.4 (3.3) | 8.6 (2.0) | 12.1 (6.9) | |
| OIDP 2012 | 9.5 (3.7) | 8.3 (1.3) | 10.9 (5.9) | |
| 2007 versus 2012 | p = 0.690[a] | p = 0.000[a] | p = 0.000[a] | 0.988 p = 0.001[b] |

[a]Wilcoxon matched pair signed rank test.
[b]GLM repeated measure.
[c]Bonferroni post hoc analyses indicated the following (p < 0.05):
● Statistically significant differences in mean OIDP change by change score of satisfaction with oral health, satisfaction with tooth appearance and tooth loss in *Norway*: group c vs. group d, group c vs. group e and group d vs. group e.
● Statistically significant differences in mean OIDP change by change score of satisfaction with oral health and satisfaction with tooth appearance in *Sweden*: group c vs. group d and group d vs. group e.
● Statistically significant differences in mean OIDP change by change score of tooth loss in *Sweden*: group c vs. group d, group c vs. group e and group d vs. group e.

evaluation of the OIDP are tests of its internal consistency reliability and reproducibility. In this study, Cronbach's alpha amounted to 0.89 at both measurement occasions and in both countries. This is above the recommended values of 0.70 and consistent with those previously reported in surveys of older people [15,18,19,21,23]. Reproducibility amounted to 0.73 and 0.77 in Norway and Sweden, indicating good stability at both sites [18]. However, reproducibility alone does not guarantee satisfactory evaluative properties. The main purpose of the study was to assess the longitudinal validity and responsiveness of the OIDP that is whether or not this inventory is responsive to changes in oral health occurring naturally or as a consequence of intervention. Without this evidence, it cannot

be ascertained whether any change in OIDP represents real change or measurement error. The mean OIDP change scores translated into effect sizes (estimations of minimal important differences, MID) ranging from 0.1 to 0.5 showed a clear gradients across the change groups of the reference variables (Table 3). The effect sizes indicated small to moderate magnitude of change using Cohen's Benchmarks [31]. A value of 0.2 should be considered small, a value of 0.4 moderate and a value of 0.8 and above large effect [31].

It should be noted that the change scores presented could be confounded by regression towards the mean effect. Thus, those with more extreme scores at baseline tended to have less extreme scores at follow-up regardless

**Table 5 Worsened and improved OIDP from 2007 to 2012 (improved versus all others and worsened versus all others) regressed on country of residence and change scores of reference variables, OR and 95% CI**

| | Worsened OIDP | | Improved OIDP | |
|---|---|---|---|---|
| | Unadjusted OR (95% CI) | Adjusted OR (95% CI) | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
| Norway | 1 | 1 | 1 | 1 |
| Sweden | 0.6 (0.5-0.7) | 0.6 (0.5-0.6) | 1.1 (0.9-1.3) | 1.1 (0.9-1.2) |
| **Satisfaction with oral health** | | | | |
| Stable | 1 | 1 | 1 | 1 |
| Worsened | 2.9 (2.5-3.5) | 1.9 (1.6-2.3) | 0.9 (0.7-1.1) | 0.8 (0.6-1.0) |
| Improved | 0.6 (0.5-0.8) | 0.5 (0.4-0.7) | 3.3 (2.8-3.8) | 2.0 (1.7-2.4) |
| **Satisfaction with tooth appearance** | | | | |
| Stable | 1 | 1 | 1 | 1 |
| Worsened | 2.6 (2.2-3.1) | 1.8 (1.5-2.2) | 0.9 (0.7-1.0) | 0.8 (0.7-1.1) |
| Improved | 0.6 (0.5-0.8) | 0.6 (0.5-0.8) | 2.8 (2.4-3.2) | 1.8 (1.5-2.1) |
| **Change tooth loss** | | | | |
| Stable all teeth | 1 | 1 | 1 | 1 |
| Lost teeth 2007-2012 | 3.6 (2.9-4.6) | 3.3 (2.6-4.2) | 1.5 (1.2-2.0) | 1.7 (1.3-2.1) |
| Stable tooth loss | 3.2 (2.7-3.7) | 3.5 (2.9-4.2) | 3.6 (3.1-4.2) | 3.2 (2.8-3.8) |
| Nagelkerke's $R^2$ | 13.5 | | | 12.4 |

of any real change in the characteristics being measured. Moreover, the great floor effect of the OIDP frequency score (prevalence of no impacts) may have limited its sensitivity to change at the extremes of oral health [25]. Whether the small to moderate changes presented here are clinically meaningful, what specific clinical conditions account for the changes remains important topic for further research. In this study and for the purpose of assessing longitudinal validity, evaluation of OIDP was limited to the comparison with change scores of self-reported oral health and tooth loss.

Results from the multivariable logistic regression analysis confirmed by and large those based on bivariate analysis. Taken together favorable and unfavorable changes in the reference variables across time were reflected by improvement and deterioration of the OIDP frequency scores. This finding has support in previous studies of prospective design [6,8,32]. Tooth loss emerged as a strong covariate of oral impacts across time independent of residence country. Accordingly, a recent systematic review of observational studies revealed that tooth loss associated with worsened OHRQoL across socio-cultural contexts and independent of the specific OHRQoL measure utilized [33]. However, participants who reported tooth loss at both survey occasions were about three times more likely to experience worsened and improved OIDP across time. Focusing elderly in Brazil, de Andrade [9] reported number of missing teeth at baseline to be the best predictor of both improvement and deterioration of OHRQoL scores at five years follow-up. There is also evidence that high risk groups (stability in reported

major tooth loss) are more likely to experience both deterioration and improvement in OHRQoL compared with low risk groups and that the positive relationship between tooth loss and worsened OHRQoL is not a simple monotonic one [4,34]. For some people, tooth loss might lead to pain relief and improved OHRQoL, whereas others may experience chewing difficulties, impaired function and problems with prosthesis leading to deteriorated OHRQoL [6,8].

Among the strengths of this study is the use of a cross-cultural prospective cohort design recognized to be highly relevant when measuring change in oral health status [7]. Although the response rate to the follow-up was good in both countries, those who completed the survey at age 70 had better oral health at age 65 than those who were lost to follow-up. Thus, the two groups differed on variables that associated with change in OIDP, implying that the generalization of the results presented should be made with caution. Due to possible selection bias, the worsening of OIDP across the survey period might be an underestimate of that actually occurring in the total sample, particularly in Norway with highest rate of non-response. However, even in those relatively well educated cohorts investigated (about one third having university education in both countries), 20%- 30% reported oral impacts and dissatisfaction with oral health suggesting need for oral health care and treatment. A second strength of this study was use of different methods to assess change, as recommended by Locker [7]. In accordance with the present results, previous studies, also from Norway, have shown positive associations between age and tooth loss

and negative associations between age and OHRQoL, respectively. However, due to their cross-sectional design, the temporal relationships have been unclear [23,35]. Longitudinal studies conducted elsewhere have reported on non-significant change in OHRQoL with increasing age in older populations [35]. In both countries about half of the participating subjects reported no change in OIDP scores, whereas about one fourth reported increase and decline during the five year survey period. This is consistent with findings among older Canadians, using the global transition scores whereby the majority reported no change across a 3-year survey period [7].

Whereas some intervention studies have addressed the evaluative properties of the OIDP inventory, this study adds to the literature by demonstrating its responsiveness to change in oral health occurring naturally among non-institutionalized elderly in a cross-cultural context [25-27]. Thus, as a longitudinal cohort study without the inclusion of an intervention of known efficacy, the changes observed might document the natural history of changes in oral health of elderly in Norway and Sweden between age 65 and 70. According to the present results, the responsiveness of OIDP to changes in tooth loss or the influence of changes in tooth loss on changes in OIDP was not dependent on study site. On the other hand, Swedish participants were less likely than their Norwegian counterparts to experience impaired OIDP. This indicates influence from a cultural dimension on the development of OHRQoL across time in older persons as suggested by previous studies [6,19]. Alternatively, this variation may be attributed to differences between Norway and Sweden regarding structure and financing of oral health care systems, such as the implementation of benefit schemes that in Sweden are of a more universal nature and the fact that per capita spending on oral health and the rate of regular adult dental attendance have been higher in Sweden than in Norway [10-12]. Previous evidence, suggesting that access to dental care acts as a proxy for OHRQoL, gives resonance here [2,23].

## Conclusion

Changes in OIDP at the individual level were more pronounced than the percentage distribution of OIDP at each point in time would suggest. The OIDP frequency score showed promising evaluative properties in terms of acceptable longitudinal validity, responsiveness and reproducibility among older people in Norway and Sweden. This suggests that the OIDP frequency instrument is able to detect change in the oral health status that occurred over the 5 year period investigated. Norwegian elderly were more likely to report worsening in OIDP than their Swedish counterparts. Disease prevention should be at focus when formulating the health policy for older people.

### Author details

[1]Department of Clinical Dentistry-Community Dentistry, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway. [2]Örebro County Council, Örebro, Sweden. [3]School of Health and Medical Sciences, Örebro University, Örebro, Sweden. [4]Dental Commissioning Unit, Östergötland County Council, Linköping University, Linköping, Sweden.

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# Erratum to: Change in Oral Impacts on Daily Performances (OIDP) with increasing age: testing the evaluative properties of the OIDP frequency inventory using prospective data from Norway and Sweden

Ferda Gülcan[1*], Elwalid Nasir[1], Gunnar Ekbäck[2,3], Sven Ordell[4] and Anne Nordrehaug Åstrøm[1]

## Erratum

After the publication of this work [1], we became aware that the total number of being "unmarried" in Table 1 was incorrect. In the Norwegian study, marital status was originally categorized as (1) married, (2) unmarried, (3) divorced and (4) widowed. For the purpose of analysis, the variable was dichotomized as (1) married (including the original category 1) and (0) unmarried (including the original categories (2,3), whereas the original category (4) was set to missing instead of correctly being included into the unmarried category of the dichotomy variable. This error has been corrected in a revised Table 1 included in this erratum. The new categorization of the variable marital status did not influence the results and conclusion of the article. We regret any inconvenience that this inaccuracy might have caused.

## Author details

[1]Department of Clinical Dentistry-Community Dentistry, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway. [2]Örebro County Council, Örebro, Sweden. [3]School of Health and Medical Sciences, Örebro University, Örebro, Sweden. [4]Dental Commissioning Unit, Östergötland County Council, Linköping University, Linköping, Sweden.

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* Correspondence: Ferda.Gulcan@iko.uib.no
[1]Department of Clinical Dentistry-Community Dentistry, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway
Full list of author information is available at the end of the article

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**Table 1 Socio-demographics and oral health status at baseline according to follow-up status in Norway and Sweden**

| | Norway | | | Sweden | | |
|---|---|---|---|---|---|---|
| | Lost to Follow-up n = 1264 % (n) | Followed up n = 2947 % (n) | Baseline n = 4211 % (n) | Lost to Follow-up n = 1216 % (n) | Followed up n = 4862 % (n) | Baseline n = 6078 % (n) |
| *Gender* | | | | | | |
| Males | 48.3(561) | 51.2(1486) | 50.4(2047) | 51.4(625) | 48.8(2373) | 49.3(2998) |
| Females | 51.7(600) | 48.8(1415) | 49.6(2015) | 48.6(591) | 51.2(2489) | 50.7(3080) |
| *Marital status* | | | | | | |
| Unmarried | 22.9(262) | 19.6(565) | 20.5(827) | 32.2(378) | 20.8(995) | 23.1(1373) |
| Married | 77.1(883) | 80.4(2314)* | 79.5(3197) | 67.8(797) | 79.2(3781)** | 76.9(4578) |
| *Country of birth* | | | | | | |
| Native | 97.2(1120) | 98.1(2822) | 97.8(3942) | 90.1(1057) | 94.6(4520)** | 93.7(5577) |
| Foreign | 2.8(32) | 1.9(56) | 2.2(88) | 9.9(116) | 5.4(259) | 6.3(375) |
| *OIDP* | | | | | | |
| OIDP = 0 | 66.7(724) | 71.0(1975) | 69.8(2699) | 67.2(751) | 72.7(3375) | 71.6(4126) |
| OIDP > 0 | 33.3(361) | 29.0(806)* | 30.2(1167) | 32.8(367) | 27.3(1269)** | 28.4(1636) |
| *Satisfaction with oral health* | | | | | | |
| Satisfied | 72.2(824) | 78.2(2241)** | 76.5(3065) | 69.2(801) | 78.6(3748)** | 76.8(4549) |
| Dissatisfied | 27.8(318) | 21.8(625) | 23.5(943) | 30.8(356) | 21.4(1018) | 23.2(1374) |
| *Satisfaction with tooth appearance* | | | | | | |
| Satisfied | 75.4(859) | 80.3(2306)** | 78.9(3165) | 72.2(837) | 78.9(3768)** | 77.6(4605) |
| Dissatisfied | 24.6(280) | 19.7(567) | 21.1(847) | 27.8(323) | 21.1(1008) | 22.4(1331) |
| *Tooth loss* | | | | | | |
| All/Almost all teeth | 65.4(738) | 78.2(2224) | 74.6(2962) | 62.8(723) | 74.1(3515) | 71.9(4238) |
| Lost teeth | 34.6(390) | 21.8(619)** | 25.4(1009) | 37.2(428) | 25.9(1230)** | 28.1(1658) |

Chi Square test: *p < 0.05, **p < 0.001.

**II**

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**RESEARCH ARTICLE**                                                                                  **Open Access**

# Inequality in oral health related to early and later life social conditions: a study of elderly in Norway and Sweden

Ferda Gülcan[1*], Gunnar Ekbäck[2,3], Sven Ordell[4], Stein Atle Lie[1] and Anne Nordrehaug Åstrøm[1]

## Abstract

**Background:** A life course perspective recognizes influences of socially patterned exposures on oral health across the life span. This study assessed the influence of early and later life social conditions on tooth loss and oral impacts on daily performances (OIDP) of people aged 65 and 70 years. Whether social inequalities in oral health changed after the usual age of retirement was also examined. In accordance with "the latent effect life course model", it was hypothesized that adverse early-life social conditions increase the risk of subsequent tooth loss and impaired OIDP, independent of later-life social conditions.

