ORAL HEALTH AND DIETARY HABITS
IN AN ELDERLY CITY POPULATION

A report from the Umeå longitudinal study

Göran Nordström

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ABSTRACT

Oral health and dietary habits in an elderly city population. 
A report from the Umeå longitudinal study.

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In 1981, no representative studies of oral health and dietary habits in an elderly population in northern Sweden had been presented and longitudinal studies of oral health in the ageing person were in general rare. Masticatory ability deteriorates with the loss of teeth, but the impact of the dental status on dietary intake is less clear. Many age-related medical problems and diseases have nutritional aspects. Thus, the aims were to study changes in oral health in 70- and 79-year-old samples during a 9-year period from 1981 to 1990, to compare oral health in 70-year-olds examined in 1981 and in 1990; and to study dietary habits and estimate the impact of different background factors on the dietary intake.

The longitudinal study showed a high and in many cases increasing incidence of tooth loss, root caries, and periodontal disease with increasing age. Reported denture-related problems were common but not correlated with the clinical findings. Between 29 and 54% of the cohorts reported a removable denture treatment need with the lowest frequency among the oldest subjects. The clinical need for new complete dentures decreased and the need for adjustment increased with increasing age. Total edentulousness in 70-year-old men in 1981/1990 was 31.3/21.4 and in women 53.3/35.7%. The mean number of teeth and the prevalence of recurrent caries were lower and root caries higher in dentated 70-year-old men in 1990. The 70-year-olds showed a lower denture treatment need in 1990 compared with 1981. The frequency of annual visits to a dentist was higher in the 70-year-olds in 1990 and subjects with annual dental visits reported fewer oral problems.

Cohort differences and longitudinal changes in craniomandibular dysfunction (CMD) showed that although the frequency of reported CMD symptoms decreased, many clinical signs of CMD increased during the 9-year observation period. Women reported more symptoms and showed more signs of CMD than men. A great many of the clinical signs registered in 1981 persisted in 1990. The 70-year-olds studied in 1981 showed a higher frequency of CMD symptoms and a lower frequency of muscle pain and mandibular deviation than the 70-year-olds examined in 1990.

A dietary history interview showed that mean intakes of energy and nutrients, except for vitamin D among women, were above the Recommended Daily Allowance in Sweden (RDA-S). Women had lower mean intakes of calcium, iron, and vitamins C and D than men. Fat intake was high and the proportion of energy intake from fat increased with age. Those who had three cooked meals per day had a higher nutrient density than those who had one or two such meals. A further analysis showed that subjective chewing problems, low education, feeling ill, feeling lonely, stomach pain, craniomandibular dysfunction, and impaired dental status were the strongest predictors for a lower intake of energy and nutrients.

Keywords: Gerodontology, elderly, dietary habits, chewing problems, dental status, craniomandibular dysfunction, root caries, bleeding, attachment level, denture stomatitis, denture need and demand.
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IN AN ELDERLY CITY POPULATION

A report from the Umeå longitudinal study

Göran Nordström

Umeå 1995
To my parents Margit and Ragnar

and

to my wife Yvonne, my son Peter
and in memory of my late son
Pär

*If equal affection cannot be,*
*Let the more loving one be me*

*Wystan Hugh Auden*
ABSTRACT

In 1981, no representative studies of oral health and dietary habits in an elderly population in northern Sweden had been presented and longitudinal studies of oral health in the ageing person were in general rare. Masticatory ability deteriorates with the loss of teeth, but the impact of the dental status on dietary intake is less clear. Many age-related medical problems and diseases have nutritional aspects. Thus, the aims were to study changes in oral health in 70- and 79-year-old samples during a 9-year period from 1981 to 1990, to compare oral health in 70-year-olds examined in 1981 and in 1990; and to study dietary habits and estimate the impact of different background factors on the dietary intake.

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This thesis is based on the following papers which will be referred to by their Roman numerals:


INTRODUCTION

Demographic changes in Sweden

In the middle of the nineteenth century, the average life span in Sweden was little more than 40 years. The age distribution of the population was pyramidal in shape. The distribution has gradually changed over the years, and the projection for the year 2000 looks more like a rectangle or a little house (Population projection for Sweden 1983) (Fig. 1).

Birth rate, death rate, and migration rule the size and composition of a population. Women born in 1870 gave birth to an average of 3.7 children. Since then, fertility has decreased, and for women born in 1905 this figure was down to 1.8. The total fertility rate for women born in 1945 is estimated to be 2.0. Nature compensates the higher mortality rate of boys with the natural birth of 106 boys for every 100 girls. In the Swedish population, women were in the majority from the age of 52 years in 1960, from the age of 57 in 1993, and, in one estimate, are expected to be so from the age of 64 in 2025. The death rate is decreasing faster in men than women. Life expectancy was 75.9 years in men and 80.9 years in women in 1994 and is estimated to be 78.2 and 82.5 years respectively in 2025.

Emigration from Sweden between 1851 and 1930, mainly to the United States of
America, was extensive; and 1.4 million Swedes, most of them young persons, settled in North America (The Future Population of Sweden 1989). Immigration to Sweden during the same period of time was 0.4 million people. Despite a net loss of about one million people, the Swedish population increased from 3.4 to 6 million during this period.

Since 1930, immigration has dominated. During the period 1930 to 1985 the net loss of Swedish citizens because of emigration changed and 0.7 million people left Sweden compared with 1.5 million immigrants giving a positive balance of 0.8 million people. Most immigrants were young people, and the mean age of the immigrants was 22 years for the period 1985-1987. Thus, the 1.1 million immigrants living in Sweden in 1987 contributed to an increase in the size and a decrease in the mean age of the ageing Swedish population.

The proportion and the number of elderly people in the Swedish population is increasing (The Future Population of Sweden 1994). In 1970, 13.8% of the population was 65 years old or over (65+). By 1980 the proportion of people aged 65+ had increased to 16.4% and demographic prognoses forecast a probable 21.2% in 2025. The proportion of 65+ will remain fairly constant for the next ten years (about 1.5 million). Thereafter the proportion will increase rapidly to more than 2 million people in the year 2025 due to ageing of the cohorts born in 1940s. A similar picture is found in all the Scandinavian countries (Ainamo & Österberg 1992) and, although not yet to the same extent, in most western industrial countries.

**Former dentistry in Umeå**

Umeå, the administrative city of Västerbotten County, is located in the northeastern part of Sweden about 15 km from the coast, the Gulf of Bothnia, and 650 km north of Stockholm. The city was founded in 1622 by King Gustav II Adolf. In 1650 there were 217 inhabitants in the city, and about 200 years later the population had increased to 1828 citizens (Steckzén 1922). In 1860 there were only 21 licensed dentists in Sweden, most of them living in Stockholm (Grahnén et al. 1989). Oral problems in the northern parts of the country were still mainly taken care of by charlatans such as goldsmiths, barbers, and watchmakers and by barber surgeons or travelling "dentists" from Denmark, Germany, or The Netherlands who advertised their casual practice in the local papers. In the second part of the nineteenth century dentists from Stockholm were also travelling north along the coast offering dental treatment to the citizens. In 1888, the first licensed dentist was established in Umeå. His name was Sixten Malcolm Ödmann, born 1862 in
Karlstad. He advertised that he would start his practice in Umeå on the 20th of June. A couple of days after his arrival, on midsummer's day, a fire burst out and major parts of the wooden houses in central Umeå were burnt into ashes. Ödmann had to move north to Skellefteå but returned to Umeå in October and worked there for the next six years. When he left for Gävle in 1894 he was replaced by Carl Iwan Theodor Samuelson Linden, a dentist who had graduated in Stockholm the same year. Linden was born in Jönköping County in 1862.

The first military dental clinic in Sweden entirely financed by the national budget was established at the garnison hospital in Stockholm in 1907 (Bäckman et al. 1987). For the next few decades, military dentistry would play an important part in acute treatment, and thus for changes in the dental status of the Swedish population, particularly among young men coming from the rural parts of Sweden. In 1944, 196,638 teeth were extracted by military dentists in Sweden; in 1950, 1955, and 1960 approximately 30,000 teeth per year were still being extracted in military dental clinics in Sweden according to official statistics. In 1909, a clinic for military dentistry was also established in Umeå, and Iwan Linden became the first military dentist in the city. This was a part-time occupation, and in 1910 he was contracted for 185 working hours. That year Linden examined 1087 military servicemen; extracted 282 teeth; made 59 dentures; and performed 824 other treatments, mainly cleaning teeth and dentures from calculus. One of the military dentists in Umeå in the 1940s, Thure Elback, related in an interview that when the new recruits were examined at the dental clinic, more than 2000 teeth had to be extracted during the first month of their military service. This was done so that they would be able to carry out their military training properly.

The last barber surgeon in Umeå died in 1911. When Iwan Linden left the city for Gränna in 1926, there were a total of 5 licensed dentists. From this time on, Umeå has been well supplied with dentists compared with the rural areas of northern Sweden.

