Cariological and Salivary Studies in 70-Year-Old Cohorts

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Abstract

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Life expectancy after 65 years of age has increased markedly during the last decades, and is still increasing. The purpose of this thesis was to describe differences in dental health between 70-year-olds born in different years, to describe caries prevalence, incidence over a 6-year period in one cohort, and try to find risk factors for dental caries. Furthermore, the aim was to study possible effect of aging or drug treatment on salivary secretion rate, but also the utilization of dental care in all cohorts. Five 70-year-old cohorts have been studied cross-sectional and longitudinal between 1971 and 2001, within the gerontological and geriatric population study in Gothenburg, named H70. From these cohorts, subsamples (n=801) or all (n=1489) individuals were odontologically examined. The proportion of dentate subjects changed gradually from 49% in cohort I to 93% in cohort VI. Mean number of remaining teeth in the dentate also increased from 13.6, in 1971 to 20.9, in year 2001. However, factors as for example, a low education, being un-married and physically inactive were negatively related to number of teeth. In cohort III, mean number of decayed surfaces was 2.1 compared to 1.3 in cohort VI, born and examined, 20 years later. The prevalence of caries decreased between the ages of 70 and 76, in cohort III. About 60% of the individuals developed new primary caries lesions and around 50% got root surface caries. There was also an increase in number of filled tooth surfaces. A significant decrease was seen in visible plaque index, in both women and men, between 70 years and 76 years. Gingivitis and pocket depth over 4 mm correlated with decayed and missing surfaces, while the visible plaque index correlated to only missing surfaces. Men had a significant higher stimulated salivary secretion rate than women in all cohorts and at all ages. There were, however, no significant differences in unstimulated salivary secretion rate, either between women or men, or between cohorts. The individuals with drug treatment increased during these 30 years from 57 to 67%. An increase in the number of drugs was also seen. In year 1971, 10% took 4 or more different drugs, which increased to 20% in year 2001. Yearly visit to a dentist increased during the study period, most among those with less number of teeth. Conclusively this thesis showed a positive cohort trend in dental health status. The prevalence and the incidence of dental caries were moderate. No decrease in salivary secretion rate with increasing age was seen. However, with an increase in number of drugs, the salivary secretion rate decreased.

Key-words: cohort differences, cross-sectional, dental health, elderly, epidemiology, lifestyle, longitudinal, medication, population study, saliva, socioeconomic

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Contents

Original papers …… 7

Introduction …… 9

Aims …… 15

Material and methods …….. 17

Results …… 21

Discussion …… 31

Conclusions …… 41

Acknowledgements ……. 43

References …… 45

Paper I – IV

Original Papers

I. Österberg T, Birkhed D, Johanson CN, Svanborg A. Longitudinal study of stimulated whole saliva in an elderly population. Scand J Dent Res 1992;100:340-345.

II. Österberg T, Johanson CN, Sundh V, Steen B, Birkhed D. Secular trends of dental status in five 70-year-old cohorts between 1971 and 2001. Community Dent Oral Epidemiol 2006;34:446-454.

III. Johanson CN, Österberg T, Steen B, Birkhed D. Prevalence and incidence of dental caries and related risk factors in 70- to 76-year-olds. Acta Odontol Scand 2009;67:304-312.

IV. Johanson CN, Österberg T, Lernfelt B, Ekström J, Birkhed D. Salivary secretion and drug treatment in four 70-year-old Swedish cohorts during a period of 30 years. Manuscript.

Introduction

Population studies

In 1971, a cross-sectional study of elderly people began in Gothenburg, Sweden, in order to examine the social and medical conditions of the older population. A systematic sample of 70-year-old people was selected born during July 1st 1901 - June 30th 1902 on dates ending with 2, 5 or 8 (Rinder et al. 1975). The examinations comprise anthropometry, hearing, cognitive functions, dietary habits, oral health and social factors. The purpose was to increase the knowledge of normal aging and make it possible to plan the care of the elderly. This study was just the start of a number of studies of 70-year-olds and longitudinal follow-ups, all the way to 101 years of age in the first examined cohort (Fig. 1). The different cohorts are named I, II, III, V and VI respectively. A 75-year-old cohort IV was examined separately in a comparative study between three Nordic countries, called NORA (Schroll et al. 1993). These gerontological and geriatric population studies in Gothenburg, Sweden (H70) have been going on for three decades (1971 to 2001) and enable both cross-sectional and longitudinal studies (Rinder et al. 1975, Österberg et al. 1983, Eriksson et al. 1987, Steen and Djurfeldt 1993) allow observations on normal aging and to identify risk indicators and risk factors for the elderly. Throughout the years the main procedures have been as identical as possible. An introductory letter was sent to each subject followed by a home visit by a registered nurse. The general examination was then carried out at Vasa Hospital in Gothenburg, Sweden.

Steen (2002) has described cohort differences between 70-year-olds found in these studies. Remarkable facts are large individual variations regarding functional age at the same chronological age but born in different years, from 1901 to 1930. Small longitudinal decline of function was seen in healthy individuals between the age of 70 and 90. Cohort differences were more often revealed. Cognitive functions were significantly better in the cohort born in 1922 than in the one born in 1906/07. Height and body weight increased in the 70-year-olds, 75-year-olds and 79-year-olds when comparing four different cohorts during a 20-year period. Increase in body weight was most marked in 70-year-old men. The choice of food changed in three cohorts born twenty-two years apart. Intake of sugar and potato decreased, for example, and intake of rice, pasta and fresh vegetables increased. The elderly followed the same trends regarding choice of foods as younger and middle-aged people. One of the most marked cohort differences is the improvement of dental health.

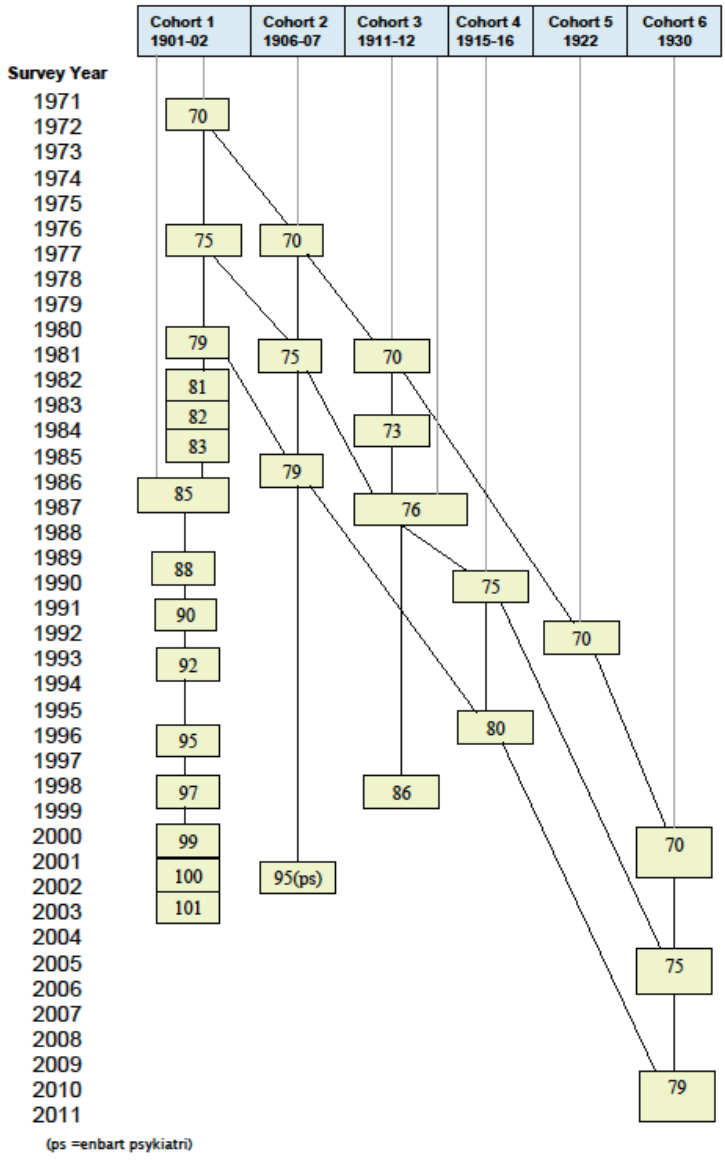

Figure 1 Age cohorts (year of birth) and year of examination in the H70 studies. This thesis is based on studies performed from 1971 until 2001.