**Methods:** Data were obtained from two cohorts studies conducted in Sweden and Norway. The 2007 and 2012 waves of the surveys were used for the present study. Early-life social conditions were measured in terms of gender, education and country of birth, and later-life social conditions were assessed by working status, marital status and size of social network. Logistic regression and Generalized Estimating Equations (GEE) were used to analyse the data. Inverse probability weighting (IPW) was used to adjust estimates for missing responses and loss to follow-up.

**Results:** Early-life social conditions contributed to tooth loss and OIDP in each survey year and both countries independent of later-life social conditions. Lower education correlated positively with tooth loss, but did not influence OIDP. Foreign country of birth correlated positively with oral impacts in Sweden only. Later-life social conditions were the strongest predictors of tooth loss and OIDP across survey years and countries. GEE revealed significant interactions between social network and survey year, and between marital status and survey year on tooth loss.

**Conclusion:** The results confirmed the latent effect life course model in that early and later life social conditions had independent effects on tooth loss and OIDP among the elderly in Norway and Sweden. Between age 65 and 70, inequalities in tooth loss related to marital status declined, and inequalities related to social network increased.

**Keywords:** Life-course perspective, Ageing, OIDP, Tooth loss, Cohort, Social inequality

## Background

Globally, the elderly population is growing faster than any other age group [1]. As a consequence of living longer and retaining their natural teeth, older populations have received increasing attention from health policy decision makers [2,3]. A reduction in the rates of tooth loss across time has occurred in many industrialized societies, including the Scandinavian countries [4]. Higher rates of dentate subjects and population ageing imply a continuously increasing demand for and expenditure on oral health care services [2]. Although the Scandinavian countries have generous redistributive policies, absolute and relative inequalities in oral health indicators have been reported to persist in the adult populations across time [3,5-9]. Consistent evidence suggests that people in lower socioeconomic position have worse health and oral health compared with their counterparts in higher socioeconomic

* Correspondence: Ferda.Gulcan@iko.uib.no
[1]Department of Clinical Dentistry, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway
Full list of author information is available at the end of the article

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position [10]. Little is known about inequalities related to social conditions in oral health of the elderly populations and whether those inequalities remain stable, increase or decrease after the usual age of retirement [10-12].

A life-course perspective to chronic disease epidemiology considers the importance of time in disease development, and offers ways of explaining the social gradient in health by recognizing influences of socially patterned exposures across the entire life span [13,14]. Life course epidemiology has been defined as the study of long-term effects on subsequent health of physical or social exposure during gestation, childhood, adolescence, young adulthood and later adult life [13,14]. According to this perspective, combinations, accumulations and/or interactions of social environments and biological insults experienced throughout the life course impact on current and future health and oral health conditions [13]. The influence of life course exposures on health and oral health has been grouped into various conceptual models that may operate simultaneously; the latent effect model or critical period model, the social mobility or trajectories model and the cumulative life course model being the most frequently investigated [13,15]. According to the latent effect life course model, adverse early-life social conditions increase the risk of chronic disease in later life, independent of subsequent, intervening social circumstances, lifestyle and traditional risk factors. It is assumed that exposures at a specific period during the life span will result in irreversible damage and insult [13,15]. The cumulative life course model considers that risk to health accumulates gradually across the life-span and focuses on the total amount of exposure, whereas the social mobility model refers to social mobility across the life-course, and to how mobility impacts adult oral health.

Consistent with various life-course models, evidence suggests that deprivation in early-life stages followed by a subsequent affluent status combine to produce elevated cardio-vascular mortality risk [14,16]. Poulton et al. [17] found that early parental socioeconomic position was associated with dental caries at age 26 after adjustment for contemporaneous adult occupational status. Nicolau et al. [18] provided evidence that parental education was related to periodontal health in middle-aged women independent of their contemporaneous educational level. In contrast, results based on the Newcastle Thousand Family study in the UK revealed no association between parental social class and tooth retention at age 50 [19,20]. Åstrøm and Wold [21] investigated how changes in socioeconomic position characteristics throughout adolescent years influenced oral impacts in young adulthood and reported that continuity of an advantaged or disadvantaged socio-economic position contributed to differing levels of oral health. Thus, participants with stable high socioeconomic

position were less likely to report oral impacts at age 30, whereas those with low socioeconomic position were more likely to report oral impacts. Using data from the Health 2000 Survey with a representative sample of Finnish adults, Bernabe et al. [22] investigated the relationship between education and several oral outcomes. They reported results that support the critical period, accumulation and social trajectories models. Whereas the critical period model has received some empirical support [16,23], the life-course perspective on oral health has been criticized for placing too much emphasis on the early life course. This is at odds with the notion that the critical period concept more broadly refers to any stage of an individual's development during which risk or protective factors may influence health at subsequent life stages. Thus, it has been suggested to include a range of different social condition measures and data from middle adulthood and large prospective studies with various life course models to allow for informed and generalizable statements about the impacts on health and oral health of adults [16]. In a previous Swedish cohort study, Åstrøm et al. [24] found that disadvantaged socio-behavioural characteristics have a long-lasting effect on oral health-related quality of life throughout middle-age life stages. It remains to be ascertained whether inequalities related to social conditions in oral health persist or change with further ageing. Few studies have compared the relative contribution of early and later life course social conditions on dentition status and oral impacts, and investigated whether social inequalities persist, broaden or narrow after the usual age of retirement in non-institutionalized elderly populations.

Focusing cohorts of the elderly in Norway and Sweden from age 65 to age 70, this study assessed the influence of early and later life social conditions on tooth loss and oral impacts on daily performances (OIDP). Whether social inequalities in oral health change during the 5 year follow-up period after the usual age of retirement was also examined. In accordance with "the latent effect life course model", it was hypothesized that adverse early-life social conditions increase the risk of subsequent tooth loss and impaired OIDP, independent of later-life social conditions. In this study, social condition was defined broadly using measures tapping into work-based and non-work-based components of the corresponding theoretical construct [25].

## Methods

### Study population

The present study is based on data from two cohort studies conducted in Sweden and Norway. The Swedish cohort study started in 1992 focusing a 1942 birth cohort, being resident in the two counties of Sweden. The Norwegian 1942 cohort study was set up as a companion to the ongoing Swedish cohort to enhance co-

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operation and cross-national comparative research. The Norwegian first wave data collection started in 2007 and was designed to provide directly comparable data with the Swedish study. In both cohorts data are collected by self-administered questionnaires every 5 years, and the study populations are defined by continuously updated versions of the 1942 cohorts in each country. The analysis of the present paper is based on data collection from 2007 and 2012 waves in both countries. The detailed methods of the two cohorts, including number of participants in both survey years as well as number of follow ups have been reported in previous studies [26,27].

In Norway, the final response rate in 2007 was 58.0% (n = 4211), and in 2012 it was 54.5% (n = 3733). Of the cohort members who completed the 2007 survey (n = 4211), a total of 70.0% (n = 2947) responded in 2012. In Sweden, the final response rates were 73.1% (n = 6078) and 72.2% (n = 5697) in 2007 and 2012, respectively. A total of 4862 (80.0% of the cohort members in 2007) participated also in 2012. The ethical considerations in these studies were in accordance with the principles of the Declaration of Helsinki, and written informed consent was obtained from the participants. In Norway, the 2007 and 2012 studies were approved by the Ethics Committee of the Norwegian Social Science Services (NSD) and Regional Committees for Medical and Health Research Ethics (REK), respectively. In Sweden, the first wave study in 1992 was approved by the Ethics Committee in Örebro, and the 2007 and 2012 studies were approved by the Ethics Committee of Uppsala.

**Measures**

Data were collected using a structured self-administered questionnaire. To ensure comparability of data, similar questionnaires were administered in the same way across the participating countries. Following the approach of Pearce et al. [19,20], early and later life social conditions assessed in 2007 and 2012 were grouped into a conceptual framework according to the life-course stages at which they would be expected to operate. Gender, country of birth and education, denoted early- life social conditions, were supposed to have been operating from early childhood (gender and country of birth)/early adult life (education), and expected to be time invariant. Marital status, working status and social network denoted later- life social conditions, were expected to occur later in life and to be time variant. *Educational level* was categorized as (1) primary school, (2) secondary school, (3) high school, (4) university/ university college and (5) other. This was dichotomized into (0) higher education (category 4) and (1) lower education (including categories 1, 2, and 3). *Working status* was assessed by asking "how many hours do you work in average per

week?" with categories (1) full-time (more than 35 hours/ week), (2) part time (between 15 and 34 hours/week), (3) between 1–14 hours and (4) not working. The variable was dichotomized into (0) working (including categories 1, 2 and 3) and (1) not working (category 4). *Marital status* was dichotomized into "married" (category married) and "single" (categories unmarried, divorced and widowed). *Social network* was assessed using the following question "How many people you know, you meet or talk with you during a typical week?" with response alternatives (1) none, (2) 1–2, (3) 3–5, (4) 6–10, (5) 11–15 and (6) more than 15. For analysis, the variable was dichotomized into (0) broad social network (category 6) and (1) narrow social network (including categories 1, 2, 3, 4 and 5).

*Dentition status (tooth loss)* was assessed by asking "How many of your own teeth do you still have (excluding baby teeth)?" with response categories (1) all (28–32 teeth), (2) missing some teeth, (3) missing many teeth, (4) almost no teeth left and (5) edentulous. A dummy variable was constructed (0) all/almost all teeth (including categories 1 and 2) and (1) lost teeth (including categories 3, 4 and 5). In a Norwegian sub-study the measure was validated providing a weighted kappa score of 0.69. Contrary to the Norwegian data, self-reported number of teeth was not validated in the Swedish study group. However, close agreement between the clinically recorded and self-reported number of teeth has been documented previously in the literature [28]. *Oral health-related quality of life* was assessed by the eight-item "Oral Impacts on Daily Performance" (OIDP) frequency inventory [29]. "During the past 6 months, how often have problems with your mouth and teeth caused you any difficulty with: eating and enjoying food; speaking and pronouncing clearly: cleaning teeth; sleeping and relaxing; smiling and showing teeth without embarrassment; maintaining usual emotional state; enjoying contact with people and carrying out major work?" Each item was scored on a 5-point scale, as follows: (1) never affected, (2) less than once a month, (3) once or twice a month, (4) once or twice a week, (5) every/nearly every day. For the purpose of analysis the items were dichotomized into (1) affected (including categories 2–5) and (0) never affected (category 1). A sum score, OIDP frequency SC, was constructed from the 8 dummy performances. OIDP frequency SC (0–8) was dichotomized into (0) no daily performance affected (score 0) and (1) at least one daily performance affected (including score 1 to 8). The OIDP inventory has been tested for psychometric properties previously both in Norway and Sweden [30,31].

**Statistical analysis**

All analyses were conducted country wise using SPSS Version 20 (SPSS Inc., Chicago, IL, USA) and STATA

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version 13.1 (Stata Corporation, College Station, TX, USA). Inverse probability weighting (IPW) was used to adjust estimates for missing responses and loss to follow- up. By IPW, the cohort participants are weighted by the inverse of their probability of being followed- up [32]. Initially, participants and drop-outs were compared on social conditions assessed in 2007 [26]. IPW were estimated by fitting a logistic regression model with variables that contributed to follow- up. The IPW was calculated in the following way: (I) a logistic regression model was fitted for each outcome variable and variables were included in the model to determine whether subjects who remained in the study differed from those lost to follow-up. (II) Based on the estimated model, probabilities were calculated for each participant. (III) Inverse of the probabilities was applied as weights in unadjusted and adjusted logistic regression models. Unadjusted bivariate analyses were performed with the intact cohorts (n = 2947 in Norway and n = 4862 in Sweden) using Cochrane's Q for repeated measures and cross tabulation with Chi-square tests. For the latent effect life course model, stepwise multiple logistic regression models adjusted using IPW were fitted separately for each survey year and country with odds ratios (OR) and 95% confidence interval (CI). Early-life social condition variables were entered in step 1 and later-life social condition variables in step 2. In each multiple logistic regression model, Nagelkerke's $R^2$ were calculated. Nagelkerke's $R^2$

is a pseudo R square that generalize the coefficient of determination with values between 0 and 1 where 0 denotes that the model do not explain anything about the variation and 1 that the model completely explains variation in the outcome variables. Changes in the association of social conditions with oral health outcomes across time were modelled using Generalized Estimating Equations (GEE) with robust variance estimates to account for the cluster effects of repeated observations.

## Results

In Norway, 74.3% and 67.5% of the non- responders and responders (p < 0.001) reported having lower education. In Sweden, statistically significant differences between respondents and non- respondents occurred regarding foreign country of birth (5.4% versus 9.9%, p < 0.001) and unmarried civil status (67.8% versus 79.2%, p < 0.001) when assessed in 2007 [26].

In Norway, the percentage of tooth loss and oral impacts (OIDP > 0) in 2007 were 21.8% and 23.2%. The corresponding figures in 2012 were 29.0% and 28.4%. In Sweden, the percentage of tooth loss and oral impacts in 2007 were 25.9% and 27.3%, and in 2012 27.3% and 20.4%. Prevalence of being single, unemployed and having narrow social network increased in both countries during the 5 year follow-up (Table 1).