Today, most people in Umeå work in the fields of education, administration, and trade, and there are no large factory plants in the city. A dental school was established in 1956, and in 1965 the fifth university in Sweden was founded in Umeå. In 1995 the 100,000th inhabitant in Umeå was registered by the local authorities. In comparison with the rest of Sweden, the structure in Umeå is one of a young population.
Dietary habits in the elderly

Earlier studies of the dietary habits of the elderly in Sweden have shown deficiencies particularly in the intake of iron (Hallberg 1964). "The gerontological and geriatric population studies in Göteborg, Sweden" (Steen et al 1977) reported a satisfactory mean dietary intake in most respects. The mean intake of fat on the individual level, however, was too high, and several subjects reported a consumption of various minerals and vitamins that was far below the Recommended Dietary Allowance for Sweden, the RDA-S (Swedish National Food Administration 1981). A longitudinal study from the population studies in Göteborg (Lundgren et al 1987) showed that between 70 and 75 years of age the probands did not change their general meal pattern but males tended to reduce the size of their portions. A comparison of 70-year-old cohorts investigated in 1971/72 and 1981/82 in Göteborg (Sjögren et al. 1994) showed that the intake of both energy and nutrients was higher in the 70-year-olds investigated in 1981/82. In one investigation of complete denture wearers receiving denture treatment at the Department of Prosthetic Dentistry, Umeå University, low intakes of vitamins A and C were found (Nilsson et al. 1970).

Many age-related medical problems and diseases have nutritional aspects (Isaksson 1975), and the ability to chew, to break up different food items, deteriorates with the loss of teeth (Helkimo et al. 1978, Chauncey et al. 1981, Wayler & Chauncey 1983). In subjects with a "better" oral status, higher serum levels of iron (Ruikka et al. 1967) and of greater intake of vegetables (Österberg & Steen 1982, Ranta et al. 1988) have been reported. In light of this, Gunne compared masticatory efficiency (ME) in 19 patients with their old and with new complete dentures (Gunne & Wall 1985) and also provided subjects with removable partial dentures (RPDs) (Gunne 1985). Both the insertion of new complete and of RPDs improved the estimated ME and the subjective experience of masticatory performance but did not change the dietary intake.

Oral health in the elderly

Craniomandibular dysfunction (CMD) in adult and elderly people has been studied as part of consecutive series (Gross & Gale 1983) and in industrial workers (Hansson & Nilner 1975). The prevalence of CMD in elderly people living in different parts of Sweden has also been reported in a few cross-sectional epidemiological studies (Agerberg & Carlsson 1972, Agerberg & Österberg 1974, Österberg 1981, Salonen et al. 1990).
The prevalence of CMD symptoms and signs have in a number of studies been reported to be higher in adult women than in men, reviewed by Moss & Garrett (1984). This sex difference has also been reported in a population study from the Västerbotten County (Agerberg & Bergenholtz 1989), and in a recent study by Galan et al. (1995). Many studies have been based on consecutive patients and there are population based studies that have not reported any sex differences (Moss & Garrett 1984, Katz & Meskin 1986). However, also in a 2-year longitudinal study of symptoms and signs of CMD in adolescents in a representative sample of a city population from northern Sweden (Wänman 1987), it was found that girls reported more symptoms and showed more clinical signs on CMD than boys.

Few of the patients attending a clinic for treatment of CMD are over sixty years old (Helöe B & Helöe 1975). Similar observations have been reported several times and this has been one reason for assuming that most CMD problems are transient problems without serious long-term effects (Greene & Laskin 1983). In a six-year longitudinal study of consecutive patients (Rasmussen 1981) it was reported that temporomandibular arthropathy symptoms lasted a mean of 5.5 years, during which all temporomandibular joint (TMJ) symptoms, except crepitation, improved. In reviews by Clark & Mulligan (1984), Dworkin et al. (1990) and Greene (1994) it was concluded that CMD symptoms decreases with increasing age and that clinical signs of CMD are found either less often in elderly or at approximately the same rate in all adult age groups. However, the prevalence of TMJ was high in a sample of 170 residents of senior housing centers of Winnipeg, Canada (mean age 82 years) as 33% of the men and 50% of the women were reported to have TMJ anomalies like pain during palpation, lateral deviations, opening limitations and clicking or crepitus (Galan et al. 1995).

Longitudinal studies of CMD in representative population samples of elderly are rare. However, in a longitudinal study of elderly people in Göteborg (Österberg et al. 1992) it was reported that symptoms as well as signs of CMD tended to decrease with increasing age.

A few odontological investigations using representative population samples of elderly people in Sweden were performed during the 1970s and 80s. Some reports were based on mailed questionnaires or interviews (Johansson 1970, Smedby 1972) and others on investigations comprising both an interview and a clinical examination (Axell & Öwall 1979, Hugosson & Koch 1986, Helldén et al. 1989, Salonen 1990). Österberg (1981) concentrating on people 70 years old or more, has performed comparisons between 70-year-old cohorts, and 5- and 10-year longitudinal studies of 70-year-olds (Österberg et al. 1983, 1990, 1992). In a study of
oral health patterns in the elderly population within one county, a comparison was made between people living in densely populated areas and people living in rural areas (Palmqvist 1986).

Studies of oral health in representative samples of elderly populations have also been performed in other Scandinavian countries, some describing county or city populations (Grabowski & Bertram 1975, Norheim 1979, Rise 1982, Ambjörnsen 1986, Sidelman-Östergaard 1987), others generalizing for the entire country (Ainamo 1983, Tuominen et al. 1983). In a review by Ainamo & Österberg (1992) a summary of the oral health situation in the Scandinavian countries was given.

During the eighties several investigations of older Canadians were performed (for a review see Leake 1988). In the Washington/Baltimore metropolitan areas in the United States, an on-going longitudinal population study of oral physiology aimed at studying the oral health status during the "normal" process of ageing, was started in 1978 (Tylenda & Baum 1988). These studies were, however, not based on representative population samples. Examples of studies based on representative samples are investigations of older Iowans (USA) (Hunt et al. 1989) and of the elderly living in Nottingham (England) (Smith & Sheiham 1980).

Climate, commerce and industry, socio-economic background factors, and dietary habits in northern Sweden differ more or less from the middle and southern parts of the country. Official health statistics have shown different patterns of medical diseases in the south and the north (Spri 1979) and prevalence of oral diseases could also differ. Other than a study of temporomandibular symptoms in 70-year-olds in Umeå made by questionnaire (Agerberg & Carlsson 1972), neither cross-sectional studies of dietary habits nor cohort or longitudinal studies of oral health in representative samples of the elderly (70 years old or more) had in 1980 been performed in northern Sweden. It was therefore considered of interest to initiate such a study.
AIMS

The general purpose of the present thesis was to describe dietary habits and oral health in the elderly city population in Umeå, northern Sweden.

The specific objectives of the present thesis were the following:

* To investigate the dietary habits and intake of energy and nutrients in 70-, 75-, and 79-year-old men and women and to compare the results with the gerontological and geriatric population studies in Göteborg (H70) (I).

* To estimate the impact of sociomedical factors, and of oral status and function on dietary intake in 70-, 75-, and 79-year-old men and women (II).

* To assess the prevalence and incidence of craniomandibular dysfunction (CMD) signs and symptoms and to estimate the impact of age, gender, and time on CMD in 70- and 79-year-old cohorts examined in 1981, -84, -87, and -90 (III).

* To compare the prevalence of CMD signs and symptoms in 70-year-olds examined in 1981 with a new 70-year-old cohort examined in 1990 (III).

* To assess the prevalence and longitudinal changes of reported oral problems; of visits to a dentist; and of tooth loss, caries, and periodontitis in 70- and 79-year-old men and women examined in 1981, -84, -87, and 1990 and compare the 70-year-olds examined in 1981 with a new 70-year-old cohort in 1990 (IV, V).

* To describe the distribution and longitudinal changes of the number of teeth and the need and demand for denture treatment in 70- and 79-year-olds in 1981 and 1990 and compare denture treatment need and demand in 70-year-olds in 1981 and 1990 (IV, V).
MATERIALS AND METHODS

THE 1981 CROSS-SECTIONAL STUDY (I, II, III, IV, V)

In 1980 there were about 82,000 inhabitants in Umeå (statistical data from the local authorities), of whom approximately 16,000 were living in the central district (parish No 1). A cross-sectional study of 70-, 75-, and 79-year-old men and women from the central district was planned. To reach sufficient precision in the estimation of the different parameters, it was necessary to choose a design assuring enough persons in each age and gender group. It was not possible to use an age and gender distribution similar to the population of Umeå. This would have resulted in too few men and too few persons in the oldest cohorts.