Life span is increasing in many industrialized countries (Ainamo and Österberg 1992, Heath 1992, Vargas et al. 2003) and survival rate has risen markedly during the studied period. Life expectancy after 65 years of age has in Sweden increased around three years in both women and men during this 30-year period. When the examinations started in 1971, the expected life span for 65-year-old women was 82 years of age while, it was 79 years for men. At the time, the last cohort was examined in 2001; the corresponding figures were 85 years in women and 82 years in men. In the Swedish population, as in many others, the survival rate is expected to increase even more until year 2050 (Statistics Sweden 2007).

Dental health

Dental health has continuously improved in adult and elderly populations in industrialized countries. National surveys in Scandinavia, Great Britain and USA indicate a marked reduction in the prevalence of edentulism during the last 20 years (Ainamo and Österberg 1992, Bourgeois et al. 1998, Suominen-Taipale et al. 1999, Steele et al. 2000, Österberg et al. 2000, Douglass et al. 2002, Mojon 2003, Petersen et al. 2004). Several studies have shown that the percentage of dentate persons is also rising (Kalsbeek et al. 1998, Steel et al. 2000, Österberg et al. 2000), as well as the number of remaining teeth among dentate inhabitants (Hugoson et al. 1995, Schuller and Holst 1998, Bourgeois et al. 1998, Ahlqwist et al. 1999, Dye et al. 2007). In this study there was also a decrease in symptoms from the masticatory system, both cross-sectionally and longitudinally (Österberg, Carlsson et al. 1992).

Among edentulous persons, the demand for oral health care is low and the need for regular dental care and prevention is different in dentate persons compared with edentulous ones. The positive development in oral health that has taken place is of great importance for the organization of and services related to dental care (Ainamo and Österberg 1992, Österberg et al. 1998, Palmqvist et al. 2000, Weyant et al. 2004). The improvement in dental health in many of the industrialized countries occurs in parallel with an increase in life span. Sweden has a large percentage of elderly people in the population and the majority of elderly people today are dentate. There will be consequences for the organization of dental care, because of these demographic and dental health changes.

Dental caries

With increasing age multiple dysfunctions, both physical and mental, can be expected to increase the risk of dental caries at high ages. In this context, it is interesting to study not only the effects

of aging on caries but also the identification of caries-related risk factors. Many epidemiological studies of the elderly have been carried out on institutionalized individuals (Jokstad et al. 1996, Guivante-Nabet et al. 1999). During the observation period there has been an increase in population studies, Emilson and Thorselius (1988) studied the prevalence of mutans streptococci and lactobacilli in elderly, other studies concern either the prevalence (Fure and Zickert 1990, Lundgren et al. 1996, Närhi et al. 1998, Krustrup and Petersen 2007, Vilstrup et al. 2007, Ellefsen et al. 2008) or incidence of caries (Locker 1996, Lawrence et al. 1996, Fure 1997, Fure and Zickert 1997, Nordström et al. 1998, Fure 2004).

Several factors have been studied in relation to dental caries in the elderly. A number of studies have reported that poor oral and general health is correlated to caries in old age (MacEntee et al. 1993, Chalmers et al. 2002) as well as previous experience of caries (Ravald and Birkhed 1992, MacEntee et al. 1993, Chalmers et al. 2002). Lundgren et al. in 1998 and Guivante-Nabet et al. in 1999 found that low salivary buffering capacity was related to root surface caries. In addition to these factors, removable partial dentures also increase the risk of root caries (Locker 1996, Steel et al. 2001). After studying middle-aged and elderly people, Fure & Zickert (1990) concluded that the risk factors for root surface caries were similar to those for coronal caries, i. e. salivary levels of mutans streptococci and lactobacilli, the percentage of surfaces with plaque, the frequency of carbohydrate intake, salivary secretion rate and buffer capacity.

Salivary secretion and drug consumption

Studies of the effect of aging on salivary flow have identified a reduction in the secretion rate in older healthy individuals (>65 yr) compared with younger ones (Bertram 1967, Gutman and Ben-Aryeh 1974, Ben-Aryeh et al. 1984, Pedersen et al. 1985, Gandara et al. 1985, Baum 1986, 1987). Other reports, however, show no significant differences in secretion rate related to age either for unstimulated or for stimulated saliva secretion (Chauncey et al. 1981, Parvinen and Larmas 1981, Heintze et al. 1983, Heft and Baum 1984, Barenthin and Johnson 1986, Tylenda et al. 1988). Eliasson et al. reported in 2006 a reduction in whole resting, but not stimulated, saliva secretion rate with age.

The functions of bodily organs decrease with age (Bulpitt et al. 1994). The kidneys become less efficient and the metabolism slows down and as a result, medicines are not processed as quickly as they are earlier in life. This requires adjustments in the prescription of medication doses. In the salivary glands, the secretory capacity of the gland is only slightly, if at all, affected with respect

to volume and saliva composition in the healthy subject (Vissink et al. 1996). Taken together, these factors may limit the "reserve capacity" of the glands and make them particularly vulnerable not only to systemic diseases but also to drugs that, as a result of side-effects, interfere with the transmission of nerve impulses or with the secretory machinery (Nagler 2004, Aps and Martens 2005).

The consumption of drugs is high in elderly people and is increasing (Landahl 1987, Jylha 1994, Rumble and Morgan 1994, Woo et al. 1995, Nobili et al. 1997, Barat et al. 2000, Lernfelt et al. 2003, Junius-Walker et al. 2007). In a number of studies, it has been shown that many drugs have side-effects that cause a reduction in salivary secretion (Nederfors et al. 1995, Sreebny and Schwartz 1997, Närhi et al. 1999, Nederfors 2000, Flink et al. 2008, Smidt et al. 2010, Smidt et al. 2010, Leal et al. 2010, Ichikawa et al. 2010). According to Flink et al. (2008), there is also an association between gender and the number of remaining teeth. Smidt et al. (2010), Nederfors et al. (1995), Scelza et al. (2009) and Torpet et al. (2004) all found that cardiovascular medicines reduce the stimulated salivary flow rate. This might be an important risk factor for the oral health since it is a common drug in the elderly (Landahl 1987, Thorselius and Emilson 1988). Antidepressants often reduce a salivary secretion and are a common drug in the elderly (Friedlander and Norman 2002). Drugs cause reactions in salivary secretion in different ways, depending on the type of medicine (Scully 2003, Mese and Matsuo 2007, Wolff et al. 2008. New classes of drugs have been introduced during this 30-year period while some others have disappeared. This results in differences in treatment between cohorts.

Aims

There is a need for continuing research to describe the present situation and identify possible problems in oral health care of the increasing percentage of dentate elderly people in the future, also from a cariological point of view. One way to analyze dental health over time is to compare groups (cohorts) of individuals of the same age but born in different years. The aims of this thesis were therefore to study:

- cohort differences and trend in dental status between 1971 and 2001 (Paper II),
- the utilization of dental care (Paper II and III),
- the prevalence of dental caries in two 72-year-old cohorts (Paper III),
- the incidence of caries over a 6-year period in age 70-76-years (Paper III),
- oral risk factors related to dental caries (Paper III),
- the effect of aging on salivary flow (Paper I and IV), and
- the association between drug treatment and stimulated and unstimulated whole saliva in four 70-year-old cohorts (Paper I and IV).

Materials and methods

Study population

Five 70-year-old cohorts, called I, II, III, V and VI, born in 1901/02, 1906/07, 1911/12, 1921/22 and 1930/31, have been investigated within the framework of the gerontological and geriatric population studies in Gothenburg, Sweden, known as H70 (Table 1). The procedure and sampling methods have been described in detail previously (Rinder et al. 1975, Steen and Djurfeldt 1993, Eriksson et al. 1987, Österberg et al. 2006). Response rate varied between 84% in cohort I to 62% in cohort VI, and decreased over time. A somewhat higher response rate was seen in men than in women. (In cohort III, an intervention study, ‘‘Intervention Elderly in Gothenburg’’ (IVEG), was added.) The investigation was multidisciplinary and included medical, odontological, psychological, sociological and dietary examinations.