Table 2 depicts the percentage of participants having major tooth loss and OIDP > 0 by early and later life

**Table 1 Socioeconomic characteristics and oral health indicators by survey year in Norway (n = 2947) and Sweden (n = 4862), based on individuals with complete data**

| Variables | Categories | Norway | | Sweden | |
|---|---|---|---|---|---|
| | | 2007% (n) | 2012% (n) | 2007% (n) | 2012% (n) |
| Gender | Female | 48.8 (1415) | | 51.2 (2489) | |
| | Male | 51.2 (1486) | | 48.8 (2373) | |
| Country of birth | Native | 98.1 (2822) | | 94.6 (4520) | |
| | Foreign | 1.9 (56) | | 5.4 (259) | |
| Education | Higher | 32.5 (770) | | 24.3 (1027) | |
| | Lower | 67.5 (1601) | | 75.7 (3192) | |
| Working status | Working | 53.3 (1498) | 33.5 (936) | 48.7 (2303) | 22.3 (1027) |
| | Not working | 46.7 (1314) | 66.5 (1858)*** | 51.3 (2428) | 77.7 (3585)*** |
| Marital status | Married | 80.4 (2314) | 77.3 (2265) | 79.2 (3781) | 76.0 (3524) |
| | Single | 19.6 (565) | 22.7 (667)*** | 20.8 (995) | 24.0 (1114)*** |
| Social network | Broad | 38.8 (1115) | 21.9 (635) | 39.8 (1880) | 25.6 (1185) |
| | Narrow | 61.2 (1758) | 78.1 (2267)*** | 60.2 (2849) | 74.4 (3441)*** |
| Tooth loss | All or almost all teeth | 78.2 (2224) | 76.8 (2164) | 74.1 (3515) | 72.7 (3404) |
| | Lost teeth | 21.8 (619) | 23.2 (655)*** | 25.9 (1230) | 27.3 (1276)*** |
| OHRQoL | OIDP = 0 | 71.0 (1975) | 71.6 (2002) | 72.7 (3375) | 79.6 (3654) |
| | OIDP > 0 | 29.0 (806) | 28.4 (796) | 27.3 (1269) | 20.4 (935)*** |

Cochrane's Q-test: *p < 0.05, **p < 0.01, ***p < 0.001.
The total number in the different categories do not add up to 2947 due to missing values.
Information regarding some parts of the table is present elsewhere [26].

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**Table 2 Percentage (n) tooth loss and OIDP (OIDP > 0) by early and later life social conditions in 2007 and 2012, in Norway (n = 2947) and Sweden (n = 4862), based on individuals with complete data**

| | Norway | | Sweden | |
|---|---|---|---|---|
| | Tooth loss% (n) | OIDP > 0% (n) | Tooth loss% (n) | OIDP > 0% (n) |
| **2007** | | | | |
| **Early-life social conditions** | | | | |
| Female | 21.2 (288) | 26.9 (356) | 26.1 (632) | 28.1 (664) |
| Male | 22.4 (326) | 30.9 (444)* | 25.7 (598) | 26.6 (605) |
| Native | 21.8 (598) | 28.7 (771) | 24.8 (1101) | 26.5 (1154) |
| Foreign | 24.1 (13) | 41.2 (21) | 46.1 (117)*** | 39.5 (96)*** |
| Higher education | 11.7 (88) | 27.4 (204) | 17.9 (182) | 29.4 (289) |
| Lower education | 27.3 (423)*** | 29.8 (451) | 28.8 (901)*** | 26.2 (808) |
| **Later-life social conditions** | | | | |
| Working | 19.5 (284) | 29.3 (419) | 23.2 (525) | 25.5 (562) |
| Not working | 24.4 (311)** | 28.8 (361) | 28.4 (679)*** | 28.9 (679)** |
| Married | 20.5 (460) | 28.5 (631) | 23.8 (888) | 25.3 (927) |
| Single | 27.5 (150)*** | 30.6 (160) | 33.8 (329)*** | 34.7 (325)*** |
| Broad social network | 17.7 (191) | 25.5 (270) | 22.3 (411) | 24.7 (446) |
| Narrow social network | 24.6 (421)*** | 31.4 (526)** | 28.1 (787)*** | 29.0 (796)** |
| **2012** | | | | |
| **Early-life social conditions** | | | | |
| Female | 21.3 (286) | 25.2 (335) | 27.3 (649) | 20.2 (467) |
| Male | 25.0 (358)* | 31.5 (450)*** | 27.3 (627) | 20.6 (468) |
| Native | 23.1 (623) | 28.3 (759) | 26.2 (1145) | 19.8 (848) |
| Foreign | 31.5 (17) | 40.7 (22)* | 46.6 (115)*** | 29.5 (70)*** |
| Higher education | 12.6 (94) | 26.8 (199) | 19.5 (195) | 20.1 (200) |
| Lower education | 28.6 (434)*** | 29.9 (452) | 29.6 (909)*** | 19.9 (600) |
| **Later-life social conditions** | | | | |
| Working | 21.4 (192) | 27.5 (244) | 25.0 (251) | 21.1 (208) |
| Not working | 23.6 (421) | 29.0 (513) | 27.5 (964) | 19.8 (681) |
| Married | 21.7 (472) | 27.2 (589) | 25.4 (875) | 18.7 (635) |
| Single | 28.3 (180)*** | 32.4 (202)** | 32.1 (348)*** | 24.7 (260)*** |
| Broad social network | 16.8 (103) | 25.3 (154) | 21.5 (251) | 19.4 (222) |
| Narrow social network | 25.1 (543)*** | 29.3 (631) | 29.1 (977)*** | 20.4 (670) |

Chi-square: *p < 0.05, **p < 0.01, ***p < 0.001.

social conditions separately for each survey year and country. Educational level, working status, marital status and social network were statistically significantly related to tooth loss. In Norway, gender was associated with OIDP in 2007, whereas both gender, country of birth and marital status were associated with OIDP in 2012. In Sweden, oral impacts (OIDP > 0) was reported by 26.5% of participants of native Swedish origin and by 39.5% of participants with foreign country origin. Corresponding figures in 2012 were 19.8% versus 29.5%. Marital status and social network were statistically significantly associated with oral impacts in 2007 and 2012.

Modelling tooth loss and OIDP using multiple logistic regression adjusted with IPW, early-life social condition indicators in terms of gender, country of birth and educational level were entered in a first step, followed in a second step by later-life social condition indicators; working status, marital status and social network. In Norway, the final logistic model for tooth loss provided a Nagelkerke's $R^2$ of 0.05 in 2007 and 2012. The corresponding figures for OIDP were 0.01 in 2007 and 2012. In 2007, major tooth loss were more likely to occur among males (OR = 1.3), lower educated (OR = 2.7), unemployed (OR = 1.5), and single people (OR = 1.5) (Table 3). In 2012, males, lower educated, single people

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**Table 3 Early and later life social conditions and two way interactions between social conditions and time regressed on tooth loss in Norway (n = 4211) and Sweden (n = 6078)**

|  | 2007 OR (95% CI)[a] | 2012 OR (95% CI)[b] | Interaction social condition X time OR (95% CI)[c] |
|---|---|---|---|
| **Norway** | | | |
| **Early-life social conditions** | | | |
| Male vs female | 1.3 (1.1-1.6) | 1.6 (1.3-2.0) | 1.2 (0.9-1.5) |
| Foreign vs native | 1.2 (0.7-2.2) | 1.6 (0.8-3.3) | 1.3 (0.6-2.5) |
| Lower vs higher education | 2.7 (2.2-3.3) | 2.5 (1.9-3.3) | 0.9 (0.7-1.2) |
| **Later-life social conditions** | | | |
| Not working vs working | 1.5 (1.2-1.8) | 1.2 (0.9-1.5) | 0.8 (0.6-1.1) |
| Single vs married | 1.5 (1.2-1.8) | 1.6 (1.2-2.0) | 1.1 (0.8-1.4) |
| Narrow vs broad social network | 1.2 (1.0-1.5) | 1.7 (1.3-2.3) | 1.4 (1.1-1.9) |
| **Sweden** | | | |
| **Early-life social conditions** | | | |
| Male vs female | 1.1 (0.9-1.2) | 1.0 (0.9-1.2) | 0.9 (0.8-1.1) |
| Foreign vs native | 2.1 (1.7-2.7) | 2.5 (1.8-3.4) | 1.2 (0.9-1.6) |
| Lower vs higher education | 1.9 (1.6-2.2) | 1.9 (1.6-2.3) | 1.0 (0.8-1.2) |
| **Later-life social conditions** | | | |
| Not working vs working | 1.2 (1.1-1.4) | 1.1 (0.9-1.3) | 0.9 (0.7-1.1) |
| Single vs married | 1.6 (1.4-1.8) | 1.3 (1.1-1.5) | 0.8 (0.7-0.9) |
| Narrow vs broad social network | 1.3 (1.1-1.5) | 1.4 (1.2-1.7) | 1.1 (0.9-1.4) |

Adjusted OR and (95% CI).
a) Logistic regression showing main effects of social conditions in 2007 on tooth loss in 2007. Inverse probability weighting (IPW) adjusted estimates.
b) Logistic regression showing main effects of social conditions in 2012on tooth loss in 2012. Inverse probability weighting (IPW) adjusted estimates.
c) Results from GEE showing two way interactions between time and social conditions on tooth loss indicating change in associations from 2007 to 2012.

and those with narrow social network were more likely to report major tooth loss. The corresponding ORs were 1.6, 2.5, 1.6 and 1.7. GEE analyses revealed a statistically significant two-way interaction between social network and survey year (time) on tooth loss, OR = 1.4 (95% CI 1.1-1.9). The ORs for having tooth loss if having a narrow network increased statistically significantly from OR = 1.2 in 2007 to OR = 1.7 in 2012 (p < 0.05) (Table 3). In Sweden the final regression models for tooth loss provided Nagelkerke's $R^2$ of 0.03 and 0.02 in 2007 and 2012, respectively. Nagelkerke's $R^2$ for OIDP were 0.01 for both survey years. Country of birth and education were the most important early-life social condition predictors of tooth loss across the survey years. Working status, marital status and social network were the most important later-life social condition predictors of tooth loss in 2007 and 2012, respectively. A two-way interaction on tooth loss between survey year and marital status occurred, OR = 0.8 (95% CI 0.7-0.9). The ORs declined from 1.6 in 2007 to 1.3 in 2012 (p < 0.05) (Table 3).

With respect to OIDP, gender and social network were the only statistically significant early and later life social condition predictors in Norway in 2007 (Table 4). Compared to females, males were more likely to report OIDP. People having narrow social network were more likely than their counterparts with large social network

to report oral impacts. In 2012, gender and educational level were significant early-life social condition predictors of OIDP, whereas marital status was the only later-life social condition predictor. In Sweden, participants of foreign country of birth, those with single marital status and narrow social network were more likely to report OIDP in 2007. Country of origin and marital status were significant early and later life social conditions predictors of OIDP in 2012 (Table 4). GEE revealed no statistically significant two- way interactions between early and later life social condition indicators and time on OIDP in either country (Table 4).

## Discussion

Few population-based prospective cohort studies have investigated social inequalities in self- reported oral health of older people across societies belonging to the same welfare regime [3,10,11,33]. This study examined inequalities in tooth loss and oral impacts on daily performances (OIDP) related to early and later life social conditions focusing on non- institutionalized Norwegian and Swedish elderly. Although 65 years of age is recognized as the norm for retirement in Norway and Sweden, many continue to work until older ages [34,35]. Evidence suggests that higher educated and married people tend to retire after age 65 more frequently than

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**Table 4 Early and later life social conditions and two way interactions between social conditions and time regressed on OIDP in Norway (n = 4211) and Sweden (n = 6078)**

| | 2007 OR (95% CI)[a] | 2012 OR (95% CI)[b] | Interaction social condition X time OR (95% CI)[c] |
|---|---|---|---|
| **Norway** | | | |
| **Early-life social conditions** | | | |
| Male vs female | 1.3 (1.1-1.5) | 1.5 (1.3-1.9) | 1.2 (0.9-1.4) |
| Foreign vs native | 1.4 (0.9-2.4) | 1.2 (0.6-2.4) | 0.8 (0.4-1.8) |
| Lower vs higher education | 1.1 (0.9-1.3) | 1.2 (1.0-1.5) | 1.1 (0.9-1.4) |
| **Later-life social conditions** | | | |
| Not working vs working | 1.0 (0.9-1.2) | 1.1 (0.9-1.3) | 1.1 (0.8-1.4) |
| Single vs married | 1.1 (0.9-1.4) | 1.4 (1.2-1.8) | 1.3 (0.9-1.6) |
| Narrow vs broad social network | 1.3 (1.1-1.5) | 1.1 (0.9-1.4) | 0.9 (0.7-1.2) |
| **Sweden** | | | |
| **Early-life social conditions** | | | |
| Male vs female | 1.0 (0.9-1.2) | 1.0 (0.9-1.2) | 1.0 (0.8-1.2) |
| Foreign vs native | 1.5 (1.2-2.0) | 1.6 (1.1-2.3) | 1.0 (0.7-1.5) |
| Lower vs higher education | 0.8 (0.7-1.0) | 0.9 (0.8-1.2) | 1.2 (0.9-1.4) |
| **Later-life social conditions** | | | |
| Not working vs working | 1.1 (0.9-1.2) | 1.0 (0.8-1.2) | 0.9 (0.7-1.1) |
| Single vs married | 1.5 (1.3-1.8) | 1.4 (1.2-1.7) | 0.9 (0.8-1.2) |
| Narrow vs broad social network | 1.3 (1.1-1.5) | 1.1 (0.9-1.3) | 0.8 (0.7-1.1) |

Adjusted OR and (95% CI).
a) Logistic regression showing main effects of social conditions in 2007 on OIDP in 2007. Inverse probability weighting (IPW) adjusted estimates.
b) Logistic regression showing main effects of social conditions in 2012on ODIP in 2012. Inverse probability weighting (IPW) adjusted estimates.
c) Results from GEE showing two way interactions between time and social conditions on OIDP indicating change in associations from 2007 to 2012.

their single counterparts with lower-level education [34,35]. In both countries, being at work after age 65 may reflect social differences in terms of educational level, perceived health, occupational status and working environment.

Across countries, major tooth loss and OIDP at ages 65 and 70 were more prevalent among those with lower social-condition categories, independent of how social condition was measured. The latent effect life-course model was supported in that both early and later social conditions had independent effects on tooth loss and OIDP. Moreover, with few exceptions, social inequalities in major tooth loss and oral impacts remained stable across the survey years. These results corroborate previous population based studies reporting consistent education and income gradients in clinical and subjective oral health indicators similarly to respective social gradients in general health [3,4,10,11,21]. National health surveys have reported that considerable social inequalities in health are present in European countries [36,37]. In spite of their emphasize put on egalitarian principles, Norway and Sweden being no exception in this respect [36,37].