Sampling procedure

The samples were selected from the official population registers of 1980. A calculation was made to obtain a sample with normal distribution, i.e. that we would be able to examine at least 30 men and 30 women in each of the three age groups. The following procedure was used: the total number of 70-, 75-, and 79-year-old men and women in the central district, born in 1902, 1906, and 1911 respectively, was divided by the number of people needed to get a sample that could be supposed to have a normal distribution. The result of this calculation was that every third 70-year-old man and woman; every second 75-year-old man and every third 75-year-old woman; and all 79-year-old men and every second 79-year-old woman should be drawn in consecutive order from the national population register. The register was organized according to year and date of birth. Thus a sample of 37 men and 37 women born in 1911, 39 men and 36 women born in 1906, and 41 men and 41 women born in 1902, a total number of 231 persons, was systematically selected for the investigation. Sixty-two 70-year-olds, 60 75-year-olds and 65 79-year-olds agreed to participate in the study in 1981.

THE LONGITUDINAL STUDY (III, IV, V)

In 1983, it was decided to make the study longitudinal. Since available resources were limited and the results from the 1981 investigation showed that a 5-year age difference was too small to expose any significant age-related differences, the 75-year-old group was not included in the longitudinal study. The 70- and 79-year-old age groups from 1981 were re-examined in 1984, 1987, and 1990 (Fig. 2).
Both the participants in the 1891 study and the non-responders were offered the opportunity to participate in the longitudinal study. During the 9-year study, the sample size decreased because of an increasing death rate, primarily among men but also in the older cohort of women. In 1990, 40.5, 58.5, and 46.3 per cent of the 79- and 88-year-old men and of the 88-year-old women respectively had died, compared with only 8.0% of the 79-year-old women. The non-response among the survivors increased from 16.2% in 1984 to 19.5% and 24.2% in 1987 and 1990 respectively (Table 1).
Socio-medical background

In 1981, 88 of 127 people (69.3%) stated that they had been living in Umeå for more than 30 years and only 3% for less than 5 years. Nine years later, in 1990, 72.7% of the surviving subjects stated that they had lived in Umeå for more than 39 years and none for less than 14 years.

Most subjects (82.6%) reported in 1981 only a 6-year elementary school education or less, and the frequency had decreased to 76% of the remaining sample by 1990. Any educational differences between men and women were insignificant.

Some important changes in marital status and living conditions occurred during the observation period. In 1981 more 79-year-old men (71%) than women (23%) were married (95% CI). In 1990 less than one-fifth of the 88-year-old women (18%), compared with half the 88-year-old men, were still married. In 1984, -87, and -90 more than 70% of the 82-, 85-, and 88-year-old women were living alone. For every widowed 79-year-old man there were fourteen 79-year-old widowed women in the remaining sample in 1990.

The housing conditions did not differ between men and women, and in 1981 almost 95% were living in their own house or apartment. In 1990 at the age of 88, however, almost half the remaining sample of men and women were living in a service house or institution.

A NEW CROSS-SECTIONAL STUDY IN 1990 (III, IV, V)

In the 1990 study, a new 70-year-old cohort, born in 1920, was selected in the same way as the 1981 cohort born in 1911. Of the 179 men and 214 women living in the central city parish, every fifth male and sixth female were invited to participate in the study. Of the 70 people chosen for the sample, 60 (85.7%) joined the study and 10 refused to participate. Half the new 70-year-old cohort examined in 1990 stated that they had lived in Umeå for more than 31 years and 10% for less than 5 years, compared with 63% and 3% respectively of the 70-year-olds in 1981. About 95% of the 70-year-olds in 1981 and 1990 were living in a house or apartment of their own. Sixty-seven per cent and 36% of the women compared with 78% of the men were married in 1981 and 1990 respectively. Thirty-seven subjects (61.6%) of the "new" 70-year-old cohort had only a 6-year elementary school education or less compared with 82.3% of the 70-year-olds in 1981. Sixty-seven per cent of the 70-year-olds in 1990 were married compared with 76% of the 70-year-olds in 1981. In both cohorts, about 10% of the men and 25% of the women were widowed (Table 1).
Table 1. The number of 70-, 75-, and 79-year-old men and women living in central Umeå and systematically selected for the original samples in 1981, and the examined subjects, non-responders, and deceased in the follow-ups in 1984, 1987 and 1990. In 1990, a new 70-year-old cohort was selected and examined as in 1981.

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RESPONSE AND NON-RESPONSE

Of the 231 persons chosen in the 1981 study, 187 (97 men and 90 women) agreed to participate (Table 1). Two were examined in their homes and one in hospital. Three subjects 79 years of age (2 men and 1 woman) died between the date they were randomly chosen and the date for the interview and examination. Eighteen men (15.4%) and 23 women (20.2%) refused to participate. The total non-response rate was 17.7%. The mean age of the examined sample was 74.7 years.

The responders and non-responders in the total sample from 1981 were compared according to register data and found not to differ regarding age, marital status, income, or in-patient care occasions or days in 1980 (Österlind et al. 1984). Excluding the 75-year-old group did not alter this result.

The most common reasons given for not participating in the study were: "I feel all right, and I am so busy and have no time for this study", "I already have a doctor to go to and need no further examinations", and "I simply don't want to participate". The latter statement was sometimes combined with "I'm afraid of the doctor/dentist", "I need no treatment", or "I need treatment, but no doctor has been able to help me so far, and this would only be a waste of time".
The oral health investigation was one part of "The Umeå longitudinal study (U70)", a multidisciplinary longitudinal study carried out from February to April every third year. The study also consisted of a socio-medical interview and of separate medical and dietary studies. The various parts of the investigation were all assigned to one clinic at the Department of Geriatric Medicine and four probands were examined every day between 07.30-12.00 a.m. (Fig 3).

The subjects were informed by letter-two by telephone-about the investigation and asked to participate. They were asked to fast 10 hours before scheduled interview and told that they would be given breakfast immediately after the blood sample had been taken. Those who needed assistance were accompanied by a relative or a member of their institutional staff. Home visits were made to those who wanted to participate but did not want to or could not come to the clinic. The oral health interview and the clinical dental examination were conducted in a room furnished with equipment ordinarily used for oral examinations. The dentist was assisted by a dental nurse.

In 1981 the study was performed by one examiner (Göran Nordström), in 1984 by two (G.N. and Håkan Wenslöw), in 1987 by three (G.N., Kenneth Borg, and Hans Nilsson) and in 1990 by two (G.N. and Anders Tillberg). The examiners had all been trained at the Dental School in Umeå and worked as teachers there in the same Department of Prosthetic Dentistry. In order to confirm definitions and calibrate clinical examination methods, G.N. examined 40 patients simultaneously with H.W. in the 1984 study, and 20 patients each with K.B and H.N in 1987, and with A.T. in 1990.
HOME VISITS

Before 1990 only a few patients were examined at home. In the 1990 study, however, 27 patients were examined at home or in some kind of service house or institution. Sixteen of these "home-visits" were to 88-year-old men and women, and most of these examinations were performed by G.N assisted by a dental nurse.

DIETARY HISTORY INTERVIEW (I, II)

The dietary interview was performed using the dietary history method (Burke 1947). The question forms were adapted to elderly people (Steen et al. 1977), and the interviews were carried out by dietician students supervised by their teacher. The intake of energy and nutrients was compared to recommendations by the Swedish National Food Administration (1981), and calculated using a computer program based mainly on data published by Abrahamson (1971) and further developed at the Department of Clinical Nutrition, Göteborg University, Göteborg, Sweden (Arvidsson-Lenner et al. 1977).

Three men and one woman were excluded from the dietary interview because their answers were incomplete or unclear. Thus, the dietary investigation was based on 94 men and 89 women, constituting 80% of the systematic sample. Two per cent were hospitalized, 5% were living in nursing homes, and 94% had their own households. Of those living in their own houses or flats, 96% had a kitchen and 4% a kitchenette. All had an electric stove with an oven and a refrigerator, and 92% had a freezer.

ORAL HEALTH INTERVIEW (II, III, IV, V)

Both the interview and the clinical examination were performed by the same person, the dentist, in all but one patient where the interview was performed by the dental nurse. The wording of the questions was identical throughout the 9-year study, and the interview followed fixed forms. The question forms and all clinical procedures had been tested out in a pilot study.

In 1981, ten odontological questions were also included in the sociomedical interview. Some of these questions, slightly altered, reappeared in the dentist's question forms, and could thus serve as a check to estimate reliability. In addition to this, the computed material was subjected to logic control. The intention of this
thesis is not to give a complete account of the results of these test questions. One example of this technique, however, can be cited: In the 1981 study, the Pearson coefficient of correlation (r) calculated for the two questions, "When was the last time you visited a dentist?"-asked in the sociomedical interview and the slightly altered "How long ago did you last visit a dentist?"-asked in the oral health interview, was r=0.87 (p<0.001). The estimation of the contingency coefficient (C), which also takes into account the influence of pure chance in, was r=0.81 (p<0.001) (Anastasi 1966). The reliability of questions where personal feelings and opinions were involved seemed to be somewhat lower. For instance, similar questions about chewing problems, asked in the different interviews, showed a C value=0.69 (p<0.01).