Table 1 Number of participants from the different cohorts examined in the studies.

Cohort	I				II		III			V	VI	
Examination at age	70	75	79	82	70	75	70	72	75/76	70	70	72
Paper	n				n		n			n	n	
I	108	243	189	88	280	168	543	382	564			
II	386				415		583			422	484	
III							135		135			139
IV	108				280		543					141

Odonotological examinations

Odontological investigations were performed in representative sub-samples of 40% of cohorts I and II and the total samples in cohorts III, V and VI. The number of participants in these examinations from the six 70-year-old cohorts were from cohort I =386, II =415, III =583, V =422, and VI =484, respectively (Table 1). The odontological studies were based on clinical and radiographic examinations and interviews. In cohort III, no radiographic examination was performed. In the interview, questions about dental health, hygiene and the utilization of dental care was based on questions about the time of the latest visit to a dentist and on the regularity of visits to the dentist. The reason for not visiting a dentist within the last 5 years was also asked

about in cohort II, III and VI. The clinical investigation included an examination of dental status, oral mucosa, salivary secretion and signs of mandibular dysfunction (Österberg et al. 1983).

The clinical examinations of the subjects in cohort I, II, III and V were performed by dentists. The subjects in cohort VI were at the age of 70-years examined by three dentists and two dental hygienists and at the age of 72-years by author CJ. The examinations in cohort III were carried out by one of the authors (CJ) and another experienced dentist. For calibration, the two dentists examined the first 57 subjects simultaneously at the age of 70 years. Inter-observer variation was analyzed by comparing the mean values of all registrations. There were no significant differences in the odontological parameters between the dentists and dental hygienists who carried out the clinical examinations in the present study.

Caries on enamel and root surfaces was registered when a cavitation was diagnosed with a mirror and explorer (Koch 1967). Decayed (DS), filled (FS) and sound (SS) tooth surfaces were registered separately, as well as primary decayed (DpS), secondary decayed (DsS) and root decayed (RDS) surfaces. Dental plaque was scored by a visible plaque index (VPI) and gingivitis by a gingival bleeding index (GBI) (Ainamo and Bay 1975) on four surfaces of all teeth, mesial, buccal, distal and lingual/palatinal. All exposed root surfaces were registered, as well as pockets ≥4 mm, on all mesial, buccal, distal and lingual surfaces.

Salivary sampling

In cohorts I, II and III, the sample was taken in the morning between 8 am and 9 am after an overnight fast (Österberg et al. 1992). The subjects were allowed to drink water but not to eat, drink coffee or tea, smoke or take their drugs in the morning before collection. Nor were they allowed to brush their teeth. In cohort VI, the saliva was collected during daytime, with no eating, toothbrushing or tobacco use in the 1 h before the examination. Buffer capacity was measured using the Dentobuff chairside test (Ericson and Bratthall 1989) in cohort III and the method described by Ericsson (1959) in cohort VI.

The subjects were allowed to rest for a few minutes before saliva sampling. Before collecting unstimulated saliva, they rinsed their mouth with water. They were then instructed to swallow the saliva present in the mouth and then to lean the body forward, to allow the saliva to drip passively, without moving their lips or tongue, through a funnel into an ice-chilled cylinder graduated in 0.1 ml, for 15 min.

A paraffin-stimulated whole saliva sample was collected according to Ericsson et al. (1954) and Österberg et al. (1992). The subject was instructed to hold a piece of paraffin wax (~1.5 g) in the mouth without chewing for a couple of minutes and then to chew for 1-2 min. Afterwards, the subject swallowed all the saliva and then continued to chew the wax for 5 min and to spit out the saliva at regular intervals into a graduated cylinder. If the volume was less than 2 ml, collection was continued for another 5-min period. The salivary secretion rate was calculated in ml/min.

Statistical methods

Paper I. To test simple hypotheses about group difference and case wise change in salivary secretion rate and in subjective mouth dryness, appropriate variants of the permutation test of trend were used (Bradley 1968, Odén and Wedel 1975). The central 0.95 fractile intervals of the distribution were calculated with a parametric method according to the recommendations of the International Federation of Clinical Chemistry (IFCC) (Solberg 1983). The Andersson-Darling test was used to determine whether the distribution was normal.

Paper II. Fisher's exact test was used to test difference in proportion between two groups. A two-sample t-test was used to test differences in the mean between two groups. Regression models, univariate and multivariate, were used to test cohort trends in dental status in subgroups with different characteristic. For continuous variables of dental status, linear regression models were used. For dichotomies, variable binary logistic regressions were used. A cohort is coded as the year of birth (1901-1930) and a unit is 1 year. Odds ratios estimate changes in the odds of being dentate and having 20 or more teeth for each subsequent year of birth. To test if the importance of predictors of dental status change over time, the product between year of birth and the each other predictor is added to the regression models as interaction effects. In the multiple regression models, the following factors were including as independent variables: cohort, marital status, education, smoking habits, physical activity, self-assessed health, body height, waist circumference and drug treatment.

Paper III. Differences in mean values between two groups were tested with the t-test. Confidence intervals for means were calculated using the formula for normally distributed data. Tests of correlations between factors were performed by testing partial correlation coefficients adjusted for the number of tooth surfaces. The change in mean value between the ages of 70 and 76 was checked by paired one-sample t-tests. Predictors in a multivariate setting of the prevalence of caries were evaluated in ordinary least squares linear regression models. For cohort differences,

an asymptotic permutation t-test was used. Factors included in the partial correlation and the regression models were stimulated salivary secretion, buffer capacity, visible plaque index (VPI), gingival bleeding index (GBI), pocket depth of ≥4 mm, exposed root surfaces and visits to the dentist.

Paper IV. All statistical analyses were based on linear regression models with the salivary secretion rate as the dependent variable. An unadjusted model with a single dichotomous predictor corresponds to the Student's t-test, and an unadjusted model with a single ordinal/linear predictor corresponds to the test of Pearson's correlation coefficient. When adjusting for gender, cohort and/or number of teeth, the test of a dichotomous predictor can be described as a t-test adjusted for covariates.

Results

Paper I

There was no significant cohort difference either in the mean or in the distribution of the secretion rate at the ages of 70 and 75 in women. About a quarter of the women, compared with one-eighth of the men, had values below 0.5 ml/min (Fig. 2) and 2 and 6% respectively had extremely low secretion rates (<0.2 ml/min). In men, the secretion rate was significantly higher in cohort I compared with the other two cohorts ($p<0.01$). At all ages, men had a significantly higher secretion rate than women ($p<0.01$) (Fig. 3). No statistically significant decline was found longitudinal either for men or for women, in any of the three cohorts. On the contrary, there was an increase for the 75-79 years age interval in cohort I and for the 70-75 years age interval in cohort III. This trend was independent of dental status and drug treatment. In all age groups, women reported mouth dryness more frequently than men. The frequency of this symptom increased with age, especially in women ($p<0.01$). A complaint of mouth dryness was significantly associated with lower salivary secretion rate and with the number of drugs the subject consumed. In higher age groups, these relationships became weaker.

In all three cohorts together, linear regression analysis showed a highly significant correlation between salivary secretion rate and the ages of 70 and 75 ($p<0.001$).

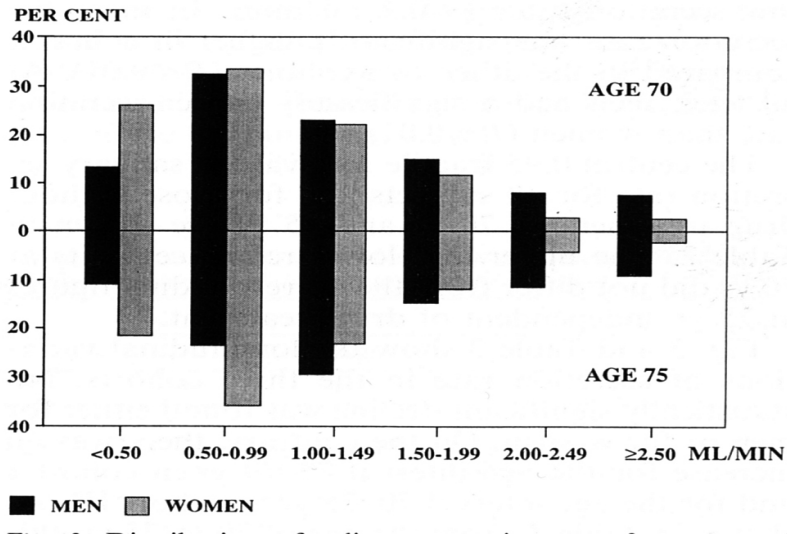

Figure 2 Distribution of salivary secretion rate for men and women in cohorts I, II and III at the age of 70 and 75 year.