Consistent with previous studies, the present findings indicate that disadvantage in early life would have an enduring detrimental effect on future health, irrespective of intervening later life experiences [13]. A cohort study

from United Kingdom demonstrated persistent influence of early-life social conditions on tooth loss at age 50 [19]. In a Danish study [38], early-life social conditions in terms of higher education predicted higher number of filled teeth at age 85, suggesting that well educated people seek dental care more frequently than their lower educated counterparts. Bernabe et al. [22] showed that both parental and own education contributed independently to adult oral health among Finnish adults. The results of the present study corroborate evidence suggesting that early-life social conditions influence mortality and chronic diseases at older ages [16]. In addition to the cross-sectional analyses in 2007 and 2012, GEE was utilized to examine whether changes occurred in the social inequalities of major tooth loss and oral impacts from 2007 (age 65) to 2012 (age 70). The results revealed a significant increase in social network related inequality of tooth loss in Norway and a significant decrease in marital status related inequality of tooth loss in Sweden. Previous studies have shown that social differentials in mortality based on employment and occupational status tend to decrease with increasing age after retirement, whereas inequalities based on social structural measures such as social support and marital status seem to either persist or decrease marginally [39]. This study supports previous conflicting evidence from

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longitudinal studies, suggesting both persisting, increasing and declining social inequalities in oral health with increased age in Norway and Sweden.

Few studies have provided evidence of educational gradients in broad subjective oral health measures. Contrary to the present results of no significant relationship between education and OIDP, Tsakos et al. [40] found a clear educational gradient in oral impacts as measured by the Geriatric Oral Health Assessment Index; the lower the educational level the worse the oral health perceptions. An inverse graded association between education and oral impacts on daily performances was also reported from the English Longitudinal Survey of Aging, but only among dentate individuals [10]. Cross-national studies have revealed morbidity to be most prevalent among lower educated younger and higher educated older individuals [22,41]. Nevertheless, the lack of an educational gradient in oral impacts as observed in this study is inconsistent with previous studies focusing broad subjective measures of oral health [10,21]. This might be attributed to differences in study populations with various cultural background and the type of educational measures utilized. It has been recognized that education could be a poor measure of material wealth due to different social meanings attached to this concept across time and cultures [42].

Whereas Norway has several social security and welfare benefits by which particular population subgroups have their dental care expenses refunded, Sweden implements benefit schemes of a more universal nature. In spite of between country difference when it comes to inclusiveness of social assistance, the country specific analyses of this study suggest that social inequalities in oral health of the elderly were as profound in Sweden as in Norway [43]. The present results are in keeping with previous ones, suggesting that cross-national variation in health inequalities are smaller within than between various welfare regimes [36,37]. In this study problems making between country comparisons were avoided by similarities in sampling frames, survey questions and the distribution of responders across social condition categories. Nevertheless, the results should still be interpreted by caution since the social meaning of the various social condition groups (e.g. educational level) might vary slightly across study sites. Moreover, the choice of social indicator may have an influence on the disparity estimates presented. Previous studies have shown that social factors related to wealth and prestige may be more sensitive indicators than income and occupational status among older people [44]. Consistent with this evidence, structural measures, such as education, marital status and social network were among the strongest predictors of tooth loss and OIDP in this study.

Some weaknesses of the present study should be considered. In cohort studies, selection biases may arise from unwillingness to participate, missing information and losses to follow-up. Thus, this study had limitations first and foremost in terms of the rates of non-response and losses to follow-up that occurred across time in both countries. Compared to individuals retained across the survey years, those lost to follow-up tended to be disadvantaged in terms of early and later life social condition indicators and also regarding the oral health outcomes investigated. Previous studies have shown that being single is correlated with migration out of the study area which is consistent with the present finding that married were more likely to retain in the survey than non-married [45]. Consistent with the present results, higher educational level is a predictor of missing in cohort studies [33,45]. Although it has been acknowledged that failure to correct for nonresponse in cohort studies produces biases in self-reported health, the IPW attached to subjects included in the analysis may have restored representation of those lost to follow-up and thus reinforced the internal and external validity of the study [32]. Exclusion of institutionalized elderly is another problem that may have led to selection bias since institutionalized people tend to have lower socioeconomic position and are less healthy than their non-institutionalized counterparts [46]. However, this bias has been marginal as institutionalized people in Norway and Sweden are usually above 80 years. The rate of the population between 65 and 74 that are institutionalized is below 5% [47]. Although it is not possible to conclude whether social inequalities in oral health can be attributed to health selection or social causation, previous studies have shown that health selection explains only a minor portion of the observed social gradient in health [48].

## Conclusion

The results confirmed the latent effect life course model in that early and later life social conditions had independent effects on tooth loss and OIDP among the elderly in Norway and Sweden. Social inequalities in oral health remained stable after the usual age of retirement at age 65. Inequalities in tooth loss related to social network and marital status increased and declined from age 65 to 70. The results are important for public oral health decision makers who plan strategies for optimal oral health and quality of life in the older population.

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## Author details
[1]Department of Clinical Dentistry, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway. [2]Örebro County Council, Örebro, Sweden. [3]School of Health and Medical Sciences, Örebro University, Örebro, Sweden. [4]Dental Commissioning Unit, Östergötland County Council, Linköping University, Linköping, Sweden.

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III

COMMUNITY
DENTISTRY AND
ORAL EPIDEMIOLOGY

# Social predictors of less frequent dental attendance over time among older people: population-averaged and person-specific estimates

**Ferda Gülcan[1], Gunnar Ekbäck[2,3], Sven Ordell[4], Stein Atle Lie[1] and Anne Nordrehaug Åstrøm[1]**

[1]Department of Clinical Dentistry, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway, [2]Örebro County Council, Örebro, Sweden, [3]School of Health and Medical Sciences, Örebro University Örebro, Sweden, [4]Dental Commissioning Unit, Östergötland County Council, Linköping University, Linköping, Sweden

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Abstract – *Objectives:* Longitudinal studies considering social disparities in the utilization of dental services are scarce. Repeated measures should be accounted for by the use of appropriate statistical methods. The purpose of this study was first to describe the patterns of less frequent dental attendance (less than once a year) over time from the age of 65–70 in Norwegian and Swedish 1942 cohorts. Second, this study estimated the influence of predisposing, enabling and need-related social predictors using marginal model with robust variance estimators and random intercept model, RIM, to account for the clustered structure of the repeated observations. Third, the study aimed to compare the estimates of associations between social predictors and less frequent dental attendance derived from marginal and random intercept models. *Methods:* In 2007 and 2012, all residents born in 1942 in selected counties of Norway and Sweden were invited to participate in a questionnaire survey. In Norway, the response rate was 58.0% ($n = 4211$) in 2007 and 54.5% ($n = 3733$) in 2012 with a follow-up rate of 70%. The corresponding figures in Sweden were 73.1% ($n = 6078$) and 72.2% ($n = 5697$), with a follow-up rate of 80%. Marginal and random intercept models were fitted for population-averaged and person-specific estimates. Design effects were calculated by comparing the results from ordinary logistic regression analyses and the marginal model with robust variance estimators. The proportion of the total variation due to differences between persons was reported using the intraclass correlation coefficient (ICC). *Results:* Less frequent dental attendance declined from 14.5% to 12.2% in Norway and from 13.6% to 12.9% in Sweden. According to marginal and random intercept models, time-invariant (gender, country of birth, education) and time-variant social predictors (working status, social network, marital status, smoking and perceived health) contributed to less frequent dental attendance. A likelihood ratio test confirmed that adjustment for clustered observations was appropriate. The ICC was 0.90 in Norway and 0.85 in Sweden. *Conclusions:* The prevalence of less frequent dental attendance was low and dropped by increasing age from 65 to 70 years. Both at population and at person-specific levels, being advantaged on social aspects protects against less frequent dental attendance after 65 years of age in the Norwegian and Swedish cohorts investigated.

Social disparities in dental care utilization may contribute to inequalities in oral health and oral health-related quality of life.[1,2] Frequent dental attendance and routine or preventively oriented dental attendance have been associated with better oral health[3] and are recognized to be more prevalent in people belonging to the upper end of the socioeconomic scales.[1,4–7] Income, education and marital status have been identified as important social predictors of dental visiting in the general US population.[6] Using data from the Survey of Health, Ageing and Retirement in Europe (SHARE), Listl[8] reported on considerable income-related inequalities in dental service utilization among elderly across several countries. In Norway, similar income-related inequalities are low or not existing.[9,10] Social predictors of dental care utilization have been identified among Norwegian and Swedish community-dwelling older adults.[5,11] Østerberg et al.[11] reported that social support influenced elderly's timely dental visits in Sweden. Other studies suggest that some but not all aspects of social support are positively associated with dental care utilization.[12,13] Considerable socioeconomic inequalities have also been reported for the nonuse of dental care within and between European countries.[14]

Methodological shortcomings may challenge previous healthcare service research and may have contributed to inconsistent findings in the dental healthcare literature. A major caveat associated with cross-sectional studies is that the influences of social factors across time cannot be considered. Moreover, cross-sectional studies in general do not facilitate causal inferences. Sequential cross-sectional studies may misinterpret cohort differences as individual change across time. Few longitudinal studies have been conducted investigating accessibility to and use of dental care in the fast-growing older populations.[15]

Research on dental healthcare service often includes hierarchical data structures where cluster effects arise, for instance, due to several patients attending the same dentist or multiple teeth that are aggregated within the same individual.[16,17] In longitudinal studies with repeated measurements, clustering of data is the norm because observations obtained from the same individual are correlated.[16,18] Such studies include multilevel (ML) data with measurement occasions clustered within individuals. Conventional statistical methods, assuming statistically independent observations, ignore dependencies due to clustered or multilevel

structures in data.[16,17,19] Omitting to account for clustering may result in the underestimation of standard errors, too narrow confidence intervals, too small $P$-values and consequently increased type 1 error rates.[20,21] To handle clustering, different statistical models are available. *Mixed effects models*, such as the *random intercept model (RIM)*, are commonly used to estimate effects that are person specific and conditional on the cluster. *Marginal models*, on the other hand, describe the average risk difference between groups and hence provide population-averaged estimates.[16,17,19] In marginal models, the correlated observations are commonly taken into account by an empirical robust (sandwich-type) variance estimator, treating the cluster effects as nuisance and thus being of no intrinsic interest. A RIM is an alternative approach for incorporating repeated data where the intercept is considered random and allowed to vary between persons.[16,17,19]

Studies with clustered designs have been poorly handled in the dental research literature.[22–24] Recent reviews have shown that deficiencies in report of cluster randomized trials remain common.[25] In a study of the quality of 23 cluster randomized studies, only 65–78% had accounted appropriately for clustering in sample size calculations and analyses.[23,26] A methodological review found that only 12 of 21 cluster randomized studies included used analytical methods accounting for clustering.[23,27] So far, multilevel modelling has been applied in cluster randomized trials where oral health-related interventions are allocated to individuals or dental clinics and evaluated at lower levels, such as individual's teeth or teeth surfaces.[26] ML modelling in observational studies of dental care utilization is not common. Theoretically, dental healthcare utilization is a function of predisposing (sociodemographic), enabling (social resources) and need-related factors (perceived health).[28] The purpose of the present study was first to describe the patterns of less frequent dental attendance (attendance less than once a year) over time from the age of 65–70 in Norwegian and Swedish 1942 cohorts. Second, this study estimated the influence on less frequent dental attendance across time from predisposing, enabling and need-related social predictors using marginal model with robust variance estimators and random intercept model, RIM, to account for the clustered structure of repeated observations. Third, the study aimed to compare the estimates of associations between social predictors and less frequent dental

## Methods

attendance derived from marginal and random intercept models.

Data applied in this study have been described in detail in previous studies based on the Norwegian and Swedish 1942 cohorts.[29,30] Briefly, the study population consisted of individuals born in 1942, being residents in selected counties of Norway and Sweden. Data were collected by self-administered questionnaires in 2007 and 2012. In Norway, the response rates were 58.0% in 2007 ($n = 4211$) and 54.5% ($n = 3733$) in 2012. Of the participants who completed the 2007 survey, a total of 2947 (70%) participated in 2012. In Sweden, the response rates were 73.1% ($n = 6078$) in 2007 and 72.2% ($n = 5697$) in 2012. Of the participants who completed the 2007 survey, a total of 80% ($n = 4862$) participated in 2012. The Norwegian and Swedish 1942 cohort has been tracked since 2007 and 1992, respectively. In Norway, ethical approvals were obtained from the Ethics Committee of the Norwegian Social Science Services (NSD) in 2007 and Regional Committees for Medical and Health Research Ethics (REK) in 2012. In Sweden, the 2007 and 2012 studies were approved by the Ethics Committee of Uppsala.

To ensure the comparability of data, similar questions were administered at each data collection in Norway and Sweden. The outcome variable was less frequent dental attendance assessed using the question 'Roughly, how often do you visit a dentist?' with response categories (1) 'twice or more yearly', (2) 'once a year', (3) 'every second year' and (4) 'more seldom than every second year'. This outcome does not consider the reason for dental attendance in terms of being problem or preventively oriented. A dummy variable was constructed as (0) 'frequent dental attendance' (including categories 1 and 2) and (1) 'less frequent dental attendance' (including the categories 3 and 4).

The study contained both *time-invariant* and *time-variant* covariates. Gender, country of birth and education were considered *time invariant*, reflecting characteristics defined in early childhood or early adult life. Marital, working and smoking statuses, social network and perceived health are considered to constitute later life characteristics that are *time variant* because they may change across time. *Education* was categorized as (1) 'primary school', (2) 'secondary school', (3) 'high school', (4) 'university/university college' and (5) 'other'. For analyses, education was dichotomized into (0) 'higher education' (category 4) and (1) 'lower education' (categories 1, 2 and 3). *Working status* was assessed by asking 'How many hours do you work in average per week?' with categories (1) 'full-time (more than 35 h/week)', (2) 'part-time (between 15 and 34 h/week)', (3) 'between 1 and 14 h and (4) 'not working'. For analysis, this variable was dichotomized into (0) 'working' (including categories 1, 2 and 3) and (1) 'not working' (category 4). *Marital status* was dichotomized into (0) 'married' (category married) and (1) 'single' (including original categories unmarried, divorced and widowed). *Social network* was assessed using the question 'How many people you know, do you meet or talk with you during a typical week?' with response alternatives (1) 'none', (2) '1–2', (3) '3–5', (4) '6–10', (5) '11–15' and (6) 'more than 15'. For the analyses, the variable was dichotomized into (0) 'broad social network' (including the original category 6) and (1) 'narrow social network' (including the original categories 1–5). The distribution of this variable justified the cut-off point. *Smoking status* was assessed by asking 'What are your smoking habits?' with categories (1) 'smoking daily', (2) 'smoking occasionally', (3) 'have been smoker but quitted' and (4) 'never smoked'. For the purpose of the analyses, the variable was dichotomized into (0) 'no' (category 4) and (1) yes (categories 1–3). *Perceived health* was assessed by asking 'Do you consider yourself to be in good health?' with the categories (1) 'yes, absolutely', (2) 'yes, largely', (3) 'no, not particularly', (4) 'no, absolutely not' and (5) 'don't know'. For the analyses, a dichotomized variable was constructed (0) 'good perceived health' (including the original categories 1 and 2) and (1) 'bad perceived health' (including the original categories 3–5).