The validity of the interview was supported by the fact that both the oral health interview and the clinical examination of each subject was performed by the same dentist. This made it possible to detect questions that did not seem to have been correctly understood and to give clarification when needed. The answers from the interview made by the dentist were used in the analysis.

CLINICAL EXAMINATION METHODS (II, III, IV, V)

CMD examination methods (II, III)

In the 1981 investigation the clinical examinations of craniomandibular dysfunction (CMD) included all the parameters necessary to complete the anamnestical and clinical indices according to Helkimo (1974). These indices, however, are rather extensive, time consuming, and tiring in elderly subjects. Thus, in 1984, -87, and -90 the number of questions and clinical registrations of CMD parameters were reduced.

The clinical examination started with an extra-oral examination and a simultaneous bilateral palpation of the temporomandibular joints. Palpation was performed at rest and during opening and closing movements with the patient sitting in an upright position. The joints were palpated laterally and posteriorly via the auditory meati to discover any irregularities on opening and closing and to register clicking or crepitus (without stethoscope) according to whether single (a distinct cracking, snapping sound) or multiple (grinding, scraping) sounds were found. Any locking or luxation during this examination was recorded. Deviation or irregular opening was recorded if the mandibular midline deviated more than 2 mm during the opening movement, as evaluated by the naked eye.
The anterior and posterior portions and the insertion of the temporal muscle in the coronoid process, the superficial and the deep portions of the masseter muscle, and the region of the lateral pterygoid muscle were palpated bilaterally. Tenderness or pain in the joints and muscles on palpation was registered only if a palpebral or protective reflex was evoked.

Maximal mouth-opening capacity was measured to the nearest mm with a plastic ruler as the distance between the superior incisor and its horizontally marked projection on the buccal surface of the lower jaw incisors. It was also measured in people with removable dentures if the dentures were stable in situ.

**Caries examination methods (IV, V)**

The criteria for a positive clinical diagnosis of caries were:

* Primary and recurrent caries was defined as a loss of tooth substance detectable when gentle probe causes the probe to stick and a definite pull is required before the probe releases (Koch 1967).

* Root caries was defined as an area softer than the surrounding tissue below the cementoenamel junction, with or without cavitation (Hix & O’Leary 1976).

* Caries encompassing both the coronal and root parts of the same tooth/surface was registered as root and coronal (primary or secondary) caries and was recorded as one decayed tooth in the DMFT index. If a tooth had only root caries it was scored in the same way as a tooth with only coronal caries. The third molars were excluded from the DMFT sums. Root remnants without enamel were recorded as one decayed tooth in the DMFT index. The incisors and the canines were, in congruence with premolars and molars, given the value of 5 surfaces Thus, the DMFS index was calculated on 140 surfaces in a 28-tooth dentition.

The tooth surface was dried by use of cotton rolls and air. New plane mirrors and Maillefers 4/6 explorers were used for the caries examination.
Periodontal examination methods (IV, V)

The prevalence of periodontal disease was estimated by registration of:

* the Attachment Level (AL) (Ramfjord et al. 1973) and of
* the Gingival Bleeding Index (GBI) (Carter & Barnes 1974, Ainamo & Bay 1975)

The GBI was measured with a pocket probe (Michigan) inserted parallel to the axis of the tooth. Bleeding was registered 10-20 seconds after probing for the AL was performed. The AL was measured from the bottom of the gingival pocket to the cemento-enamel junction. AL greater than 3 mm was noted in the protocol. The measurements were made to the nearest millimeter. If the cementoenamel junction was covered by a crown or filling, the cervical border of the restoration was used as a reference point. The percentages of bleeding sites and of sites with AL > 3 mm were calculated.

Dental status (IV, V)

Dental status was also described using the functional index according to Eichner (Eichner 1955). This index consists of three main groups: A, B, and C. Occluding teeth in the molar and premolar regions are registered. If there are occluding contacts in the premolar and molar regions bilaterally, a maximum of four supporting zones are obtained, and the person belongs to group A. Accordingly, persons with 1 to 3 supporting zones are placed in group B and those with no supporting zones in the premolar/molar regions in group C. Occlusal contacts with fixed crowns and bridges, but not with removable dentures, were included in the index. Thus, a complete denture places the wearer in Eichner group C, those without supporting zones. Groups A, B, and C can also be divided into 3, 4, and 3 subgroups respectively. Subdividing the material, however, would split the sample into as many as 10 groups, the size of which would be too small for statistical calculations.
Removable dentures (IV)

* Denture stomatitis in the oral mucosa was registered according to criteria proposed by Budtz-Jörgensen & Bertram (1970).
* Denture-related pressure sores were registered when there was a tender impression or wound in the denture-bearing mucosa.
* Dentures were assessed for stability, retention, and occlusion according to criteria proposed by Bergman et al. (1964).

Occlusal wear, fractures, missing teeth, discoloring, and surface porosities were also registered. Need for clinical treatment was registered if there were obvious esthetic, phonetic, or material problems or if the subject reported a loose denture, problems with chewing, a denture-related pressure sore or discomfort, cheilitis, or simply disliked the old denture. If the prognosis for treatment was judged to be poor because of physical and mental illness relining or rebasing was preferred before to make a new denture.

Comment

The same clinical equipment, questions, protocols, and methods were used in all investigations. The general impression was that most probands were open, honest, and cooperative and thought that the investigation was a good opportunity for receiving extra dental attention and help with problems.
INTRA-ORAL PHOTOGRAPHY (II, III, IV, V)

Intra-oral photography were taken of the subjects at all examinations using positive colour film (Kodachrome 64), and the same photographic equipment (Nikon FM with Micro Nikkor 2.8/55mm and a 2X extender with 2 electronic flashes mounted on each side of the lens system). These colour positive photographs were compared with clinical registrations to correct faulty registrations on the written forms regarding number of teeth, type of dentition and material, and condition of denture teeth and the base material (abrasion, discoloring, missing or fractured teeth).

STATISTICAL PROCEDURES

The chi-square test and the t-test for individual samples were used to evaluate differences between the samples (papers I-V). Pearson's coefficient of correlation (papers I-V) and the contingency coefficient (papers I, II) (Anastasi 1966) were used to test the correlation between parameters and reliability in interview answers. The means and proportions in two populations were regarded as different when there was no overlapping between the 95% confidence intervals (CI 95%) (Colton 1974) (papers I-V).

In paper II the impact of different sociomedical and odontological background factors on dietary intake was evaluated in a cross-sectional study of a sample of 70-, 75-, and 79-year-old people living in the city of Umeå. The attempt to analyse the impact on the dietary intake of a large, complex, and highly intercorrelated set of background factors needed a statistical method that took care of the complexity and intercorrelation of the data and made it possible to further analyse the variables in multiple regression models. Thus, a set of uncorrelated principal components was formed and used in the multiple regression analysis in order to eliminate the collinearity problem. The statistical method is described below.

A cluster analysis was used to detect natural groupings in the data. A principal components analysis (Chatfield & Chapman 1986) with rotation of the component loadings (Varimax) was performed on both the dependent and the explanatory variables. The factor scores were then used in a multi-variate analysis made by multiple regression. P ≤ 0.05 was considered statistically significant. The Systat® statistical program for the Macintosh® computer (Wilkinson 1987) was used for the calculations.
The impact on dietary intake of various background factors was analyzed in three different ways:

1. The continuous dietary intake variables were transformed into 4 orthogonal principal components. The rotated principal component scores were then used as dependent variables in a multiple regression model where the most important single background factors, which had been previously dichotomized and selected by stepwise regression, were estimated (Table 2, p. 33).

2. The dichotomized explanatory background variables were transformed into a set of 9 orthogonal principal components. The most important explanatory principal components were selected by stepwise regression and then estimated in a multiple regression model together with the same 4 dependent dietary principal components used in analysis 1.

3. The dietary intake was also compared with the RDA-S. The same set of single explanatory variables used in analysis I was used in a stepwise regression and the selected variables were then estimated in a multiple regression model. Details about the dichotomized variables and the analysis are described in paper II.