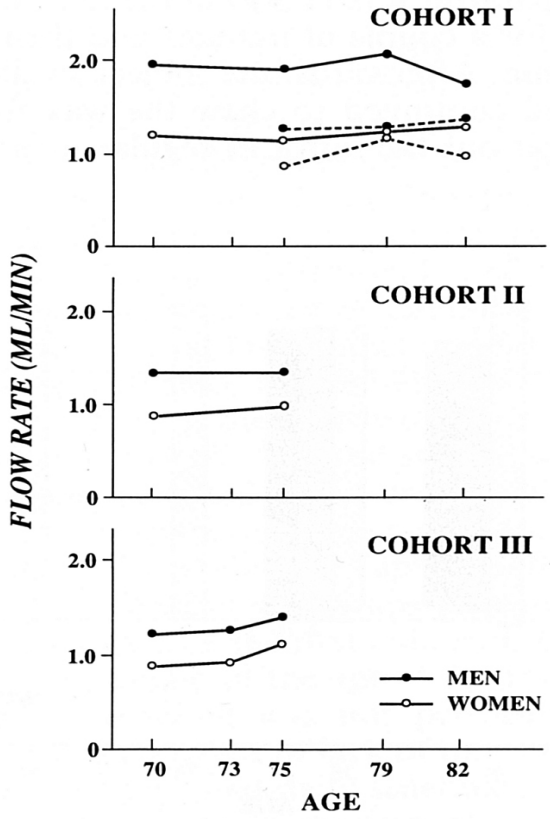

Figure 3 Longitudinal changes (mean values) in salivary secretion rate for the three cohorts. Dashed lines in cohort I represent new group of 75-year-olds who were followed until 82 year.

Paper II

The mean number of remaining teeth in dentate 70-year-olds was 13.6, 13.4, 14.5, 18.1 and 20.9 in the five cohorts. The average cohort trend per birth year 1901-1930 is an increase of 0.3 teeth/year. The percentage of dentate subjects in the different cohorts changed gradually from 49% in cohort I to 93% in the last examined cohort VI (Fig. 4). The most obvious cohort difference in the distribution of teeth was seen in the proportion of subjects with >20 teeth which increased from 19% in cohort III to 65% in cohort VI. In the first three cohorts, the prevalence of edentualism was significantly higher in females than in males, but in the last two cohorts there was no significant difference. The prevalence of edentualism was more common in the maxilla compared with the mandible in all cohorts.

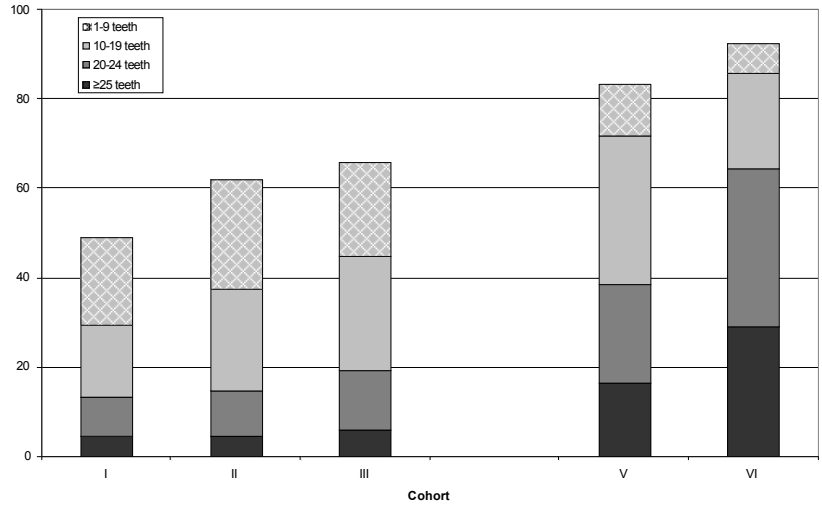

Figure 4 Distribution of remaining teeth in five 70-year-old cohorts examined between 1971/72 and 2000/01.

At the examination of the 70-year-olds in cohort I, 72% of the females wore removable complete dentures and 11% partial dentures. In males, the corresponding figures were 62% and 18%. In cohort VI, 12% of women and men had complete dentures and 8% had partial dentures.

Yearly visits to a dentist during the last 5 years among the edentulous women were uncommon in all cohorts. In the dentate subjects in each cohort, the frequency of regular dental care increased with an increase of the number of remaining teeth. The cohort comparisons indicate a marked

increase in regular visits to a dentist over time among the dentate persons, independent of the number of teeth.

Figure 5 illustrates the positive cohort trend concerning proportion of subjects with 20 or more teeth in different subgroups. In the latest examined cohorts V and VI, however, the marked differences between non-smokers and previous and current smokers and between subjects with only elementary school and those with higher education remained.

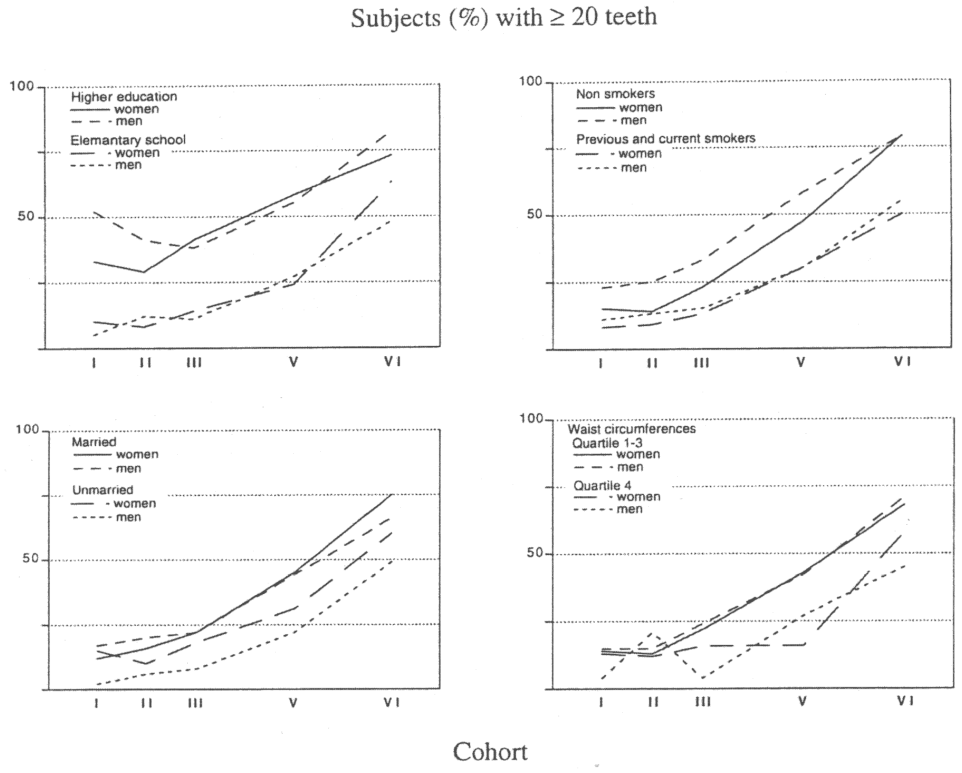

Figure 5 The prevalence of subjects with 20 teeth or more in subgroups with different characteristics in five 70-year-old cohorts.