Statistical analyses were conducted by country using STATA version 13.1 (Stata Corporation, College Station, TX, USA). The level of statistical significance was set at 5%. Cross-tabulation and chi-square statistics were used to assess bivariate relationships. The proportions of Norwegian and Swedish participants reporting less frequent dental attendance at each survey year were compared using Cochrane's Q for equality proportions in matched samples (participation in both survey years). Inverse probability weighting (IPW) was used to adjust for loss to follow up and missing responses. By IPW, the cohort participants are weighted by the inverse of their probability of

being followed up.[31] Participants who dropped out were compared on social variables assessed at baseline (Table 1). IPW was estimated by fitting a logistic regression model with all social variables that contributed to follow-up.

Marginal and random intercept models were fitted to regress less frequent dental attendance on time-invariant and time-variant covariates with estimates presented as odds ratios (OR) with 95% confidence intervals (CI). To enable cluster-adjusted multivariable logistic regression analyses, data were reshaped from wide to long format, with one row of data per occasion for each person and with time (survey year) as a fixed variable. Time-variant covariates and outcome variable have a 2-level structure with occasion (survey year) as the unit at level 1 and the individual as the level 2 unit. While time-variant covariates vary both at level 1 and level 2, time-invariant covariates vary only at level 2. For the comparison of cluster-unadjusted and adjusted models and calculation of design effects, an ordinary logistic regression model was fitted. This model ignores intracluster dependency and yields population-averaged estimates. Secondly, a multiple variable logistic regression model with robust estimation of the variances (using sandwich estimators) was fitted, whereby the regression coefficients denote the differences in the average of less frequent dental attendance across groups. The option 'cluster (id)' was used for the correlated observations, yielding identical regression coefficients as in an ordinary logistic regression, but with standard errors that are robust to the independency assumption. The implication of ignoring the adjustment of clustering was examined by calculating design effects ($D = (se_{\text{robust variance estimation}}/se_{\text{ordinary logistic regression}}^2)$), which provides an indication of over ($D < 1$)- or under ($D > 1$)-estimation of the variance revealed by ordinary logistic regression relative to the model with robust variance estimation[20]. Third, a random intercept model (RIM) was fitted using the gllamm program (generalized linear latent and mixed models).[32] RIM explicitly allows for clustering by including both inter- and intracluster variation in the model. Relationships between covariates and outcome variable are assumed with all the cluster regression lines having a fixed slope, but different intercepts. The intercept is allowed to vary with individuals and assumed to be normally distributed with mean zero and variance component at level 2 which is estimated. The effect of cluster-

ing was assessed by calculating intracluster correlation coefficient (ICC), representing the correlation between two randomly chosen level 1 units within randomly chosen level 2 unit. ICC expresses the variation between clusters as a proportion of the total (within- and between-person) variance. ICC ranges from 0 when there is no variation between clusters to 1, which indicates no within-cluster variation. Also, a likelihood ratio test was calculated to test the null hypothesis that ICC equals 0. Rejection of the null hypothesis implies that a multilevel model is appropriate.[18]

## Results

Baseline characteristics by follow-up status are presented in Table 1. In Norway, lower education, narrow social network, being a smoker, reporting bad perceived health and reporting less frequent dental attendance were significantly associated with a higher probability of attrition ($P < 0.05$). In Sweden, compared with participants who followed up, those lost to follow up were more likely to be of foreign country of birth, single marital status, being a smoker, reporting bad perceived health and reporting less frequent dental attendance (Table 1). The proportions reporting less frequent dental attendance decreased from 14.5% to 12.2% ($P < 0.001$) in Norway and from 13.6% to 12.9% ($P = 0.28$) in Sweden (not in table).

The Norwegian data included 2947 clusters (individuals), each with 2 observations. The Swedish data included 4862 clusters (individuals) also with 2 observations. Tables 2 and 3 show one-way tabulations of time-variant social predictor and outcome variables with counts decomposed into overall, between and within components. As depicted in Table 2, overall, the Norwegian participants reported less frequent dental attendance in 13.4% of the occasions across all subjects and occasions. According to the between-subject variability, 18.4% of the participants reported less frequent dental attendance for at least one occasion. The within-subject variability revealed that for participants who were reporting less frequent dental attendance during the survey period, the average percentage of occasions they were reporting was 75.3%. In Sweden overall-, between- and within-subject variability regarding less frequent dental attendance were 13.2%, 18.7% and 72.4%, respectively (Table 3). The average percentage of occasions reporting not-working status, being single,

Table 1. Baseline characteristics by follow-up status and adjusted OR (95% CI) of loss to follow up according to these characteristics

| | Norway | | | | Sweden | | | |
|---|---|---|---|---|---|---|---|---|
| | Follow-up (n = 2947) n (%) | Loss to follow up (n = 1264) n (%) | Total (n = 4211) n (%) | Adjusted OR (95% CI) | Follow-up (n = 4862) n (%) | Loss to follow up (n = 1216) n (%) | Total (n = 6078) n (%) | Adjusted OR (95% CI) |
| Gender | | | | | | | | |
| Female | 1415 (48.8) | 600 (51.7) | 2015 (49.6) | 1 | 2489 (51.2) | 591 (48.6) | 3080 (50.7) | 1 |
| Male | 1486 (51.2) | 561 (48.3) | 2047 (50.4) | 0.8 (0.7–0.9) | 2373 (48.8) | 625 (51.4) | 2998 (49.3) | 1.1 (0.9–1.3) |
| Country of birth | | | | | | | | |
| Native | 2822 (98.1) | 1120 (97.2) | 3942 (97.8) | 1 | 4520 (94.6) | 1057 (90.1) | 5577 (93.7) | 1 |
| Foreign | 56 (1.9) | 32 (2.8) | 88 (2.2) | 1.6 (0.9–2.6) | 259 (5.4) | 116 (9.9)*** | 375 (6.3) | 1.4 (1.1–1.9) |
| Education | | | | | | | | |
| Higher | 770 (32.5) | 246 (25.7) | 1016 (30.5) | 1 | 1027 (24.3) | 206 (19.8) | 1233 (23.4) | 1 |
| Lower | 1601 (67.5) | 711 (74.3)*** | 2312 (69.5) | 1.2 (0.9–1.4) | 3192 (75.7) | 835 (80.2)** | 4027 (76.6) | 1.1 (0.9–1.3) |
| Working status | | | | | | | | |
| Working | 1498 (53.3) | 544 (49.0) | 2042 (52.1) | 1 | 2303 (48.7) | 471 (40.9) | 2774 (47.2) | 1 |
| Not working | 1314 (46.7) | 567 (51.0)* | 1881 (47.9) | 0.9 (0.8–1.1) | 2428 (51.3) | 680 (59.1)*** | 3108 (52.8) | 1.1 (0.9–1.3) |
| Marital status | | | | | | | | |
| Married | 2314 (80.4) | 883 (77.1) | 3197 (79.5) | 1 | 3781 (79.2) | 797 (67.8) | 4578 (76.9) | 1 |
| Single | 565 (19.6) | 262 (22.9)* | 827 (20.5) | 1.1 (0.9–1.4) | 995 (20.8) | 378 (32.2)*** | 1373 (23.1) | 1.5 (1.3–1.8) |
| Social network | | | | | | | | |
| Broad | 1115 (38.8) | 368 (32.3) | 1483 (36.9) | 1 | 1880 (39.8) | 376 (32.5) | 2256 (38.3) | 1 |
| Narrow | 1758 (61.2) | 772 (67.7)*** | 2530 (63.1) | 1.2 (1.0–1.5) | 2849 (60.2) | 782 (67.5)*** | 3631 (61.7) | 1.2 (0.9–1.3) |
| Smoking status | | | | | | | | |
| No | 1243 (43.2) | 412 (35.8) | 1655 (41.1) | 1 | 2136 (44.7) | 370 (31.6) | 2506 (42.1) | 1 |
| Yes | 1637 (56.8) | 738 (64.2)*** | 2375 (58.9) | 1.3 (1.1–1.5) | 2644 (55.3) | 802 (68.4)*** | 3446 (57.9) | 1.6 (1.3–1.8) |
| Perceived health | | | | | | | | |
| Good | 2321 (80.8) | 797 (69.4) | 3118 (77.5) | 1 | 3887 (81.2) | 777 (66.3) | 4664 (78.3) | 1 |
| Bad | 553 (19.2) | 351 (30.6)*** | 904 (22.5) | 1.7 (1.4–2.0) | 901 (18.8) | 395 (33.7)*** | 1296 (21.7) | 1.8 (1.6–2.2) |
| Dental attendance | | | | | | | | |
| Frequent dental attendance | 2448 (85.5) | 856 (75.6) | 3304 (82.7) | 1 | 4120 (86.4) | 903 (78.0) | 5023 (84.8) | 1 |
| Less frequent dental attendance | 415 (14.5) | 276 (24.4)*** | 691 (17.3) | 1.7 (1.4–2.1) | 647 (13.6) | 255 (22.0)*** | 902 (15.2) | 1.5 (1.2–1.8) |

Chi-square test: *P < 0.05, **P < 0.01, ***P < 0.001.

Table 2. Overall, between and within frequency (%) for time-variant social predictors and dental attendance in Norway (*n* = 2947) (based on the complete data)

| | | Overall % (n) | Between[a] % (n) | Within[b] % |
|---|---|---|---|---|
| Working status | Yes | 43.4 (2434) | 59.9 (1755) | 71.8 |
| | No | 56.6 (3172) | 73.9 (2164) | 77.1 |
| | Total | 100 (5606) | 133.8 (3919) | 74.7 |
| Marital status | Married | 78.8 (4579) | 81.5 (2401) | 96.5 |
| | Single | 21.2 (1232) | 24.2 (713) | 88.2 |
| | Total | 100 (5811) | 105.7 (3114) | 94.6 |
| Social network | Narrow | 69.7 (4025) | 82.9 (2439) | 84.1 |
| | Broad | 30.3 (1750) | 43.4 (1278) | 69.7 |
| | Total | 100 (5775) | 126.3 (3717) | 79.2 |
| Smoking status | No | 43.7 (2532) | 44.8 (1320) | 97.1 |
| | Yes | 56.3 (3260) | 57.8 (1702) | 97.7 |
| | Total | 100 (5792) | 102.7 (3022) | 97.4 |
| Perceived health | Good | 81.7 (4745) | 88.7 (2612) | 91.9 |
| | Bad | 18.3 (1065) | 25.6 (753) | 72.2 |
| | Total | 100 (5810) | 114.2 (3365) | 87.6 |
| Dental attendance | Frequent dental attendance | 86.6 (4987) | 90.7 (2656) | 94.9 |
| | Less frequent dental attendance | 13.4 (769) | 18.4 (539) | 75.3 |
| | Total | 100 (5756) | 109.1 (3195) | 91.7 |

[a]Proportion of individuals who were observed at some time in same category.
[b]Proportion of individuals who were observed both times in same category.

Table 3. Overall, between and within frequency (%) for time-variant social predictors and dental attendance in Sweden (*n* = 4862) (based on the complete data)

| | | Overall % (n) | Between[a] % (n) | Within[b] % |
|---|---|---|---|---|
| Working status | Yes | 35.6 (3330) | 53.3 (2576) | 67.2 |
| | No | 64.4 (6013) | 81.6 (3942) | 78.6 |
| | Total | 100 (9343) | 134.9 (6518) | 74.1 |
| Marital status | Married | 77.6 (7305) | 80.0 (3868) | 96.6 |
| | Single | 22.4 (2109) | 25.4 (1226) | 89.4 |
| | Total | 100 (9414) | 105.4 (5094) | 94.9 |
| Social network | Narrow | 67.2 (6290) | 81.1 (3923) | 82.9 |
| | Broad | 32.8 (3065) | 46.5 (2248) | 70.3 |
| | Total | 100 (9355) | 127.6 (6171) | 78.4 |
| Smoking status | No | 45.3 (4330) | 47.0 (2275) | 96.2 |
| | Yes | 54.7 (5224) | 56.5 (2734) | 96.8 |
| | Total | 100 (9554) | 103.5 (5009) | 96.6 |
| Perceived health | Good | 81.2 (7742) | 87.9 (4254) | 92.3 |
| | Bad | 18.8 (1790) | 25.6 (1240) | 73.6 |
| | Total | 100 (9532) | 113.5 (5494) | 88.1 |
| Dental attendance | Frequent dental attendance | 86.8 (8253) | 91.6 (4431) | 94.4 |
| | Less frequent dental attendance | 13.2 (1257) | 18.7 (902) | 72.4 |
| | Total | 100 (9510) | 110.3 (5333) | 90.7 |

[a]Proportion of individuals who were observed at some time in same category.
[b]Proportion of individuals who were observed both times in same category.

having narrow social network, being a smoker and reporting bad perceived health ranged from 72.2% (bad perceived health) to 97.7% (smoking) in Norway and from 73.6% (bad perceived health) to 96.8% (smoking) in Sweden.