In paper III, a multiple regression analysis of principal components was performed (Table 3, p. 37) to further analyse gender differences and CMD changes with increasing age and time. Gender, age, and time per se were used as explanatory variables. The answers from the interview about CMD symptoms and the clinical findings of TMJ sounds and muscle pain were used as dependent variables. The variables were dichotomized-0=no finding and 1=unilateral finding, and 2=bilateral finding (for TMJ sounds and muscle pain) and then transformed into principal component scores which were used as variables in multiple regression models. The musculus masseter, the temporalis, and the pterygoideus lateralis were aggregated to the principal component variable "Muscle pain". Positive standardized coefficients point to a higher (in women) or increasing (with age and/or time) and negative coefficients to a lower (in men) or decreasing (with age and/or time) symptom or clinical sign. Standardized regression coefficients were then calculated in the subjects that could be properly examined 4 times during the 9-year observation period.
Principal component (PC) analysis is a statistical technique that linearly transforms an original set of variables into a smaller set of uncorrelated variables. Its purpose is to reduce the dimensionality of the original data set. A smaller set of uncorrelated variables is easier to understand and use in further analysis than a larger set of intercorrelated variables. PC analysis searches for a few linear combinations of the original variables that capture most of the information (variance) of the original variables. The orthogonal rotation most often used is Varimax (Dunteman 1989). The rotated component loadings are the PCs correlation with the original variables. To combine a PC analysis with a multiple regression model is statistically accepted (Dunteman 1989). In the present study, each of the PCs were characterized by its content of rotated component loadings with scores as high and close to 1.0 as possible. \( P \leq 0.05 \) was considered significant. The p-values calculated for the regression coefficients were tested with Post-Hoc tests. The Systat® statistical program for the Macintosh® computer (Wilkinson 1987) was used for the calculations.

RESULTS

PAPER I

Intake of energy and nutrients

The intake of energy and nutrients was compared with the recommendations given by the Swedish National Food Administration in 1981. The Swedish recommendations are known as the RDA-S values (Recommended Dietary Allowance for Sweden). The calculated 95% confidence interval (95% CI) was placed above the RDA-S for energy, protein, fat, all minerals, and all vitamins except for vitamin D. Among men, the RDA-S for vitamin D was embraced by the 95% CI, but in women the 95% CI was below the recommended mean value, indicating a vitamin D intake below the RDA-S in the female population. The RDA-S for calcium, iron, and vitamins C and D was the same for men and women. A comparison of the 95% CIs between men and women showed that the 95% CIs for calcium, iron, and vitamin D did not overlap. This indicated that women in the population also could be expected to have lower intakes than men. Figure 5 shows that intake of energy was unevenly distributed with upper extremes of 21 and 14 MJ and about 10% of the men and women below 7 and 5 MJ.
respectively. The RDA-S for energy cuts the curves at the 40% line. The intake of protein showed a similar picture and considerable parts of the sample had undesirable intakes far below the RDA-S for other important nutrients, minerals, and vitamins or far above the RDA-S for the intake of fat. The RDA-S for energy intake in men and women is marked in Fig 5.

Fig. 5. The cumulative intake of energy. The RDA-S is marked for men and women in the diagram.

**Age and sex differences in daily intakes of calcium, iron, and vitamins C and D**

Seventy-year-old men had a higher mean intake of iron (p<0.05) and vitamin D (p<0.01) than 70-year-old women. In contrast, the 70-year-old women had a higher mean intake of vitamin C (p<0.05) than the 70-year-old men. The 79-year-old men had a higher mean intake than the 79-year-old women of calcium (p<0.05), iron (p<0.001) (the 99% CIs for iron did not overlap), and of vitamin D (p<0.05). The mean intake of vitamin C was 54 mg among the 79-year-old women, clearly below the RDA-S (60 mg), compared with 94 mg in the 70-year-old women (p<0.001, the 95% CIs did not overlap).

**Energy intake from protein, fat and carbohydrates**

The mean energy intake from fat was 37.5 E% fat among men and 36.7 E% among women, i.e. above the interval for the RDA-S (25-35 E%). The 70-year-old men had 36.6 E% fat compared with 39.5 E% among the 79-year-old and the 70-year-old
women had 35.5 E% fat compared with 38.2 E% among the 79-year-olds (Fig. 6).

![Fig. 6. Per cent of energy derived from fat. RDA-S=25-35 E%. Only a few of the subjects had an energy intake from fat below the RDA-S, and 88% and 80% of the 79-year-old men and women respectively exceeded the RDA-S level.](image)

Analysis of variance for the sample showed that the E% of fat intake was age-related and increased with increasing age (p<0.05). The mean intake of energy from protein and carbohydrates seemed to compare satisfactorily with the RDA-S recommendations.

**Number of meals and dietary intake**

Men had, on the average, 4.2±0.87 (M±SD) and women 4.3±1.07 meals a day (including snacks) with a range of 2-8 (men) and 2-9 (women). The daily number of cooked meals was 2.0±0.51 among men and 1.96±0.54 among women. Men and women who had one cooked meal a day had more snacks than those who had two or three cooked meals. Men and women who had two cooked meals a day had the highest mean intakes of energy, protein, fat, carbohydrate, iron, and thiamin. Those who had one cooked meal had the lowest mean values for protein, carbohydrate, calcium, iron, retinol equivalents, thiamin, and riboflavin. An analysis of variance, however, did not reject H0: M1=M2=M3.

Men who had three cooked meals a day derived more energy from protein than those who had one or two meals (p<0.05), and women showed the same
tendency (n.s.). Women who had three cooked meals a day derived less energy from fat (p<0.05), and more from carbohydrates (p<0.05) than women who had one or two cooked meals a day. Men who had three cooked meals a day showed the same tendency as women, with the lowest E% of fat and the highest E% intake of carbohydrates, compared with men who had one or two cooked meals.

**Comparison between U70 and the population study in Gothenburg, H70**

The general tendency for the intake of energy, protein, carbohydrate, calcium, iron, thiamin, and riboflavin, was that the U70 sample showed an equal or a slightly higher intake than the H70 (Steen et al. 1977) sample. Despite the high consumption of fat in U70, the mean intake of fat in H70 was even higher. However, the 95% CIs overlapped for energy and all nutrients but retinol. The intake of retinol was considerably higher in U70 compared with in H70, and the 95% CIs differed both between the men and the women in the two cities.

There were no significant differences in the proportion of energy intake from protein in U70 (men 13.6 E%, women 14.1 E%) compared with H70 (men 13.0 E%, women 13.7 E%). Energy intake from fat did not differ between men (36.6 E% vs. 37.9 E%, n.s.), but was significantly lower in women in U70 (35.5 E%) compared with women in H70 (38.4 E%) (p<0.05).

**The combination of Ca/vitamin D and of Fe/vitamin C**

Most subjects had an intake of calcium and iron above the RDA-S. However, nearly half the sample showed levels below the RDA-S for vitamin C intake, and 55% of the men and 78% of the women had an intake of vitamin D below the RDA-S. Ten per cent of the men and 13% of the women had the combination of an intake of Ca<600 mg and of vitamin D<5.0 μg.

The intake of iron differed very little between 70- and 79-year-olds. However, 70-year-old women had an intake of 94 mg vitamin C per day compared with 54 mg/day among the 79-year-old women (95% CI). Three per cent of the 70-year-old men and 7% of the 70-year-old women had the combination of an iron intake <10 mg and a vitamin C intake <60 mg. None of the 79-year-old men but 17% of the 79-year-old women showed this combination.
Reported oral problems

In answer to a general question about oral problems, two-thirds of the probands said they had no oral problems at all. The most common problems were unsatisfactory complete dentures (14%) and denture-related pressure sores (8%). Only 2% reported temporomandibular joints that hurt and none reported chewing problems. When the question was directed towards temporomandibular joint and chewing problems, 6% reported painful joints, and 12% of the men and 15% of the women reported clicking sounds coming from the mandibular joints. Moreover, 23% of the men and 34% of the women stated they had chewing problems. In Fig. 7, reported problems and symptoms are compared with what was found in the clinical investigation.

![Fig. 7. Reported symptoms and clinical signs on CMD.](image)

There was no difference between men and women concerning reported problems, but the results from the clinical investigation of signs of CMD showed that the women in the sample had a significantly higher frequency of painful mandibular joints, crepitus, mandibular deviation, and tenderness in the masseter muscle ($p<0.05$, chi-square test). A calculation of the 95% confidence intervals for these CMD symptoms showed, in most instances, an almost complete overlapping of the intervals for men and women. For clinical findings of mandibular deviation, crepitus, and painful joints, however, the overlap of the intervals was rather small, indicating a tendency towards differences in the underlying population.
Dental status

A full denture (FD) (complete upper and lower denture) was the most common dentition and more women (46.7%) than men (27.8%) had a FD. More men (40.2%) than women (21.1%) had their own teeth and/or fixed crown and bridge prosthodontics in both jaws. Five to ten per cent of the men and women had complete upper denture and natural teeth or a partial denture in the lower jaw. Between two and five per cent had complete upper dentures and were edentulous in the lower jaw or were totally edentulous and without dentures. The rest of the men (11%) and women (13.2%) had various combinations of complete and partial dentures and natural teeth.

A total 49.5% of the men and 67.1% of the women had had or were still wearing a complete denture in one or both jaws. Fifty per cent of the women and 36.1% of the men were edentulous.

The dietary intake

The mean intake of energy and most nutrients, minerals, and vitamins was satisfactory according to the RDA-S. Among women, however, the mean intake of vitamin D among women was below the allowance. A calculation of the 95% CIs showed that women, although the same RDA-S, could be expected to have lower intakes of calcium, iron, and vitamin D, than men.