Logistic multiple regression analysis showed that education higher than elementary school was positively associated in both women and men with the percentage of dentate subjects and the percentage of subjects with 20 or more teeth, independent of birth year and other characteristics ($p<0.01$). Other characteristics, such as smoking ($p<0.001$), higher waist circumference, being un-married and physical inactivity, were negatively associated with the dependent variables in both genders ($p<0.05–0.001$). In men, the number of drugs was also negatively related to the number of teeth ($p<0.05$). Regression analysis indicated that independent of birth year, men

(p<0.01) and unmarried subjects (p<0.01) had a lower prevalence of regularity in the frequency of dental care.

Paper III

Cross-sectional

The mean number of teeth was significantly higher (p<0.001) in cohort VI, 21 teeth (22.1 in women and 20.2 in men) compared with 14.1 teeth (14.7 in women and 13.4 in men) in cohort III. The percentage of dentate subjects with 1-9 remaining teeth changed from 32% in cohort III to 4% in cohort VI, and the percentage of subjects with ≥20 teeth changed from 30 to 70%. The percentage of surfaces, on molars and premolars, is significantly higher in cohort VI, but significantly lower on incisors and canines. The differences in remaining teeth in the lateral and frontal segments are more pronounced in the lower than in the upper jaw (Fig. 6). The differences between the cohorts, are more marked in the upper than in the lower jaw.

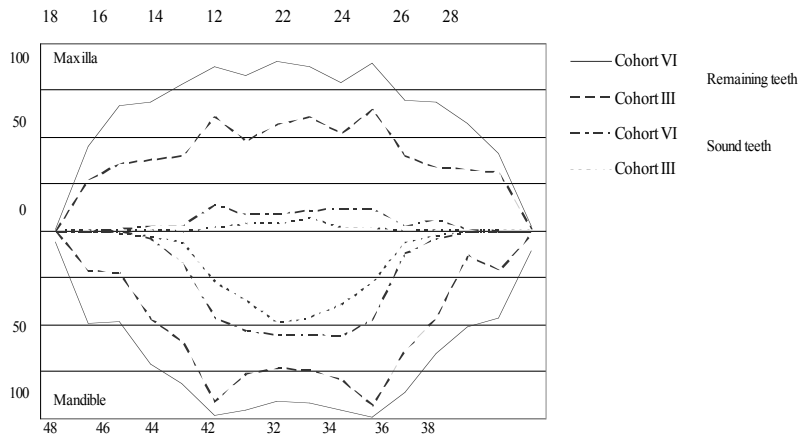

Figure 6 Frequency of distribution of remaining and intact teeth in each cohort.

On average, 2.1 surfaces per subject were decayed in cohort III, 1.9 in women and 2.3 in men. The corresponding figures in cohort VI were 1.3, 1.4 in women and 1.2 in men. The difference between the cohorts was significant in men ($p<0.05$). Periodontal status, gingivitis and plaque index were higher in cohort VI ($p<0.001$) and furcation defects were also higher, approximately twice as high. Gingival pocket depth was about the same in both cohorts.

No caries was found in 28% of the individuals in cohort III and 58% of the individuals in cohort VI, a significant difference in both women and men ($p<0.001$) (Fig. 7). The majority of individuals with caries had 1-4% decayed surfaces of all. In cohort III, 10% had a high share of decayed surfaces, ≥15% while the corresponding figures in cohort VI was only 1% ($p<0.05$).

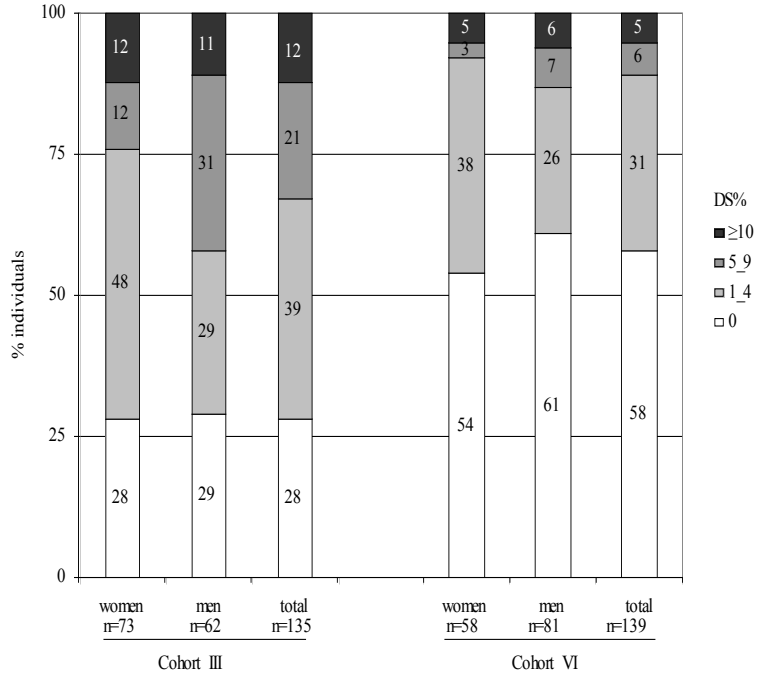

Figure 7 Distribution of individuals in terms of percentage of decayed surfaces (DS%). The figures within bars are expressed as percentages.

The difference between the cohorts, as well as between genders, was significant ($p<0.05$). The pooled data (cohort and gender) showed that the number of tooth surfaces ($p<0.01$) and filled surfaces ($p<0.001$) was higher in those who had visited a dentist during the last year compared

with those that had not. They also had a lower total percentage of totally decayed surfaces ($p<0.05$), decayed root surfaces ($p<0.05$) and a lower percentage of surfaces with plaque ($p<0.01$), gingivitis ($p<0.01$) and exposed root surfaces ($p<0.01$) and a higher salivary secretion rate ($p<0.01$).

A large number of surfaces with plaque or gingivitis were related to a significantly higher number of surfaces with caries, secondary and root decayed, as well as to decayed surfaces ($p<0.05$-0.001). The prevalence of gingivitis was correlated to primary decayed surfaces, while a pocket depth of ≥6 mm was only correlated to a larger number of decayed root surfaces. The salivary secretion rate was negatively associated with secondary caries ($p<0.05$). The subjects who had visited a dentist during the last year had significantly fewer sound and primary decayed surfaces and a larger number of filled surfaces.

Longitudinal

The mean number of tooth surfaces decreased from 65.1 at 70 years of age to 59.2 at 76 years, in women from 70 to 63.2 and in men from 59.1 to 54.4 ($p<0.001$). Sound surfaces also decreased during this period. The prevalence of caries decreased between the age of 70 and 76, from 3.0 to 2.0 DS ($p<0.05$). Forty-nine percent of all participants did not develop any new decayed surfaces (53% for women and 44% for men) and 11% developed ≥5, about the same in women and men. Almost 20% of the individuals had only one new decayed surface. About fifty percent developed root surface caries, 23% only one new root decayed surface, while 27% developed ≥2, during the 6-year period.

When testing predictive factors for the incidence of caries in a multiple regression model, it was shown that the percentage of gingival pocket depth of 4 mm or more was predictive for the incidence of missing surfaces ($p<0.001$), decayed surfaces ($p<0.01$) and root decayed surfaces ($p<0.01$). With a large amount of dental plaque, there is a higher incidence of primary decayed surfaces ($p<0.01$). A higher buffer capacity was associated with a lower incidence of decayed root surfaces ($p<0.05$).

Paper IV

In each separate cohort, the stimulated secretion rate was significantly higher in men than in women ($p<0.001$). Stimulated secretion was higher in cohort I and VI than in the other two cohorts, both in women and in men. There were no significant differences between cohort I and VI or between gender concerning unstimulated salivary secretion rate. A stimulated salivary secretion rate of ≤0.7 ml/min was found in 205 (38%) women of the total examined, and in 121 (23%) of the men.

The percentage of subjects taking drugs increased during the observation period (Fig. 8). On average, 64% of the women and 55% of the men were being treated with drugs. The use of 2-3 different drugs was most common. The percentage of individuals taking 4 drugs or more increased from 10% in 1971-72 to 20% in 2002. The most common drugs used in all four cohorts were cardiovascular (52% of the women and 46% of the men) and psychotropic drugs (in women 17% and in men 10%).