Table 4 depicts adjusted OR estimates and 95% confidence intervals (CI) for less frequent dental attendance by social predictors in the Norwegian cohort. Fitting a marginal model with robust variance estimators revealed population-averaged ORs and 95% CI that were identical in direction but considerable smaller in size than the person-specific estimates based on the RIM. Both time-invariant and time-variant covariates were

Table 4. Adjusted ORs and 95% CI of less frequent dental attendance by time-invariant and time-variant social factors across time (2007/2012) in Norway

| | Robust variance estimation[a] | Design effect (D)[b] | Random intercept model (RIM)[c] |
|---|---|---|---|
| Time | 0.6 (0.6–0.7)*** | | 0.4 (0.2–0.5)*** |
| Time invariant | | | |
|   Gender | | | |
|     Male versus female | 1.7 (1.4–2.1)*** | 1.37 | 4.7 (2.6–8.6)*** |
|   Country of birth | | | |
|     Foreign versus native | 2.0 (1.1–3.4)* | 1.39 | 7.9 (1.4–44.5)* |
|   Education | | | |
|     Lower versus higher | 1.7 (1.4–2.1)*** | 1.47 | 6.2 (3.0–12.5)*** |
| Time variant | | | |
|   Working status | | | |
|     Not working versus working | 1.2 (0.9–1.4) | 1.14 | 1.2 (0.7–2.0) |
|   Marital status | | | |
|     Single versus married | 1.7 (1.3–2.1)*** | 1.33 | 3.3 (1.7–6.3)*** |
|   Social network | | | |
|     Narrow versus broad | 1.5 (1.2–1.8)*** | 1.12 | 2.8 (1.6–5.0)*** |
|   Smoking status | | | |
|     Yes versus no | 1.3 (1.1–1.6)** | 1.39 | 3.0 (1.6–5.5)*** |
|   Perceived health | | | |
|   Bad versus good | 1.8 (1.4–2.1)*** | 1.17 | 2.7 (1.4–4.9)** |
| Random part | | | |
|   Random intercept variance (SE) | | | 31.9 (6.0) |
|   Rho (ICC) | | | 0.90 |
|   Log-likelihood | | | −1913.43 |
|   LR test (Chi$^2$; $P$-value) | | | 901.49; $P < 0.001$ |

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. OR = odds ratio; CI = confidence interval; SE = standard error; ICC = intraclass correlation; LR = likelihood ratio (likelihood ratio test of rho = 0 $P < 0.001$ for the null hypothesis that the residual between-cluster variance or the intracluster correlation is 0. A significant test suggests that the multilevel model is appropriate).
[a]Population-averaged estimates adjusted for loss to follow up and missing responses using inverse probability weighting (IPW); robust estimation of variances (sandwich estimators), ordinary logistic regression adjusted for correlated observations.
[b]Design effects were calculated as $(se_{\text{robust variance estimation}}/se_{\text{ordinary logistic regression}})^2$.
[c]Person-specific estimates adjusted for loss to follow up and missing responses using inverse probability weighting (IPW); random intercept model using generalized linear latent and mixed models (gllamm).

statistically significantly associated with less frequent dental attendance across the two estimation methods. Population-averaged ORs based on robust variance estimation varied from 1.3 (95% CI 1.1–1.6) to 2.0 (95% CI 1.1–3.4). The corresponding person-specific ORs based on RIM were 3.0 (95% CI 1.6–5.5) and 7.9 (95% CI 1.4–44.5). Person- or cluster-specific ORs describe the risk for an individual for reporting less frequent dental attendance if, for instance, reporting smoking compared to his/her risk if reporting not smoking. As indicated by the design effects (all larger than 1), standard errors using ordinary logistic regression models would have been underestimated for all time-invariant and time-variant covariates by a factor varying from 12% to 47%. The ICC was 0.90, implying that 90% of the variance was between rather than within individuals after having accounted for all covariates in the models. The likelihood ratio test showed

that ICC was significantly different from zero ($P < 0.001$).

Table 5 depicts adjusted OR estimates and 95% confidence intervals for less frequent dental attendance by social predictors in the Swedish cohort. As shown, the ORs based on robust variance estimation were considerably smaller compared to the person-specific ORs based on RIM. Population-averaged ORs based on robust variance estimation varied from 1.2 (95% CI 1.0–1.5) (lower education) to 1.8 (95% CI 1.6–2.1) (being single). Person-specific ORs varied from 1.6 (95% CI 1.0–2.6) to 4.9 (95% CI 2.4–10.1) regarding, respectively, education and country of birth. As indicated by the design effects, standard errors using ordinary logistic regression models would have been underestimated for all time-invariant and time-variant covariates by a factor varying from 5% to 39%. The ICC was 0.85, indicating that 85% of the variance in less frequent dental attendance explained by the covariates was

Table 5. Adjusted ORs and 95% CI of less frequent dental attendance by time-invariant and time-variant social factors across time (2007/2012) in Sweden

| | Robust variance estimation[a] | Design effect (D)[b] | Random intercept model (RIM)[c] |
|---|---|---|---|
| Time | 0.8 (0.8–0.9)** | | 0.8 (0.6–1.0)* |
| Time invariant | | | |
| Gender | | | |
| Male versus female | 1.3 (1.1–1.5)*** | 1.39 | 2.2 (1.5–3.2)*** |
| Country of birth | | | |
| Foreign versus native | 1.6 (1.2–2.1)*** | 1.38 | 4.9 (2.4–10.1)*** |
| Education | | | |
| Lower versus higher | 1.2 (1.0–1.5)* | 1.39 | 1.6 (1.0–2.6)* |
| Time variant | | | |
| Working status | | | |
| Not working versus working | 1.1 (0.9–1.3) | 1.05 | 1.2 (0.9–1.6) |
| Marital status | | | |
| Single versus married | 1.8 (1.6–2.1)*** | 1.32 | 3.9 (2.6–5.9)*** |
| Social network | | | |
| Narrow versus broad | 1.2 (1.0–1.4)* | 1.14 | 1.4 (1.0–2.0) |
| Smoking status | | | |
| Yes versus no | 1.2 (1.1–1.4)** | 1.09 | 1.6 (1.1–2.3)* |
| Perceived health | | | |
| Bad versus good | 1.7 (1.5–2.0)*** | 1.24 | 3.0 (2.0–4.4)*** |
| Random part | | | |
| Random intercept variance (SE) | | | 19.2 (2.1) |
| Rho (ICC) | | | 0.85 |
| Log-likelihood | | | −3248.97 |
| LR test (Chi²; P-value) | | | 1193.82; $P < 0.001$ |

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. OR = odds ratio; CI = confidence interval; SE = standard error; ICC = Intraclass correlation; LR = likelihood ratio (likelihood ratio test of rho = 0 $P < 0.001$ for the null hypothesis that the residual between-cluster variance or the intracluster correlation is 0. A significant test suggests that the multilevel model is appropriate).
[a]Population-averaged estimates adjusted for loss to follow up and missing responses using inverse probability weighting (IPW); robust estimation of variances (sandwich estimators), ordinary logistic regression adjusted for correlated observations.
[b]Design effects were calculated as $(se_{robust\ variance\ estimation}/se_{ordinary\ logistic\ regression})^2$.
[c]Person-specific estimates adjusted for loss to follow up and missing responses using inverse probability weighting (IPW); random intercept model using generalized linear latent and mixed models (gllamm).

between individual and 15% within individuals. Likelihood ratio test confirmed the alternative hypothesis that ICC was different from 0 and that a multilevel approach is justified and appropriate ($P < 0.001$).

## Discussion

Although statistical models for cluster adjustment are well established in medical research, their application to dental public health has been very limited.[22–24,26,33] This study suggests that the robust variance estimation and random intercept models are appropriate and efficient methods for the analyses of less frequent dental attendance in cohorts of Norwegian and Swedish older people. Using two statistical methods to account for the clustered structure of repeated data, social inequalities were confirmed both at population and at person-specific levels. In accordance with theory and previous research, the population-averaged odds ratios based on marginal models were identical in direction, but of less magnitude, than the analogous person-specific estimates based on RIM.[17,19,21] Neuhaus[34] has shown that when the variance of the random intercept is greater than zero, as was the case in this study, the regression coefficients based on RIM are larger than those based on marginal models. For some social predictors, such as country of birth, the differences in log odds were substantial in both countries. In longitudinal studies, responses over time for the same individual are correlated, implying greater between-individual variation and smaller within-individual variation. Due to large study groups and small cluster size (an average of 2 observations per cluster) and also due to the fact that many covariates were adjusted simultaneously, the design effects observed in both cohorts were

moderate in size. Nevertheless, all design effects were above 1, suggesting that ordinary logistic regression would not be an efficient method as it wrongly assumes independent data. Overall, the observed design effects suggest that ignoring the clustered structure of the repeated data would have resulted in some underestimation of standard errors and thus an overestimation of the precision of the regression coefficients.

Since the regression coefficients based on the population-averaged marginal model and person-specific RIM differed in magnitude and precision, the difference in the interpretation of those estimators should be acknowledged.[16] In marginal models, the parameter is defined as the difference in less frequent dental attendance among population groups with opposite characteristics, for instance males and females and smokers and nonsmokers. Population-averaged estimation may be of interest from a public health perspective by describing how groups of individuals, for instance, with different smoking status vary in their probability of less frequent dental attendance over time. A RIM estimates the change in risk that occurs within a person according to the change in the risk exposure. This person-specific approach may be of greater clinical relevance, for instance, if a dentist wants to explain to a patient his or her probability of dental attendance in the presence of changing personal smoking status. Whether to choose a marginal or person-specific approach depends on the scientific question of interest, the nature of data and the type of covariates utilized.[16,20] From a practical point of view, mixed and random effects models (multilevel models) are computationally intensive. Thus, marginal models might have an advantage over mixed effect models in epidemiologic studies.

A principle finding of this study was a drop in the low prevalence of less frequent dental attendance by increasing age among participants exposed to different public insurance and social security systems both aiming to reduce inequalities in the access and utilization of dental care.[2,9–11] Declining prevalence estimates of unfavourable dental attendance patterns were somehow unexpected because costs of dental care, reduced mobility and physical and mental handicaps may adversely influence the frequency of health and dental health care sought by older people.[9,35] According to previous findings in the Nordic countries, the majority of adults visit a dentist on a regular 12-month basis, whereas younger people attend less often. This may reflect generational differences in preferences and needs related to health and oral health.[9,10,36]

The social predictors identified coincide with Andersen's behavioural model featuring predisposing (country of birth, education, marital status, smoking, working status), enabling (social network) and need (perceived health status)-related variables in the explanation of healthcare service utilization.[37] In particular, lower education, foreign country of birth, single marital status, reporting bad perceived health and being a smoker increased the likelihood of less frequent dental attendance over time. This indicates limited access to dental care for socially disadvantaged groups, both at population and at the person-specific level. The social disparities observed in the present study confirm the findings from previous studies[1,2,4–14] and should cause concerns as the oral health situation of socially disadvantaged groups of older people is poorer than that of their more advantaged counterparts.[1,2,38] A recent study comparing social inequalities in oral health did not support the assumptions that inequalities in the Nordic countries with generous welfare provisions are smaller than those in other European welfare state regimens.[39] Although most research on social relationships and health behaviours has been conducted in children, studies considering adults have shown that social networks influence dental care utilization irrespective of social deprivation in general.[40] More recent evidence suggests that inequalities in dental attendance tend to establish in childhood and persist throughout the life course, making later life social disparities less responsive to contemporaneous oral health interventions.[8] In this study, early life course social indicators such as country of birth and education appeared to have enduring influence on less frequent dental attendance. This suggests that social inequalities among older people may be tracked back into young adult and early childhood.

This study confirms current research through its novel use of statistical methods. Although the extent to which ordinary logistic regression incorrectly estimated the precision of covariate effects was not large, using the methods that account for independency in clustered data has been recommended.[16,19] In this study, the use of population-averaged and person-specific approaches to account for clustering allowed the interpretation of the effect of the social predictors at the population as well as at the person-specific level. Also, large

study groups followed across 5 years provide a level of robustness to the present findings. However, a number of limitations of the longitudinal design utilized need to be highlighted. Although IPW was used to account for selection bias due to the differential retention observed, by restoring the representation of individuals lost to follow up, selective mortality could challenge the present findings. For instance, smokers are known to have higher mortality rates and may be underrepresented leading to a biased association with less frequent dental attendance. Biased results occur, however, only in the presence of differential survival or if attrition of smokers differs between less frequent and frequent dental attenders. Because the present study group was restricted to adults aged 65 and above living in the community settings, the extent to which the findings can be generalized to other populations is unknown and warrants further investigation. As with other epidemiological studies, there is concern regarding residual confounding due to measurement error and incomplete characterization of variables in the models. A substantial proportion of the variance in less frequent dental attendance remained unexplained, implying that future research should incorporate a broader range of social variables.

In conclusion, the prevalence of less frequent dental attendance was low and dropped by increasing age from 65 to 70 years in Norway and Sweden. Using approaches to account for independence in the repeated data revealed design effects greater than 1, justifying multilevel analyses of the present data. Being advantaged on social aspects protects against less frequent dental attendance over time at the population as well as at the person-specific level.

## Acknowledgements

## Conflict of interest

None to declare.

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# Appendix I

**I**

# TANNHELSEVANER

# OG

# LIVSKVALITET HOS 65-ÅRINGER

Skjemaet inneholder spørsmål om munn- og tannhelsevaner, samt livskvalitet. Din deltagelse er frivillig og besvarelsen behandles konfidensielt.

Hensikten med undersøkelsen er å studere den eldre befolkningens tannhelse og tannhelserelaterte forhold slik at dette blir kartlagt og planlegging av tilbud kan baseres på dette grunnlag.

Vi ber deg svare på **alle** spørsmål så fullstendig som mulig og returnere besvarelsene i medsendt konvolutt senest innen to uker.