Although the mean intake for the population in general was satisfactory, there were many individuals with low intakes. A comparison with the RDA-S showed that approximately one-third of the subjects had an intake of energy and protein below the recommended levels. Only about half the sample had a satisfactory intake of vitamin C and 55% of the men and 78 per cent of the women had an intake of vitamin D below the RDA-S. Approximately 60% of the probands had a fat intake above the Swedish recommendation.

Dental status and dietary intake

In the present study, none of the 6 men and 5 women in Eichner group A reported chewing problems (Fig 8). In Eichner group B (38 men and 21 women)-subjects with 1-3 supporting zones-11% of the men and 29% of the women stated that they had chewing problems, and in group C (50 men and 63 women)-those without supporting zones, mainly complete denture wearers-36% of the men and
38% of the women reported chewing problems. The food reported to cause the greatest chewing problems were, in decreasing frequency, meat, hard bread, and soft bread, with the addition in group C of raw vegetables and fruit.

![Chart](image)

**Fig. 8.** Per cent of subjects in the main Eichner groups A, B, and C that stated chewing problems.

**Energy intake in contrasting groups**

The energy intake was strongly correlated to the intake of protein, fat, and carbohydrates (r=0.88-0.92), to iron, potassium, and calcium (r=0.69-0.89) and to thiamin and riboflavin (r=0.77-0.85). Vitamin D (r=0.55) showed a moderately good correlation to energy and retinol (r=0.28) and vitamin C (r=0.21) a weak correlation. Because of this high correlation between energy and most nutrients, minerals, and vitamins, energy intake was used as a representative variable to describe the difference between the dichotomized background factors (contrasting groups) in a simple way. Men with subjective chewing problems had on the average 234 kcal less energy intake than those without chewing problems; the corresponding figure for women was 190 kcal. Men and women who reported CMD problems had 127 kcal less energy intake than those who did not report CMD problems, and those feeling healthy and those not feeling lonely also reported a higher energy intake of between 118 - 133 kcal than those not feeling healthy and those feeling lonely.
The multiple regression models with the 4 dependent principal components (PCs) A, B, C, and D and with the set of 14 single background variables (Table 2).

**Table 2.** Using principal component analysis, 19 dietary variables were transformed to a set of PCs called A, B, C, and D. Single predicting variables were then chosen by stepwise regression and estimated in a multiple regression model.

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<tr>
<td></td>
<td>Upper denture status/ Eichner index</td>
<td>-0.11</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>

PCs A, B, C, and D are defined under statistical methods, and showed that women (p≤0.01) and individuals with subjective chewing problems (p≤0.05) had a significantly reduced intake of the contents of PC A, while people with less education had an increased intake of A (p≤0.05).

For PC B no predictor was found.

Female sex (p<0.01), reported mandibular dysfunction problems (p≤0.05), and less education (p≤0.05) showed a negative influence on the intake of PC C, while stomach pain (p=0.01) seemed to have a positive co-variation with C. Women (p<0.001), higher education (p<0.05) a "better" Eichner index (p=0.06) were associated with a lower intake of alcohol/and more vitamin D. Those who reported CMD problems had less alcohol/vitamin D (p>0.05).

Higher age was connected with a reduced intake of vitamin C (p=0.01).
In analysis 2, both the dependent and the explanatory variables were represented by sets of PCs, defined under statistical methods. The 27 background variables from analysis I formed a new set of PC's and the PC's from analysis I were used as dependent variables. Predicting PC's were chosen by stepwise regression and estimated in a multiple regression model.

Female sex ($p<0.01$) had the strongest negative influence on the "main" dietary PC variable A (energy, protein, fat, carbohydrates, all minerals, vitamins B1, B2, B6, and D. Living alone/feeling lonely ($p<0.05$) and having CMD symptoms ($p=0.07$) were also found to have negative standardized regression coefficients, i.e. were connected with a reduced intake of PC A. Predictors for the intake of vitamin D/alcohol were found to be relatively strong and a bad upper denture status, an Eichner index indicating fewer supporting zones, female sex, and stomach pain, were all connected to a reduced intake of vitamin D and alcohol ($p<0.001$). Female sex was connected to an increased intake of vitamin C ($p<0.05$), and a worse upper denture status/Eichner index predicted a lower vitamin C intake, although not statistically significant ($p=0.06$).

In analysis 3, the dietary intake defined as being below or above the RDA-S was studied. The same set of explanatory variables used in analysis 1 was used again. The stepwise regression picked out chewing problems, education and age for the PC A, representing energy, protein, fat, carbohydrates, all minerals, and vitamins B1, B2, B6, and D. Those with chewing problems had a significantly higher frequency of subjects with intakes below the RDA-S for PC A ($p<0.05$). The PC represented mainly by vitamin C showed a negative correlation with greater age ($p=0.05$). No predictor was found for the calcium/iron PC. Finally, for the PC representing the vitamin D intake, female sex ($p<0.01$) and reported CMD problems ($p<0.05$) seemed to be overrepresented among those with intakes below the allowance.

PAPER III

The paper on craniomandibular dysfunction (CMD) comprises a longitudinal observation of a 70- and a 79-year-old cohort from 1981 to 1990, an analysis of the persistence of different CMD signs in the subjects that could be followed during the 9-year observation period and a cross-sectional comparison of 70-year-olds examined in 1981 and 1990.
Reported CMD symptoms

There was a general tendency for the frequency of reported symptoms to decrease in both age cohorts of men and women during the 9-year period. This tendency was stronger in the 79-year-old age-group. For instance, about 20% of the 79-year-olds reported clenching or grinding their teeth in 1981 compared with only a few per cent of the 88-year-old women and none of the 88-year-old men in 1990.

Luxation or locking of the mandibular condyle was reported by 8.6% and 16.7% of the 79-year-old men and women respectively in 1981 and by none of the 88-year-olds nine years later. The 88-year-old men reported no CMD symptoms at all in 1990. It should, however, be mentioned that the frequency of the "Don't know" alternative answered by the older cohort increased almost as much as the decrease in reported symptoms. The only reported problem that seemed to increase during the 9-year period was chewing problems. In 1981 22% of the 70-year-old men reported chewing problems compared with 28% in the new cohort in 1990. The corresponding figures for chewing problems in 70-year-old women was 13% and 21% in 1981 and 1990 respectively.

Comparisons between the "old" 70-year-old cohort examined in 1981 and the "new" 70-year-old cohort studied in 1990 showed in general a lower frequency of reported symptoms in the "new" cohort. Pain in the face, neck, or back of the head was much less common in the "new" 70-year-old cohort and a calculation of the 95% CI showed that this difference could also be expected in the underlying 70-year-old population of women (p<0.05).

Clinical CMD signs

The overall result was that the frequency of TMJ sounds-clicking and crepitus-increased in all cohorts, during the 9-year period except for the 79-year-old male cohort. The 79-year-old men and women showed the highest frequency of clicking in 1990, 33% and 34% respectively, and the 88-year-old women showed the highest frequency of crepitus in 1990, 47.1%.

Pain on palpation of the masseter, the temporalis, and the pterygoideus lateralis muscles was a common finding and the frequency of muscle pain increased during the 9-year observation period among both men and women. In general the masseter muscle showed the lowest (range 6-32%) and the pterygoideus lateralis muscle the highest frequency (range 30-71%) of muscle pain on palpation with the highest figure among 88-year-old women. The frequency of
mandibular deviation increased in all cohorts during the 9-year period (range 37-71%) with the highest frequency among 88-year-old women and the lowest in 70-year-old men in 1981.

There was no difference in the frequency of joint sounds between the 70-year-old cohorts examined in 1981 and 1990. Women in both cohorts however, showed in general a tendency towards higher frequencies of muscle pain than men. There was also a general tendency towards a higher frequency of muscle pain in the "new" 70-year-olds cohort in 1990 compared with the 70-year-old examined in 1981. The frequency of deviation in the "new" 70-year-old cohorts of men (72%) and women (82%) was higher than in the "old" cohorts (men=44%, women=50%) and the 95% CI indicated that this difference could be expected in the 70-year-old population of men and women in Umeå. Pain on palpation of the TMJs was much more uncommon in comparison to muscle pain and other CMD signs. In 1981 only 6% of the joints in the 70-year-olds showed a pain reaction on palpation compared with none of the "new" 70-year-olds examined in 1990.

Multiple regression analysis of principal components

The analysis showed that reported bruxism (p≤0.05) and TMJ luxation or locking (p≤0.05) decreased with time during the 9-year period (Table 3). Women reported in general more pain than men, and headache was more common among women (p≤0.001) according to the regression analysis. A decrease in reports of pain from the head, face, and neck (p≤0.001) and of headache (p≤0.05) was found with increasing age.

Chewing problems, which are not necessarily associated with CMD findings, increased in frequency in the course of time in all cohorts and the multiple regression analysis showed a statistically significant increase in reported chewing problems with increasing age (p<0.05).