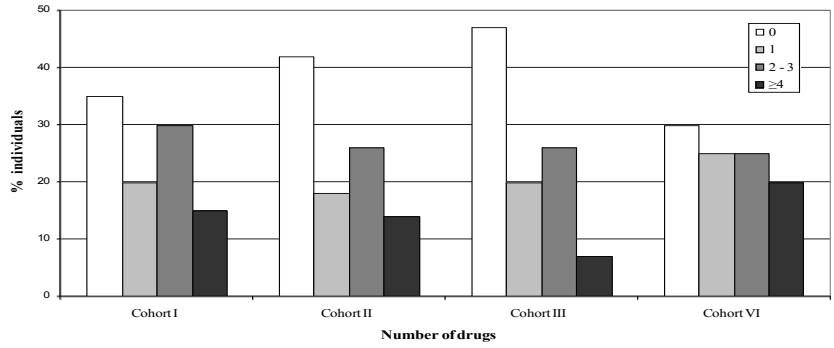

Figure 8 Drug consumption in four 70-year-old cohorts.

As new classes of drugs were introduced and other disappeared during the observation period, differences in treatment were seen between cohorts. The use of β-adrenoceptor blockers increased over time. Older types of antidepressant had been replaced by selective serotonin reuptake inhibitors (SSRIs) in the last studied cohort. Apresolin was a common antihypertensive drug in the 1970s, but it has not been used in recent years.

In all four cohorts, subjects on drug treatment had a lower secretion rate than those without drug treatment ($p<0.05$) (Table 2), even when adjusted for the number of teeth and gender. The unstimulated secretion rate in women in cohort VI was halved when they were treated with 4 or more drugs compared to those on no drugs.

Table 2 Mean value and (SD) for stimulated and unstimulated salivary secretion rate total as well as in groups with different consumption of drugs (0, 1, 2-3, ≥4).

		Stimulated					Unstimulated				
		Women		Men			Women		Men		
	Number of drugs	n		n			n		n		
Cohort I	0	17	1.1±0.9	28	1.7±1.0		16	0.2±0.2	29	0.3±0.2	
	1	10	0.8±0.5	7	2.0±1.1		10	0.2±0.2	8	0.5±0.7	
	2-3	22	1.1±0.7	13	1.5±1.0		22	0.2±0.1	15	0.1±0.1	
	≥4	4	1.1±0.7	7	1.2±0.7		4	0.1±0.1	7	0.2±0.2	
	Total	53	1.0±0.7	55	1.7±1.0	1.3±0.9	52	0.2±0.1	59	0.3±0.3	0.2±0.3
Cohort II	0	53	1.1±0.7	57	1.4±0.7						
	1	29	0.8±0.5	28	1.3±0.7						
	2-3	42	0.9±0.5	37	1.1±0.8						
	≥4	20	0.7±0.4	14	0.8±0.5						
	Total	144	0.9±0.6	136	1.2±0.7	1.1±0.7					
Cohort III	0	110	1.0±0.6	122	1.3±0.8						
	1	57	0.9±0.7	52	1.1±0.7						
	2-3	86	0.9±0.7	60	1.0±0.6						
	≥4	27	0.8±0.5	29	1.0±0.6						
	Total	280	0.9±0.6	263	1.2±0.7	1.0±0.7					
Cohort VI	0	14	1.5±0.8	32	2.1±1.0		14	0.2±0.2	32	0.2±0.1	
	1	11	1.7±0.6	21	1.6±0.7		11	0.2±0.1	21	0.2±0.2	
	2-3	18	1.5±0.8	17	1.9±0.8		17	0.2±0.1	17	0.2±0.1	
	≥4	16	1.6±0.5	12	1.5±0.9		15	0.1±0.1	11	0.2±0.2	
	Total	59	1.5±0.7	82	1.8±0.9	1.7±0.8	57	0.2±0.1	81	0.2±0.1	0.2±0.1

Among both women and men, there was a negative correlation between the number of cardiovascular drugs (ATC code C) and salivary secretion rate ($p<0.001$) independent of cohort, number of teeth and treatment with other drugs. Similarly, a large number of drugs in the central nervous system category (ATC code N) was correlated to lower salivary secretion ($p<0.05$). However, these associations did not remain after adjustment for number of teeth and treatment with other drugs. When multiple regression analysis was carried out, a significant correlation remained between low salivary secretion and treatment with five drug groups, loop diuretics ($p<0.001$), non-selective β-adrenoceptor blockers ($p<0.001$), selective β-adrenoceptor blockers

and other antihypertensives ($p<0.05$), antipsychotics ($p<0.05$) and antidepressants ($p<0.05$). This correlation was independent of gender, cohort and number of teeth.

Discussion

Cohort differences

There has been a marked increase in life expectancy during the 30 years (1971-2001) these studies were performed. This will result in a large number of elderly people in the future. To be able to give them appropriate dental care, it is of interest to know their dental status. During the same period, the prevalence of edentualism at the age of 70 has decreased. The decline was most pronounced in women, from 55% in 1971/72 to 6% in 2000/01, compared with 46% and 8% in men. It should be observed that in the last cohort, there were more edentulous men than women. Similar trends have been found in many western countries, but the change appears to be faster and more extensive in Sweden than in most of the other countries (Ainamo and Österberg 1992, Bourgeois et al. 1998, Suominen-Taipale et al. 1999, Steele et al. 2000, Österberg et al. 2000, Douglass et al. 2002, Mojon 2003, Petersen et al. 2004). Thus, in the national survey in Sweden carried out in 1975-1997 reported by Österberg et al. in 2000, 15% of the participants in the 65–74 age group were edentulous. The corresponding figures were 36% in the UK in 1998 (Steele et al. 2000) and 29% in the USA 1991 (Douglass et al. 2002). However, there are substantial regional differences in dental health among the elderly, as demonstrated by the Swedish study (Österberg et al. 2000). In 1996/97, the prevalence of edentulousness in the 65–74 age group was about 10% in the three largest cities (including Gothenburg) and 25% in rural areas. These figures correspond fairly well to the prevalence of edentulous (7%) among the 70- year-olds observed in the present study in 2000/01.

During the studied decades, there has been a marked change in attitude towards the retention of teeth among both patients and dentists. The extraction of teeth has become an infrequent therapy in Sweden during this time, even in the elderly (Hugoson et al. 1995, Österberg et al. 1995, Palmqvist et al. 2001). The proportion of restored teeth has increased more than the proportion of non-restored teeth, found when comparing cohorts. One reason for this difference may be that molars are retained to a greater extent in later cohorts. However, it also indicates that the prevalence of caries has not changed as much as the number of teeth which means that, the changes in figures may be more due to changes in professional and patient preferences rather than to preventive outcomes.

Comparisons of the 70-year cohorts in Gothenburg also revealed a marked change in the number of remaining teeth among the dentate subjects over the 30-year period, from a mean value of 14 teeth in 1971/72 to 21 teeth in 2000/01. This is higher than the figures reported by Fure and Zickert in 1997 in Sweden and Bourgeois et al. in 1998 from other European countries, but the same as in other studies (Hämäläinen et al. 2004, Hugoson et al. 2005). During the first 10 years of the examination period, there was no change in the number of teeth for the whole group. Thus the largest increase occured during the last 20 years of the examination. This trend has also been described for the whole country (Österberg et al. in 2000) as well as for the whole of Scandinavia (Ainamo and Österberg 1992). Nordström et al. (1995) on the other hand noted a decrease in the number of teeth in two 70-year-old cohorts examined 1981 and 1990 in a city population in the north of Sweden. Tooth survival patterns are similar to those in other studies (Fure and Zickert 1990, Nordström et al. 1998, Vilstrup et al. 2007).

The prevalence of decayed surfaces in the present population was fairly low in both cohorts. Similar prevalence has been reported by Krustrup and Petersen in 2007. Twice as many participants in cohort VI had no caries compared with cohort III, while three times as many individuals had a large percentage of decayed surfaces, ≥5%, in cohort III than in cohort VI. Root caries was found in 58% of the individuals in cohort III and only 33% in cohort VI, which is somewhat higher than in other populations (Närhi et al. 1998). Both the number of remaining teeth and the prevalence of caries are comparable to the findings in middle-aged people (Fure and Zickert 1990, Kalsbeek et al. 1998). Women in both cohorts had more filled surfaces than men, which is in agreement with Fure and Zickert (1990) and Hämäläinen et al. (2004). The main reason for this is probably the fact that women visit a dentist more frequently. Fure and Zickert (1990) showed that women visit a dentist more frequently than men and this was also found in this study. In the first cohort, examined in 1972, Österberg et al. (2006) reported that 71% only went to the dentist for acute treatment. In 1981/82 and 2001/02, the contrary was found, i.e. 73% visited a dentist during the last year in cohort III and as many as 91% in cohort VI and they did so on a regular basis. A similar increase in regular dental visits can be seen in the whole country (Österberg et al. 2000, Hugoson et al. 2005).