**Takk for ditt bidrag!**

Institutt for klinisk odontologi, Det medisinsk – odontologiske fakultet, Universitetet i Bergen

**Bruk helst kulepenn eller tusj når du fyller ut spørreskjemaet.**

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### *Først noen spørsmål om din sosiale situasjon*

---

**1.    Kjønn**          ☐    Mann
                         ☐    Kvinne

**2.    Fødeland**       ☐    Norge
                         ☐    Annet nordisk land
                         ☐    Annet land, hvilke?
                              _____
                         ☐    Vet ikke

**3.    Bosted**         ☐    Stor by (100.000 eller mer)
                         ☐    Mindre by
                         ☐    Landkommune

**4.    Hvor mange personer som du kjenner, treffer du eller prater du med i løpet av en vanlig uke?** (Regn ikke med personer som du treffer tilfeldig, og som du neppe vil se igjen, f. eks. kunder i en forretning)

                         ☐    Ingen
                         ☐    1 - 2
                         ☐    3 - 5
                         ☐    6 - 10
                         ☐    11 - 15
                         ☐    Mer enn 15

**5.a.  Yrke** (eller tidligere yrke. Oppgi så nøyaktig som mulig, ikke bare yrkestittel)
_____

**b.    Arbeider du hovedsakelig som selvstendig næringsdrivende?**
                         ☐    Ja
                         ☐    Nei

**6.    Hvor mange timer arbeider du i gjennomsnitt per uke?**
                         ☐    Heltid (mer enn 35 timer/uke)
                         ☐    Deltid (mellom 15 og 34 timer/uke)
                         ☐    Mellom 1 – 14 timer
                         ☐    Ikke i arbeid

**7.    Har du skiftarbeid?**   ☐   Ja

☐   Nei

**8.    Hvilken utdanning har du?**

☐   Folkeskole/grunnskole

☐   Realskole, folkehøyskole …

☐   Videregående/artium

☐   Høyskole/universitet

☐   Annet (hvilke?)

_____

**9.    Hva er din sivile status for øyeblikket?**

☐   Gift/samboer

☐   Ugift

☐   Skilt

☐   Enke/enkemann

---

*Her følger noen spørsmål om din generelle helse*

---

**10.    Anser du deg for å være helt frisk?**

☐   Ja – absolutt

☐   Ja – stort sett

☐   Nei – ikke spesielt

☐   Nei – absolutt ikke

☐   Vet ikke

**11.    Anser du din allmenne helse for bedre eller dårligere sammenlignet med dine jevnaldrende?**

☐   Ja - mye bedre

☐   Ja - stort sett bedre

☐   Omtrent like bra

☐   Nei – stort sett dårligere

☐   Nei – mye dårligere

☐   Vet ikke

3

**12.** **Har du tatt medisiner de siste 14 dagene?**

    ☐ Ja

    ☐ Nei

    ☐ Husker ikke

**13.** **Har du vært sykemeldt de siste tre månedene?**

    ☐ Ja, til sammen mer enn en uke

    ☐ Ja, en eller flere dager

    ☐ Ja, en dag

    ☐ Nei

    ☐ Husker ikke

**14.** **Har du vært i kontakt med lege de siste tre månedene?**

    ☐ Ja – flere ganger

    ☐ Ja – noen ganger

    ☐ Ja – en gang

    ☐ Nei

    ☐ Husker ikke

**15a.** **Hvor høy er du? Skriv høyden din i <u>centimeter</u> i rutene** ☐☐☐cm

**15b.** **Hvor mye veier du? Skriv din vekt i <u>kilo</u>** _____ kg

**16.** **Hva er dine røykevaner?**

    ☐ Røker daglig

    ☐ Røker av og til

    ☐ Har røkt, men har sluttet

    ☐ Har aldri røkt

**17.** **Hva er dine snusvaner?**

    ☐ Snuser daglig

    ☐ Snuser av og til

    ☐ Har snuset, men har sluttet

    ☐ Har aldri snuset

**18.** **Hvor ofte drikker du sterkøl, vin eller sprit?**

☐ Mer enn et par ganger i uken

☐ Omtrent et par ganger i uken

☐ Omtrent en gang i uken

☐ Omtrent et par ganger i måneden

☐ Aldri

---

### *Her følger noen spørsmål om din munn og dine tenner*

---

**19.** **Tror du at du kan beholde tennene dine livet ut?**

☐ Ja, helt sikkert

☐ Ja, kanskje

☐ Vet ikke

☐ Nei, lite sannsynlig

☐ Nei, absolutt ikke

**20.** **Er du generelt fornøyd med tennene dine?**

☐ Ja, veldig fornøyd

☐ Ja, stort sett fornøyd

☐ Nei, ikke særlig fornøyd

☐ Nei, absolutt ikke fornøyd

**21.** **Kan du tygge all slags mat?**

☐ Meget bra

☐ Ganske bra

☐ Mindre bra

☐ Dårlig

**22.** **Er du generelt fornøyd med <u>utseende</u> til tennene dine?**

☐ Ja, veldig fornøyd

☐ Ja, stort sett fornøyd

☐ Nei, ikke særlig fornøyd

☐ Nei, absolutt ikke fornøyd

**23. Føler du deg tørr i munnen?**

*På dagtid:*
- ☐ Ja, ofte
- ☐ Ja, av og til
- ☐ Nei, sjelden
- ☐ Nei, aldri

*Om natten:*
- ☐ Ja, ofte
- ☐ Ja, av og til
- ☐ Nei, sjelden
- ☐ Nei, aldri

**24. Når hadde du tannverk sist?**
- ☐ I løpet av de siste 3 månedene
- ☐ I løpet av det siste året
- ☐ Mer enn ett år siden
- ☐ Har aldri hatt tannverk
- ☐ Husker ikke

**25. Hvilke av følgende tannpleiemidler bruker du?**
**Oppgi hvor ofte du bruker <u>hver</u> type.**

| | | Sjelden/ aldri | En gang i <u>uken</u> | En gang om <u>dagen</u> | To ganger om <u>dagen</u> | Mer enn to ganger om <u>dagen</u> |
|---|---|---|---|---|---|---|
| **a)** | Tannbørste | ☐ | ☐ | ☐ | ☐ | ☐ |
| **b)** | Tannkrem <u>med</u> fluor | ☐ | ☐ | ☐ | ☐ | ☐ |
| **c)** | Tannstikker | ☐ | ☐ | ☐ | ☐ | ☐ |
| **d)** | Tanntråd | ☐ | ☐ | ☐ | ☐ | ☐ |
| **e)** | Fluortabletter | ☐ | ☐ | ☐ | ☐ | ☐ |
| **f)** | Fluorskylling | ☐ | ☐ | ☐ | ☐ | ☐ |
| **g)** | Annet | ☐ | ☐ | ☐ | ☐ | ☐ |

Oppgi hva
_____

**26. Hvor mange av dine naturlige egne tenner (unntatt melketenner) har du?**
- ☐ Alle (28-32 tenner)
- ☐ Mangler noen få tenner
- ☐ Mangler ganske mange tenner
- ☐ Har nesten ikke tenner igjen
- ☐ Er helt tannløs

**27. Har du trukket noen tenner de siste 12 månedene?**

☐ Nei

☐ Ja → ☐ Et par tenner
☐ Noen flere tenner
☐ Mange tenner

**28. Man kan ha mange forskjellige plager med munn og tenner. Har du hatt en eller flere av nedenstående plager, problem eller bekymringer? Tenk etter og besvar <u>alle</u> eksemplene.**

| | | Ingen plager | Noen plager | Ganske mange plager | Store plager |
|---|---|---|---|---|---|
| **a)** | Tennenes farge | ☐ | ☐ | ☐ | ☐ |
| **b)** | Tennenes form | ☐ | ☐ | ☐ | ☐ |
| **c)** | Skjeve tenner | ☐ | ☐ | ☐ | ☐ |
| **d)** | Over- eller underbitt | ☐ | ☐ | ☐ | ☐ |
| **e)** | Mellomrom mellom tennene | ☐ | ☐ | ☐ | ☐ |
| **f)** | For trangt mellom tennene | ☐ | ☐ | ☐ | ☐ |
| **g)** | Svie i munnen | ☐ | ☐ | ☐ | ☐ |
| **h)** | Sår eller blemmer i munnen | ☐ | ☐ | ☐ | ☐ |
| **i)** | Smaksforandringer | ☐ | ☐ | ☐ | ☐ |
| **j)** | Smerter i kjeveleddene | ☐ | ☐ | ☐ | ☐ |
| **k)** | Knepping eller knase-lyder fra kjeveleddene | ☐ | ☐ | ☐ | ☐ |
| **l)** | Vanskelig for å gape høyt | ☐ | ☐ | ☐ | ☐ |
| **m)** | Skjære tenner/pressing | ☐ | ☐ | ☐ | ☐ |
| **n)** | Blødning fra tannkjøttet | ☐ | ☐ | ☐ | ☐ |
| **o)** | Dårlig ånde | ☐ | ☐ | ☐ | ☐ |
| **p)** | Problem fra tannfyllingsmaterialer | ☐ | ☐ | ☐ | ☐ |
| **q)** | Ising i tennene | ☐ | ☐ | ☐ | ☐ |

**Man kan ha ulike holdninger til sine tenner.**

**Her følger noen påstander og synspunkter som kan forekomme.**

**Vi ber deg oppgi om du er enig eller uenig i disse påstandene.**

| | | Helt enig | Enig | Uenig | Sterkt uenig |
|---|---|:---:|:---:|:---:|:---:|
| **29.** | "Å ha pene og perfekte tenner er svært viktig for hvordan folk oppfatter deg" | ☐ | ☐ | ☐ | ☐ |
| **30.** | "Mindre skjønnhetsfeil på tennene har ingen betydning, bare de fungerer" | ☐ | ☐ | ☐ | ☐ |
| **31.** | "En tannluke/manglende tann som viser bør man skjemmes over" | ☐ | ☐ | ☐ | ☐ |
| **32.** | "Det spiller ingen rolle hvordan man ser ut i munnen, bare man kan tygge maten man liker" | ☐ | ☐ | ☐ | ☐ |

**Her følger så noen spørsmål om din tannpleie**

**33. Hvor har du <u>hovedsakelig</u> fått tannbehandling de siste 5 årene?**

☐ Privat praksis

☐ Den offentlige tannhelsetjenesten

☐ Har ikke fått behandling

☐ Annet

_____

**34. Omtrent <u>hvor ofte</u> går du til tannbehandling?**

☐ To eller flere ganger i året

☐ En gang i året

☐ Annethvert år

☐ Sjeldnere enn annethvert år

**35. Har du det siste året vært nødt til å avstå fra tannlegebesøk fordi du ikke hadde råd til det?**

☐ Ja – flere ganger

☐ Ja – en enkelt gang

☐ Nei

**36.** **Har du det siste året vært nødt til å avstå fra behandling som tannlegen foreslo fordi du ikke hadde råd?**

☐ Ja

☐ Nei

**37.** **Har du endret dine besøksvaner (hos tannlegen) i senere år?**

☐ Ja, jeg går oftere

☐ Ja, jeg går sjeldnere

☐ Nei

☐ Vet ikke

**38.** **Anslagsvis hvor mye betalte du for tannpleie det siste året?**

☐ Ingenting

☐ 1 – 1000 kr

☐ 1001 – 2000 kr

☐ 2001 – 8 000 kr

☐ Mer enn 8 000 kr

☐ Husker ikke

**39.** **Er du behandlet av spesialist (-tannlege)?**

☐ I løpet av det siste året

☐ I løpet av de siste 5 årene

☐ For mer enn 5 år siden

☐ Aldri

☐ Vet ikke

**40.** **Har du vært til tannpleier <u>det siste året</u>?**

☐ Ja

☐ Nei

☐ Vet ikke

**41.** **Man kan ha mange foreskjellige materialer i fyllinger og tannerstatninger. Hvordan er det med dine tenner? Oppgi <u>alle</u> alternativene som gjelder ditt tilfelle med ett kryss!**

**Har du:**
☐ "Hvite" fyllinger
☐ Gull
☐ Amalgam
☐ Porselen
☐ Implantat
☐ Midlertidige fyllinger
☐ Avtakbar delprotese
☐ Helprotese i en kjeve
☐ Helprotese i begge kjever
☐ Annet, hvilke?_____

**42.** **Har du i løpet av det siste året spurt tannhelsepersonell om bivirkninger av materialer som brukes i fyllinger og tannerstatninger?**

☐ Ja
☐ Nei
☐ Vet ikke

**43.** **Har du fått skiftet ut fyllinger eller kroner fordi du følte at de ga deg problemer?**

☐ Ja, alle jeg har
☐ Ja, en del
☐ Ja, enkelte
☐ Nei

**44.** **Er du fornøyd eller misfornøyd med tannbehandlingen du tidligere har fått?**

☐ Svært fornøyd
☐ Fornøyd
☐ Misfornøyd
☐ Svært misfornøyd

**45.** **Har det stort sett <u>vært mulig</u> for deg å gå til den tannlegen du ønsket å gå til behandling hos?**

☐ Ja, alltid
☐ Ja, for det meste
☐ Bare nå og da
☐ Nei, sjelden
☐ Nei, aldri

**46.** Synes du det er viktig å kunne gå til <u>samme</u> tannlege/tannpleier hver gang?

☐ Ja, svært viktig

☐ Ja, viktig

☐ Nei, ikke spesielt viktig

☐ Nei, ikke viktig i det hele tatt

**47.** Går du regelmessig til din nåværende tannlege?

☐ Ja

☐ Nei

**48.** Har du noen gang i <u>løpet av de siste 5 årene</u> ønsket å bytte tannlege fordi du var misfornøyd?

☐ Ja, flere ganger

☐ Ja, enkelte ganger

☐ Nei

☐ Husker ikke

**49.** Har du noen gang <u>i løpet av de siste 5 årene</u> byttet tannlege fordi du var misfornøyd?

☐ Ja, flere ganger

☐ Ja, enkelte ganger

☐ Nei

☐ Husker ikke

**50.** Har du hatt noen virkelig <u>ubehagelig</u> eller <u>skremmende</u> opplevelse under tannbehandling som barn eller ungdom (opp til ca. 20 års alder)?