The analysis of clinical signs of CMD showed that women had more crepitus (p≤0.001) and muscle pain (p≤0.01) than men. Mandibular deviation increased with increasing time (p≤0.001) and muscle pain increased with age (p≤0.05) and time (p≤0.05).
Table 3. CMD differences according to gender and changes with increasing age and time. Multiple regression analysis of reported symptoms and clinical signs of CMD. A negative standardized regression coefficient for the explanatory variables age and time, indicates a decreasing finding. A positive coefficient indicate that the finding is more common in females.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Sex</th>
<th>Age</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reported symptoms:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clenching or grinding teeth</td>
<td>0.05</td>
<td>-0.04</td>
<td>-0.12*</td>
</tr>
<tr>
<td>Suffer from head, face or neck pain</td>
<td>0.03</td>
<td>-0.16***</td>
<td>-0.19***</td>
</tr>
<tr>
<td>Suffer from headache</td>
<td>0.30***</td>
<td>-0.13*</td>
<td>0.03</td>
</tr>
<tr>
<td>TMJ luxation or locking</td>
<td>-0.02</td>
<td>0.10</td>
<td>-0.21*</td>
</tr>
<tr>
<td>Have problems to swallow</td>
<td>0.05</td>
<td>0.04</td>
<td>-0.12</td>
</tr>
<tr>
<td>Have chewing problems</td>
<td>0.04</td>
<td>0.13*</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical signs:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clicking sounds</td>
<td>0.05</td>
<td>-0.08</td>
<td>0.02</td>
</tr>
<tr>
<td>Crepitus</td>
<td>0.18***</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Mandibular deviation</td>
<td>0.08</td>
<td>-0.05</td>
<td>0.20***</td>
</tr>
<tr>
<td>Muscle pain</td>
<td>0.16**</td>
<td>0.14*</td>
<td>0.14*</td>
</tr>
</tbody>
</table>

*p ≤ 0.05 > 0.01  **p ≤ 0.01 > 0.001  ***p ≤ 0.001

Individual changes of CMD signs

In 1981 clicking was registered in 30 of the 126 joints (23.8%) that could be re-examined in 1990. Of these 30, 17 (56.7%) were still clicking in 1990; in addition 24 of the joints not registrated for clicking in 1981 had begun to click by 1990. Thus, 32.5% of the joints were clicking in 1990. The frequency of crepitus increased from 29.4% in 1981 to 36.5% in 1990. Nine (32.1%) of the 28 joints registering crepitus for the first time in 1990 had had clicking sounds in 1981.

In 1981 mandibular deviation was registered in 29 of 61 persons (47.5%) (Fig. 9). At the follow-up in 1990, 24 of these subjects (82.8%) deviated to the same side and 5 now deviated to the opposite side. Moreover, in 1990, 11 subjects that had shown no deviation in 1981 deviated to the left and 4 to the right. Altogether, a total of 72.1% deviated in 1990. In 1981 72.4% and in 1990 65.9% of the deviating mandibles deviated to the left.
The maximal opening capacity showed a mean decrease of 1.3 mm in men (range=35-66 mm) and a 0.9 mm mean decrease in women (range= 35-58 mm) during the 9-year observation time. In 1981 12.1% (8 subjects) and in 1990 13.6% (9 subjects) had a maximal opening <40 mm. Four of the 8 subjects with a maximal opening capacity <40 mm in 1981 also had an opening <40 mm in 1990 and the other 4 had improved to just above 40 mm in 1990.

Changes in muscle pain in the masseter (122 separate muscles), the temporalis (122 separate muscles), and the pterygoideus lateralis muscles (119 separate muscles) could be evaluated in 61 persons examined in both 1981 and 1990. More than 80% of the muscles painful in 1981 were still painful in 1990, and 42% of the muscles without pain in 1981 had become painful in 1990. Sixty-three per cent of the muscles had the same status in 1981 and 1990. Only 4% of the muscles had become "better" during the observation period.

Individual changes in reported chewing problems

Fifteen of 66 people (22.7%) interviewed in both 1981 and 1990 reported chewing problems in 1981. Ten of the 15 subjects still had chewing problems nine years later. A correlation between the Eichner index and chewing problems showed
that 30.6% of Eichner group C (those without supporting zones, mainly complete denture wearers) in 1981 and 44.7% of group C in 1990 reported problems with chewing food.

A multiple regression model was performed using chewing problems and the various signs and symptoms of CMD shown in Table 3 (p.37) as the dependent variables and subjective medical health and the Eichner index as explanatory variables. A impaired dental status defined by the Eichner index (std reg coeff=0.24, p<0.001), muscle pain (std reg coeff=0.22, p<0.01), and poor subjective medical health (std reg coeff=0.13, p<0.05) were estimated to be the most important variables in explaining chewing problems.

PAPER IV

Annual visits to a dentist

In 1981 39% of the 70- and 27% of the 79-year-olds stated annual dental visits and 37% and 24% respectively reported being called by the dentist. Nine years later, in 1990, 52% of the younger cohort and 25% of the older cohort, now 79 and 88 years old, stated annual visits and 50% and 26% respectively reported being called to the oral examination by the dentist. A cross tabulation of the questions "How often do you visit a dentist?" and "Did the dentist call you or did you call yourself?" showed that of the 70-year-old men and women studied in 1981 that stated annual visits to a dentist, 75% were recalled by the dentist. Furthermore, all the 79-year-old men and 90% of the 79-year-old women with at least one visit per year were also recalled in 1981. In 1990 this picture was even more unequivocal in that a 100% of the 79- and 88-year-olds visiting the dentist at least once a year reported that they were recalled by the dentist. Only 15% of the 70- and 79-year-old and none of the 88-year-old complete denture wearers were called by the dentist in 1990.

The subjects were also questioned about the Dental Insurance System, "Do you know about the Dental Insurance System? What does it mean financially?" At this time, 1981, the economic rules were easy to understand and remember: the insurance covered half the total cost and the patient the rest. This question was asked in the sociomedical interview but was not repeated in the studies after 1981 because the rules changed and became more and more complicated. In 1981 an average of 15% knew the economic rules for the Dental Insurance. A cross-tabulation showed that 23% of those who said that they had visited a dentist less
than three years ago knew the right answer compared with 2% of the others (chi-square, p<0.01). Of the nine 70-year-old men giving the right answer, eight had been to the dentist less than three years ago. There was no statistically significant difference according to age, gender, or education.

The physician in the sociomedical interview in the study in 1981 also asked one question about personal feelings before a dental appointment. It showed that more than 20% of the subjects felt uneasy or scared before an appointment with the dentist. A cross-tabulation showed that uneasy feelings or fear were just as common among complete denture wearers as among individuals with their own biological teeth. Moreover, there was no statistically significant difference according to age, gender, frequency of dental appointments, reported dental or denture problems, chewing problems, or differences in the Eichner index. This question was also dropped in the follow-up studies.

**Subjective oral problems**

In all studies the participants were asked these two questions:"Do you have any problems in your mouth or jaws now?" and "Do you think you need oral treatment now?" In 1981, 76% of the younger and 67% of the older cohort reported no oral problems. Nine years later the corresponding frequencies were 63% and 60% respectively. There was very little change in the pattern of oral problems over time. The majority of problems were related to removable dentures and 15 and 27% of the 70- and 79-year-olds in 1981 and 22% and 23% of the same cohorts in 1990 reported denture problems. There was no difference between the age groups concerning oral treatment need, but more men reported an oral treatment need in 1990: 47% and 21% of the 79- and 88-year-old men stated a treatment need compared with 15% of the 79- and none of the 88-year-old women. The 95% CIs indicated a gender difference in the population.

A cross-tabulation of the frequency of dental appointments and of reported treatment need in 1981 and 1990 showed that the reported treatment need was statistically significant more often found among those with irregular dental appointments than among those who stated annual visits (chi-square test, p<0.001). It should also be noted that 13% of the 88-year-olds did not know the answer or left the question blank.
Number and distribution of teeth

In 1981, 31.3% and 34.3% of the 70- and 79-year-old men were edentulous compared with 53.3% and 50% respectively of the 70- and 79-year-old cohorts of women. In 1990 the frequency of edentulousness had changed in the group of survivors compared with the sample examined in 1981 and 26.7% and 42.9% of the 79- and 88-year-old men and 48.0% and 47.1% of the corresponding age groups of women were now edentulous in both jaws.

Most dentated subjects only lost one or two teeth during the 9-year period, but one 79-year-old man lost all 9 of his teeth in the lower jaw and became edentulous in both jaws. One 79-year-old women lost 5 teeth in her lower jaw, but she maintained all 11 of her teeth in the upper jaw throughout the 9-year observation period. The picture of the distribution and losses of teeth was similar among men and women, but in the older cohort the front region, especially in the lower jaw, became markedly reduced.