In addition to the change in the number of teeth, there is also an increase in the number of teeth with fillings and crowns as well as endodontologically treated teeth over time. In the later cohorts compared with the earlier cohorts, lost teeth have more frequently been restored with bridges than removable dentures. Similar trends in the dental care panorama can be seen in statistics from the

National Swedish dental insurance (Sundberg and Öwall 1989). The amount of preventive and restorative therapy increased in the elderly, while extractions of teeth and treatment with removable denture decreased over time. This has been shown in different studies (Sundberg and Öwall 1989, Lewis and Thompson 1995, Ahacic et al. 1998, Löfquist et al. 2000, Kronström et al. 2001).

The estimated number of remaining teeth per 1000 individuals based on all individuals including edentulous persons was 6,700 teeth in 1971/72, compared with 19,300 in 2000/01 (Fig. 9). The corresponding figures for restored teeth were 4,300 and 15,200 teeth respectively. In 1971/72, the estimated number of teeth with crowns was 700, while the figure for endodontologically treated teeth was 1,100 compared with 5,800 and 3,700 in 2000/01. This increase in the number of teeth and restored teeth can be expected to represent a potential increase in the risk of dental caries and periodontal disease, especially in premolars and molars. Restorations of the teeth with fillings or crowns may also result in an increased risk of recurrent caries. In this context, it is important to remember that 70-year-old subjects today live much longer than they did 30 years ago. In year 1970, the 70-year-old subjects survived an average of 15 years compared with 19 years in 2000. Because of the increased life expectancy and of other demographic changes in Sweden, the number of persons aged >65 is expected to increase by 48% during the period 2002–2030, while the corresponding figure for persons aged >85 is 69%. Sweden is one of the countries with the oldest populations in the world (Statistics Sweden 2002).

A large number of studies (Suominen-Taipale et al. 1999, Avlund et al. 2001, Avlund et al. 2003, Petersen et al. 2004,) including studies based on data for 70-year-old subjects in Gothenburg (Österberg et al. 1983, Österberg et al. 1990), have shown that dental status is a good marker of socio-economic factors, lifestyle and social network factors, general health, functional capacity and mortality. The results of the present study show that these factors are significant predictors of dental status during the period. In several of the studied subgroups with different characteristics, there was a positive cohort trend for both dental status and regularity of dental care. However, in most of the subgroups, the difference in dental status remained during the period 1971-2001. A more positive cohort trend relating to the proportion of 20 teeth or more was seen in women with positive characteristics, such as “never smoked” and feeling healthy, compared with those women with the opposite characteristics.

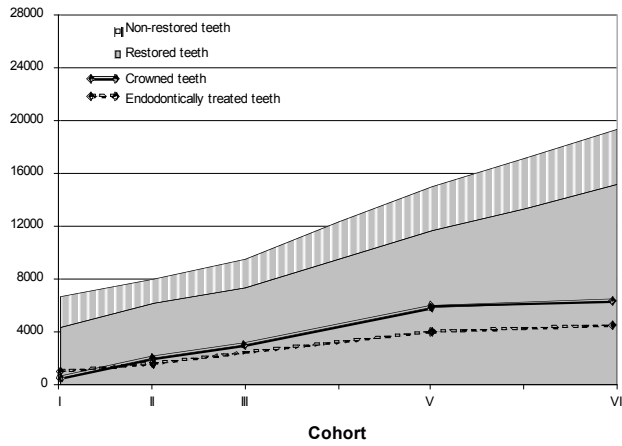

Figure 9 The estimated number of remaining and restored teeth in five 70-year-old cohorts per 1000 individuals based on means of all individuals including edentulous persons.

The positive change in dental health indicates that environmental factors could have a large impact on this trend. The reason for this positive trend in dental status is multifactorial and it can probably be partly explained by improvements in living conditions, including economy, education, housing, general health, nutrition, medical and dental care. There may therefore be several reasons for the improvement in dental health observed in the present material. The use of fluoride toothpaste, improved oral hygiene and increased regular dental care are probably the main reasons for the improvement in dental health (Hugoson et al. 1995). Differences in access and economical barriers to the use of dental care between the cohorts have changed during the observation period and they have probably contributed to the positive trend. Subsequent cohorts, born between 1920 and 1930, have had access to more extensive organized dental care in school and have received a subsidized dental care from the Swedish national dental insurance, introduced in 1974, during middle age and during a longer period compared with the cohorts born between 1901 and 1907. An increase in the utilization rate of dental services was seen after the introduction of the insurance system (Hugoson et al. 1995, Österberg et al. 1995, Palmqvist et

al. 2001). This is probably one explanation of the obvious difference in the number of retained teeth between the later cohorts and the earlier ones.

As in many other population studies throughout the world, there has been a tendency in recent decades for the non response rate to increase. In 1971/72 the response rate was 85% compared with 63% in 2000/01. The reason for the increasing non-response rate is multifactorial. It may be due in part to the growing public debate about participation in studies and where data are stored in computers. Analyses of non-response have been performed in the first cohorts and there were no significant differences between participants and nonparticipants. In the later cohorts, these differences were also small (Nilsson-Ehle et al. 1988, Lernfelt et al. 2002, Österberg et al. 2006). We therefore conclude that the examined subjects are generally representative of the 70-year-old populations in the different examination years (Svanborg 1977, Eriksson et al. 1987). The differences in the non-response between the cohorts may only explain the obvious secular trend observed in dental health to a small extent.

Longitudinal changes

Both women and men lost approximately one tooth between the age of 70 and 76 years, which is in agreement with Fure and Zickert (1997) in their study of elderly and middle-aged people. The prevalence of decayed surfaces was significantly lower at the age of 76 compared with the level at 70 years of age and both the number and percentage of filled surfaces had increased. One possible explanation is the fact that the first examination had the effect of an intervention. Men had a slightly higher incidence of caries than women, during this period but it was still fairly low. Other studies show a higher incidence of caries, even during a shorter period. In 1993, MacEntee et al. found 67% with new decayed and filled surfaces during a period of one year among subjects over 65 years of age, approximately 10% more in the institutionalized individuals than in the group of independent people. In our study, 15% of all intact surfaces at 70 years were filled or decayed at the age of 76. Fifty-one percent developed one or more decayed root surfaces, compared with 27% in the study by Locker in 1996 during a period of 3 years, in a population aged 50 years and above. In 1996, Lawrence et al. also reported an incidence of decayed root surfaces in 45% of people ≥65 years of age over five years. It is impossible to describe the exact incidence of caries in this study, as there was no possibility of checking the treatment during the period between 70 and 76 years of age. Filled surfaces may have been refilled due to caries, once or even more during this period. However, the incidence seemed to be moderate and ageing in this age group does not appear to be such a dominant risk factor for dental caries.

Cohort VI had significantly higher values for both visible plaque and gingival bleeding indices, and they also had more furcation defects than cohort III, depending on the fact that they had more molars and premolars left. The fact that visible plaque but not gingival bleeding decreased between 70 and 76 years of age may be explained by previous participation in examinations. The individuals are more aware of that they are part of a study and they probably perform better oral hygiene before the visit.

The best predictors of loss of teeth during the follow-up between 70-76 years, were the gingival bleeding index, the visible plaque index and a pocket depth of ≥4 mm. Moreover, the incidence of decayed surfaces correlated to deep pockets. A lower prevalence of secondary decayed surfaces was seen when the salivary secretion rate increased. A correlation was also observed between buffer capacity and decayed root surfaces as shown by Lundgren et al. (1998) and Guivante-Nabet et al. (1999).