☐ Ja, flere ganger

☐ Ja, enkelte ganger

☐ Nei

☐ Husker ikke

---

*Har kommer noen spørsmål om ditt <u>siste</u> tannlegebesøk.*
*Svarene dine skal altså <u>bare</u> gjelde det besøket*

---

**51.** Var ditt <u>siste</u> tannlegebesøk hos

☐ Den offentlige tannhelsetjenesten

☐ Privat praksis

☐ Annet _____

☐ Husker ikke

**52. Når var ditt <u>siste</u> besøk?**

☐ For mindre enn 1 år siden
☐ For 1 – 3 år siden
☐ For 3 – 5 år siden
☐ For mer enn 5 år siden

**53. Hvem tok initiativet til ditt <u>siste</u> besøk?**

☐ Du selv eller pårørende, f.eks. akuttbesøk, nytt besøk
☐ Tannlegen, f.eks. innkalling, gjenbesøk
☐ Husker ikke

**54. Vi vil gjerne vite hvordan du opplevde det <u>siste</u> tannlegebesøket ditt. Sett ett kryss i den ruten som beskriver hva du opplevde under besøket.**

| | | | | | |
|---|---|---|---|---|---|
| **a)** | Smertefritt | ☐ ☐ ☐ ☐ | Utholdelig smerte |
| **b)** | Intet ubehag | ☐ ☐ ☐ ☐ | Sterkt ubehag |
| **c)** | Helt rolig | ☐ ☐ ☐ ☐ | Sterk uro (angst) |
| **d)** | Bra omsorg | ☐ ☐ ☐ ☐ | Dårlig omsorg |

**55. Anslagsvis hvor lang tid tok ditt siste besøk?**

Reisen til og fra |_____| minutter (skriv antall minutter)

Ventetid |_____| minutter (skriv antall minutter)

Selve behandlingen |_____| minutter (skriv antall minutter)

**56. Fikk du <u>informasjon</u> om en eller flere av følgende tema under det siste besøket?**

| | | Ja | Nei | Husker ikke |
|---|---|---|---|---|
| **a)** | Munnhygiene | ☐ | ☐ | ☐ |
| **b)** | Kosthold | ☐ | ☐ | ☐ |
| **c)** | Fluorbruk | ☐ | ☐ | ☐ |
| **d)** | Tobakk/røyking | ☐ | ☐ | ☐ |
| **e)** | Hva behandlingen ville koste | ☐ | ☐ | ☐ |

**57. Gir du tillatelse til å komme tilbake med eventuelle oppfølgingsspørsmål?**

☐ Ja
☐ Nei

## *Til slutt noen spørsmål om hvordan du oppfatter din tannhelse*

**E1** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løs tenner eller tannprotese gjort det vanskelig for deg å spise og nyte maten?**

    ☐ Hver dag eller nesten hver dag

    ☐ En til to ganger i uken

    ☐ En til to ganger i måneden

    ☐ Sjeldnere enn en gang i måneden

    ☐ Aldri

**E2** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løstenner eller tannprotese gjort det vanskelig for deg å snakke og utrykke deg tydelig?**

    ☐ Hver dag eller nesten hver dag

    ☐ En til to ganger i uken

    ☐ En til to ganger i måneden

    ☐ Sjeldnere enn en gang i måneden

    ☐ Aldri

**E3** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løstenner eller tannprotese gjort tannrengjøring vanskelig?**

    ☐ Hver dag eller nesten hver dag

    ☐ En til to ganger i uken

    ☐ En til to ganger i måneden

    ☐ Sjeldnere enn en gang i måneden

    ☐ Aldri

**E4** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løstenner eller tannprotese gjort det vanskelig for deg å sove og slappe av?**

    ☐ Hver dag eller nesten hver dag

    ☐ En til to ganger i uken

    ☐ En til to ganger i måneden

    ☐ Sjeldnere enn en gang i måneden

    ☐ Aldri

**E5** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løstenner eller tannprotese gjort det vanskelig for deg å smile og vis tenner uten å bli brydd?**

☐ Hver dag eller nesten hver dag

☐ En til to ganger i uken

☐ En til to ganger i måneden

☐ Sjeldnere enn en gang i måneden

☐ Aldri

**E6** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løstenner eller tannprotese gjort det vanskelig for deg å være følelsesmessig stabil uten å bli irritabel?**

☐ Hver dag eller nesten hver dag

☐ En til to ganger i uken

☐ En til to ganger i måneden

☐ Sjeldnere enn en gang i måneden

☐ Aldri

**E7** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løstenner eller tannprotese gjort det vanskelig for deg å glede deg over samvær med andre mennesker?**

☐ Hver dag eller nesten hver dag

☐ En til to ganger i uken

☐ En til to ganger i måneden

☐ Sjeldnere enn en gang i måneden

☐ Aldri

**E8** **I løpet av de siste 6 månedene, hvor ofte har ulike plager med tennene, eventuelt gebiss, løstenner eller tannprotese gjort det vanskelig for deg å utføre daglige gjøremål?**

☐ Hver dag eller nesten hver dag

☐ En til to ganger i uken

☐ En til to ganger i måneden

☐ Sjeldnere enn en gang i måneden

☐ Aldri

**Andre kommentarer?**

_____

_____

_____

_____

_____

_____

_____

*Takk for hjelpen!*

# Appendix II

**II**

**EPN**
REGIONALA ETIKPRÖVNINGSNÄMNDEN · UPPSALA

BESLUT
2011-10-12                    Dnr 2011/336

**SÖKANDE FORSKNINGSHUVUDMAN**
Örebro läns landsting
Box 1613
701 16 Örebro

**Övrig deltagande forskningshuvudman**
Landstinget i Östergötland

**Forskare som genomför projektet:**
Gunnar Ekbäck
Eklundavägen 11
701 16 Örebro

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## UPPGIFTER OM FORSKNINGSPROJEKTET ENLIGT ANSÖKAN INKOMMEN TILL NÄMNDEN 2011-09-19

**Projektbeskrivning:**
Enkätundersökning av 50-åringars (urvalsundersökning), samt alla 70- och 80-åringars upplevda tand- och munhälsa i Örebro och Östergötlands län 2012

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Regionala etikprövningsnämnden i Uppsala meddelar följande

**BESLUT**

Nämnden bifaller ansökningen och godkänner med stöd av 6 § lagen (2003:460) om etikprövning av forskning som avser människor den forskning som anges i ansökan med följande villkor:

I informationsbreven ska:

1. Det utöver nu angivna kontaktuppgifter till ansvariga forskare även anges att forskningshuvudmän för studierna är Landstingen i Örebro och Östergötland;

2. Påståenden om att numrering av enkäter är till endast för att förhindra onödiga påminnelser och andra utsagor som kan ge sken av att det inte finns någon koppling mellan person och svar ersättas av den standardiserade formuleringen "Ingen obehörig kommer att få veta hur just Du svarat".

| Adress | Telefon | Fax | E-post |
|--------|---------|-----|--------|
| Box 1964 | 018-4717400 | 018-4717410 | registrator@uppsala.epn.se |
| 751 49 Uppsala | | | |

2011-10-12          **Dnr 2011/336**

**Erinran**

Godkännandet upphör att gälla om forskningen inte har påbörjats inom två år efter slutgiltigt beslut.

## BESLUTET FÅR ÖVERKLAGAS
Se bifogad anvisning.

___

På nämndens vägnar

Kristina Boutz
Ordförande

**Ledamöter med vetenskaplig kompetens**
Bo Lewin sociologi (vetenskaplig sekreterare), Ulla Berglund landskapsarkitektur, Gunilla Bohlin utvecklingspsykologi, Henry Cöster teologi, Marie Louise Hall-Lord vårdvetenskap, Staffan Hygge miljöpsykologi, Ulf P Lundgren pedagogik, Birgitta Meurling etnologi, Greta Ågren etologi (föredragande)
**Ledamöter som företräder allmänna intressen**
Maria Patel, Ebba Sverne Arvill

**Exp. till:**
Forskare: Gunnar Ekbäck
Forskningshuvudmannens företrädare: Gunnar Ekbäck, Box 1613, 701 16 Örebro

# Appendix III

III

ARKIV/PVO
2 (1)

(NSD)

Kristin S. Klock
Fagområdet samfunnsodontologi
Odontologisk institutt
Universitetet i Bergen
Årstadveien 17
5019 BERGEN

Vår dato: 07.11.2006          Vår ref: 15386/KS          Deres dato:          Deres ref:

## TILRÅDING AV BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 19.09.2006. All nødvendig informasjon om prosjektet forelå i sin helhet 06.11.2006. Meldingen gjelder prosjektet:

| | |
|---|---|
| *15386* | *En longitudinell 5-årsstudie av tannhelse, tannhelsevaner, samt holdninger til tenner og tannhelsetjenesten blant 65-åringer i Hordaland, Sogn og Fjordane og Nordland* |
| *Behandlingsansvarlig* | *Universitetet i Bergen, ved institusjonens øverste leder* |
| *Daglig ansvarlig* | *Kristin S. Klock* |

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.
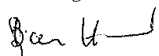
Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven/-helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/endringsskjema. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://www.nsd.uib.no/personvern/database/

Personvernombudet vil ved prosjektets avslutning, 31.12.2017 rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Bjørn Henrichsen                    Katrine Utaaker Segadal

Kontaktperson: Katrine Utaaker Segadal tlf: 55 58 35 42

Vedlegg: Prosjektvurdering

## Prosjektvurdering - Kommentar

15386

Det vil i prosjektet registreres sensitive opplysninger om helseforhold, jf. personopplysningsloven § 2 nr. 8 c).

Prosjektslutt er angitt til 31.12.12. Etter prosjektslutt vil datamaterialet lagres i avidentifisert form ved Det odontologiske fakultet ved Universitet i Bergen for eventuelle oppfølgningsstudier innen utgangen av 2017. Ombudet har registrert 31.12.17 som endelig dato for anonymisering. Senest innen denne dato vil det ikke lenger foreligge verken direkte eller indirekte personidentifiserende opplysninger i datamaterialet. Koblingsnøkkelen slettes. Indirekte personidentifiserende opplysninger slettes eller kategoriseres i vide kategorier.

Ombudet har mottatt revidert skriv (06.11.06) og finner dette tilfredstillende, men anbefaler at man spesifiserer at man ikke lenger kan trekke opplysninger om seg selv etter at data er anonymisert (dvs. etter 2017). Det anbefales at man opplyser om hvorvidt samarbeidspartnere i for eksempel Sverige vil få tilgang til indirekte personidentifiserende data.

Ombudet forutsetter at Regional komité for medisinsk forskningsetikk tilrår prosjektet dersom det er fremleggelsespliktig.

# Appendix IV

**IV**

| Region: | Saksbehandler: | Telefon: | Vår dato: | Vår referanse: |
|---|---|---|---|---|
| REK sør-øst | Gjøril Bergva | 22845529 | 01.06.2012 | 2012/782/REK sør-øst D |
| | | | **Deres dato:** | **Deres referanse:** |
| | | | 24.04.2012 | |

Vår referanse må oppgis ved alle henvendelser

Til Anne Nordrehaug Åstrøm

**2012/782 Tannhelse, tannhelsevaner og livskvalitet hos eldre voksne i Norge**

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 10.05.2012. Vurderingen er gjort med hjemmel i helseforskningsloven § 10, jf. forskningsetikklovens § 4.

**Prosjektleder:** Anne Nordrehaug Åstrøm
**Forskningsansvarlig:** Universitetet i Bergen

### Prosjektomtale
*Prosjektet er en del av en pågående 5-års longitudinell kohortstudie i Norge og Sverige, "The 65 year study in Norway and Sweden". Formålet er å studere utvikling av tannhelse og tannhelserelaterte forhold i den eldre voksne befolkningen. Den norske kohorten ble etablert i 2007, og den omsøkte studien er en oppfølging av denne kohorten. Mer spesifikt vil man studere betydningen av sosiodemografiske faktorer på tannhelse og tannhelserelaterte forhold, studere utvikling over en 5- års periode fra 2007 til 2012 og sammenligne resultater med parallellstudien utført i Sverige.*

*Det skal inkluderes ca 7000 personer. Opplysninger om tannhelse, tannhelsevaner, holdninger til tannhelsen og bruk av tannhelsetjenester samles inn ved hjelp av spørreskjema. Spørreskjema sendes til alle innbyggerne født i 1942 og med kjent adresse i Hordaland, Sogn og Fjordane og Nordland. Informasjon om bostedsadresser hentes fra Folkeregisteret, og SSB foretar utsendelse, purring og datainnlegging. Data avidentifiseres av SSB, som også oppbevarer koblingsnøkkelen.*

### Vurdering
Komiteen har vurdert prosjektsøknaden, og har ingen innvendinger mot at prosjektet gjennomføres.

Komiteen forutsetter at det kun skal inkluderes samtykkekompetente personer i prosjektet, og ber om at stedfortredende samtykke fjernes fra samtykkeerklæringen.

### Vedtak
Med hjemmel i helseforskningsloven godkjennes prosjektet gjennomført i henhold til søknad og protokoll.

Tillatelsen gjelder til 31.12. 2017. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsfilen skal lagres avidentifisert, det vil si adskilt i en nøkkel- og en opplysningsfil.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder for «Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse og omsorgssektoren».

**Besøksadresse:**
Gullhaug torg 4A, Nydalen, 0484 Oslo

**Telefon:** 22845511
**E-post:** post@helseforskning.etikkom.no
**Web:** http://helseforskning.etikkom.no/

All post og e-post som inngår i saksbehandlingen, bes adressert til REK sør-øst og ikke til enkelte personer

Kindly address all mail and e-mails to the Regional Ethics Committee, REK sør-øst, not to individual staff

Dersom det skal gjøres vesentlige endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK.

Prosjektet skal sende sluttmelding på eget skjema, senest et halvt år etter prosjektslutt.

Komiteens vedtak kan påklages til Den nasjonale forskningsetiske komité for medisin og helsefag, jfr. Helseforskningsloven § 10, 3 ledd og forvaltningsloven § 28. En eventuell klage sendes til REK sør-øst D. Klagefristen er tre uker fra mottak av dette brevet.

Vi ber om at alle henvendelser sendes inn via vår saksportal: http://helseforskning.etikkom.no eller på e-post til: post@helseforskning.etikkom.no.

Vennligst oppgi vårt referansenummer i korrespondansen.


Med vennlig hilsen

Stein A. Evensen
Professor dr. med.
leder

<div align="right">

Gjøril Bergva
Rådgiver

</div>

**Kopi til:** anne.nordrehaug@cih.uib.no; post@uib.no