Saliva

This population study did not reveal any decline in salivary secretion rate with increasing age, in contrast to several cross-sectional age comparisons indicating an age-related decrease in salivary secretion (Bertram 1967, Gutman and Ben-Aryeh 1974, Gandara et al. 1985, Pedersen et al. 1985). Our observation is in line with certain previous cross-sectional reports (Chauncey et al. 1981, Parvinen and Larmas 1981, Heintze et al. 1983, Heft and Baum 1984, Barenthin and Johnson 1986, Tylenda et al. 1988). On the other hand, in the third cohort, increasing secretion was found in the 70-75 age interval. The fact that the subjects became more and more used to the test procedure could explain this increase. According to findings by Heintze et al. in 1983, a significant increase was found in the second of two saliva tests performed within an interval of 1-2 weeks.

The percentage of individuals reporting mouth dryness increased as they became older, especially among the women. This may indicate that the major salivary glands, which act upon stimulation, e.g. while chewing on paraffin wax, retain their capacity, while the small glands, which are important for the salivary flow during rest and thereby for oral comfort, lose some of their capacity as reported by Eliasson et al. in 2006. Unfortunately, we were only able to measure the resting salivary secretion rate in the cohorts I and VI at the age of 70 and 72 years respectively. However, a statistically significant correlation has previously been reported between the resting

and the stimulated salivary flow rate by Heintze et al. (1983) and Österberg et al. (1984). Paraffin wax-stimulated saliva is less time consuming and easier to collect in an elderly population than the collection of unstimulated saliva.

In the present thesis, observations were made both cross-sectionally in the total population and longitudinally in those that could be followed for between 5 and 12 years. For practical reasons, and as there were drop-outs because of death and so on, it was not possible to follow all the individuals during the entire study period. Moreover, "new" subjects entered the study in cohort III. We therefore analyzed the data both longitudinally and cross-sectionally. The picture of the salivary secretion rate was, however, very much the same in all three cohorts, i.e. that secretion rate was fairly constant with age.

The trend of a more or less constant secretion rate with increasing age was independent of dental status and drug treatment. It may be argued that there are differences between the participants and the non-participants in the longitudinal follow-up for the age interval of 70-75 years. We therefore made a comparison of all individuals at the age of 70 and found that, in men but not in women in the third cohort, the salivary secretion rate was significantly higher ($p<0.01$) and drug consumption lower ($p<0.01$) in the individuals who were followed longitudinally compared with those that were not.

The association between the total number of drugs and the stimulated secretion rate of whole saliva may be partly due to the direct effect of certain drugs, but also to an interaction between different drugs. Multifactorial analyses revealed that cardiovascular drugs in particular, but also drugs for the central nervous system, showed this association. Other studies show the same relationship (Sreebny and Schwartz 1997, Närhi et al. 1999, Flink et al. 2008 and Leal et al. 2010). If the subjects were being treated with several drugs the effect was more marked. Anti-depressants and antipsychotics as well as diuretics had a pronounced effect on the secretion rate. Diuretics are one of the most common drugs in the elderly, and are used by about 30% of the women and 15% of the men in the studied cohorts as described by Lernfelt et al. (2003).

Drug consumption was high in study IV, which has been previously reported in the same population by Landahl in 1987 and Lernfelt et al. in 2003. The majority of the individuals had also been using their drugs for a long period and only a few medicines had been used for less than one month. In 2000, the Swedish National Board of Health and Welfare reported that 10% of the

Swedish population who are above 70 years of age purchase about one third of all the drugs sold in the country.

The effect of drug treatment on salivary secretion was more pronounced among the men than among the women. Hyposalivation, defined as a secretion rate ≤0.7 ml/min (Ericsson and Hardwick 1978), was on the other hand more common among the women. Despite the fact that those drugs which showed an association with the salivary secretion were frequently used, severe hyposalivation was rare.

It is known that the salivary secretion rate increases during the day (Flink et al. 2005). This may explain the higher secretion rate in both women and men in cohort VI when the sampling was done during the day, instead of in the morning as in the other cohorts, together with the fact that all the individuals in cohort VI were dentate. This is also reflected in the small number of individuals with a secretion rate of ≤0.7 ml/min. However, in the analyses of the associations between the salivary secretion rate and the consumption of drugs, the cohort effect was taken into consideration in the statistical analyses.

Drugs may interfere with respect to the reflex of salivary secretion at several levels. The secretory cells of the parotid and submandibular glands are both supplied by sympathetic and parasympathetic nerves and the classical transmitters, noradrenaline and acetylcholine, act on α_1- and β_1-adrenoceptors and on muscarinic receptors respectively. Drugs interfering with noradrenergic transmission are usually found within the category of antihypertensives and antiarrhythmics. However, drugs such as antipsychotics, antidepressants, antiepileptics and sedatives may not only attenuate the salivary reflex during its passage through the central nervous system but may also exert anticholinergic effects at glandular level. The action of diuretics is probably due to effects on various electrolyte exchange processes in the gland. (Goodman and Gilman´s 1996)

The β_1-adrenoceptors of salivary glands are known to mediate the secretion of both fluid and proteins (Carlsöö 1981, Ekström and Malmberg 1984). Previous human studies have shown that β_1-adrenoceptor blockade reduce the protein output (Jensen et al. 1991, Nederfors and Dahlöf 1996). It may therefore appear surprising that it was the non-selective β-adrenoceptor blockade, and not the selective β_1-adrenoceptor blockade, that affected the saliva flow rate with a higher statistically significance. The prototype of non-selective β-adrenoceptor blockers, propranolol,

exerts cell membrane-stabilizing activity. It is therefore possible that, in addition to the β_1-adrenoceptor blockade, a cell membrane-stabilizing effect contributes to the reduction in flow rate, presently observed in those subjects treated with the non-selective blocker. The diseases may also influence the salivary secretion rate per se, which we have not considered in this study. Nor have we taken in consideration the doses of the drugs.

Elderly in the future

Marked cohort differences in the population studies in Gothenburg, when it comes to cognitive function, dietary habits and social factors, for example, have been shown, as described by Steen in 2002. Changes in oral health are one of the most marked cohort differences of this kind to be observed. These ongoing secular trends (Statistics Sweden 2005) will have an obvious impact on the demand and need in dental care. The cohort differences relating to the population of the dentate elderly and the oral disease panorama also have economic consequences for the planning of oral health care at the community level. As adults today are used to visiting a dentist regularly (Hugoson et al. 1995, Österberg et al. 1995, Palmqvist et al. 2001) they will expect the dental health services to offer them care even in old age when in compensated diseases such as dementia and functional impairments become common.

There will be an increase in the number of elderly people in the future and they will also live longer, which means that there will be a larger number of very old individuals. The majority 90-95% of people aged 65 and above, will be dentate and are expected to keep their teeth for longer (Österberg et al. 2000) as we found in this study. It was also shown that the mortality during a 12-year follow up of the 70-year-old cohort I-IV was significantly higher in the edentulous subjects compared to those with 20 or more teeth (Österberg et al. 2008). This is probably the reason for mean number of remaining teeth to be the same in cohort I at 88-years of age as at 70, shown by Lundgren et al. (1996). Health will improve (Svanborg 1993) but we can assume that an increased number of elderly people will have dysfunctions, both physical and mental, such as dementia which will make them dependent (Wårdh et al. 2002). Some will be institutionalized but many of them will still live at home (Hagman-Gustafsson et al. 2008). Nordenram and Ljunggren (2002) reported dentate with reduced functional capacity, in nursing home, to be in need of oral treatment. This will be a challenge for the dental care services. They need to find a way to identify the groups at risk of dental diseases. The need for regular dental care will remain, or even increase, and more individualized prophylactic efforts will be required.

Conclusions

The main conclusions from this thesis are:

- Improved oral health is one of the most marked cohort differences and a positive cohort trend in dental status was observed between 1971 and 2001.

- The utilization of dental care increased during the study period.

- Only a moderate prevalence of dental caries was seen.

- The incidence of dental caries was also moderate.

- The proportion of gingival pocket depth of ≥4 mm, dental plaque as well as a low buffer capacity were found to be predictive factors for dental caries.

- Both cross-sectional and longitudinal comparisons indicate that on a population basis there is no decline in the salivary secretion rate with increasing age.

- Polypharmacy is an obvious risk when it comes to low salivary secretion rate.

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