The incidence of tooth loss in 23 dentate 70-year-old subjects followed from 1981 to 1990 was 0.12 teeth/year in the upper and 0.07 teeth/year in the lower jaw and the dentate 79-year-olds (n=17) lost 0.12 teeth in the upper and 0.22 teeth per year in the lower jaw during the 9-year period. A total of 39 teeth (1.7 teeth/subjects) were lost in the younger cohort and 44 teeth (2.6 teeth/subject) in the older cohort from 1981 to 1990.

The changes in the distribution of teeth among the 40 dentated subjects in the 70- and 79-year-old cohorts examined in 1981 that could be re-examined in 1990 are shown in Fig. 10.

A cross-tabulation between functional status (Eichner index) and educational level based on the results from 1981 showed that both the 70- and the 79-year-olds with more than six years of elementary school had a better functional status (chi-square test, p<0.01) than the majority (82.6%) with six years of education or less. This difference, however, was not found among the survivors after the 9-year period.
Dental caries

DMFS among the 88-year-old showed that more than 80% of tooth surfaces were missing, filled, or decayed compared with approximately 75% of the 79-year-olds in both 1981 and 1990 and 71% of the 70-year-olds (Table 4).

The frequency of DS was higher in the 70-year-old cohort than in the 79-year-old cohort in 1981 (95% CI). DT and DS showed a higher frequency in the 88-year-old than in the 79-year-old cohort in 1990 (95% CI). The decrease in the frequency of recurrent caries during the 9-year period in the older cohort could also be expected in the population (95% CI). The 79-year-olds showed a higher frequency of decayed root surfaces compared with the 70-year-olds in 1981 (95% CI), and the younger cohort showed a significant increase of root caries from 1981 to 1990 (95% CI). The number of sound teeth without fillings, crowns, or caries changed very little in the younger cohort (from 3.44 to 3.34) but more markedly in the older cohort (from 3.47 to 2.65) during the 9-year period.
Table 4. Longitudinal changes in DMFT and DMFS and in the proportion of teeth with recurrent and primary and root caries in the 23 dentate 70-year-olds and 16 dentate 79-year-olds examined in 1981 that could be re-examined in 1990. Per cent of the number and surfaces of teeth present in 1981 and 1990.

<table>
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<tbody>
<tr>
<td>DMFT</td>
<td>87.7 - 88.0</td>
<td>87.6 - 90.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DT</td>
<td>1.3 - 0.3 †</td>
<td>4.7 - 3.6 †</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FT</td>
<td>80.2 - 80.9</td>
<td>76.1 - 77.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMFS</td>
<td>71.3 - 75.1</td>
<td>74.7 - 81.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DS</td>
<td>0.5* - 0.1 †</td>
<td>3.1* - 3.8 †</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>55.5 - 59.6</td>
<td>58.1 - 58.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent caries</td>
<td>7.9 - 4.3</td>
<td>14.6 - 3.9 ‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary caries</td>
<td>1.3 - 0.3</td>
<td>2.9 - 0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root caries</td>
<td>0.2* - 3.6 †</td>
<td>8.6* - 6.8</td>
<td></td>
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</tbody>
</table>

Number of teeth 419 380 242 198

* Cohort difference in 1981: 95% CIs do not overlap.
† Cohort difference in 1990: 95% CIs do not overlap.
‡ Longitudinal change from 1981 to 1990: 95% CIs do not overlap.

GBI and AL

The GBI could not be registered in one nor AL in two 88-year-old bedridden dentate subjects (Table 5).

Table 5. Longitudinal changes in the proportion (%) of bleeding surfaces and of surfaces with an attachment level >3 mm in the dentate 70- and 79-year-olds examined in 1981 that could be re-examined in 1990. The total number of teeth were multiplied by factor 4 and 5 respectively to calculate the number of surfaces registered for bleeding and attachment level.

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<tbody>
<tr>
<td>Bleeding sites</td>
<td>30.0* - 24.0 ††</td>
<td>37.8* - 37.4 †</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachment level &gt; 3mm</td>
<td>14.3* - 16.6 †</td>
<td>23.9* - 40.3 ††</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total number of teeth 395 - 361 229 - 193

* Cohort difference in 1981: 95% CIs do not overlap.
† Cohort difference in 1990: 95% CIs do not overlap.
‡ Longitudinal change from 1981-1990; 95% CIs do not overlap.
The frequency of bleeding sites was higher in the older cohort compared with the younger in both 1981 and 1990 (95% CI). In the younger cohort, however, bleeding decreased during the 9-year period (95% CI). The frequency of sites with an AL >3 mm was also higher in the older cohort than in the younger cohort in both 1981 and 1990 and increased in the older cohort from 1981 to 1990 (95% CI).

Denture-related mucosal lesions

Forty-one to 65% of the subjects with removable dentures (RD) showed denture stomatitis in the upper mucosa and 10-33% in the lower mucosa. The frequency of denture-related pressure lesions was 0-9% in the upper mucosa and 7-26% in the lower mucosa. Fifteen to 23% of the denture wearers reported RD problems and reports of problems with dry mouth was common in all age groups (26-45%). It was surprising that the oldest age cohort, the 88-year old, reported the lowest prevalence of dry mouth, 26%. About 25% of the 79- and 88-year-olds showed clinical signs of denture-related pressure lesions, but none reported such problems in 1990. In 1981 the frequency of angular cheilitis was 10% of the total sample compared with 17% among the survivors in 1990. Four percent of those without dentures had angular cheilitis in 1981 compared with 21% of the subjects with a denture stomatitis in the palatal mucosa. The corresponding figures among the survivors in 1990 were 4% and 38%. There were no statistically significant differences according to age or gender concerning denture stomatitis, denture-related pressure lesions, reported denture problems, or dry mouth.

Estimated and reported removable denture (RD) treatment need

Thirty-one to 88% of the subjects with old FDs were estimated to have a treatment need for new full dentures (FDs) in both jaws. During the 9-year period, both cohorts exhibited statistically significant decreases in the need for new FDs and statistically significant increases in the need for RD adjustments (95% CI).

The total clinical RD treatment need is the sum of FD, CD and RPD treatment needed per cent of the total number of jaws with RDs shown within parenthesis (note that one FD=2 jaws). Between 29% and 54% of the cohorts reported an RD treatment need with the lowest frequency among the oldest subjects. A general question about oral problems was asked in 1981 and 1990, and no correlation was found between the clinical findings of denture-related pressure lesions and the treatment need reported. The common view was that "denture problems come
and go and you get used to them”.

Table 6. Longitudinal changes and cross-sectional differences in estimated clinical treatment need for removable dentures (RDs) as percentages of the total number of subjects with complete dentures in one jaw (CDs), or in both jaws=full dentures (FDs) and the per cent of jaws with removable partial dentures (RPDs). The number of CDs, FDs, and RPDs present are shown within parentheses. The question ”Do you need denture treatment” was asked, and the reported RD treatment need is shown in per cent of subjects with RDs within parenthesis.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Need a new FD</td>
<td>(15) 46.7*</td>
<td>(24) 87.5* - 50.0 (16)+</td>
<td>(26) 76.9 - 30.8 (13)+</td>
</tr>
<tr>
<td>Need FD adjustment</td>
<td>6.7</td>
<td>4.2 - 31.3+</td>
<td>23.1 - 61.5+</td>
</tr>
<tr>
<td>Need a new CD</td>
<td>(19) 21.1</td>
<td>(7) 40.0 - 33.3 (3)</td>
<td>(10) 66.7 - 28.6 (7)</td>
</tr>
<tr>
<td>Need CD adjustment</td>
<td>10.5</td>
<td>40.0 - 33.3</td>
<td>0.0 - 14.3</td>
</tr>
<tr>
<td>Need a new RPD</td>
<td>(15) 13.3</td>
<td>(9) 11.1 - 12.5 (8)</td>
<td>(10) 50.0 - 0.0 (7)</td>
</tr>
<tr>
<td>Need RPD adjustment</td>
<td>13.3</td>
<td>33.3 - 37.5</td>
<td>0.0 - 57.1</td>
</tr>
<tr>
<td>Reported RD treatment need</td>
<td>(42) 35.8</td>
<td>(37) 54.1 - 43.5 (23)</td>
<td>(39) 46.2 - 29.2 (24)</td>
</tr>
<tr>
<td>Total clinical RD treatment need</td>
<td>(64) 57.1*</td>
<td>(64) 81.1* - 73.9 (43)</td>
<td>(72) 92.3 - 75.0 (40)</td>
</tr>
<tr>
<td>Proportion of subjects with RD</td>
<td>70.0</td>
<td>59.7 - 57.5</td>
<td>60.0 - 77.4</td>
</tr>
</tbody>
</table>

| Number of subjects | 60 | 62 - 40 | 65 - 31 |

* Cohort difference between the 70-year-olds in 1981 and 1990: 95% CIs do not overlap.
† Longitudinal change from 1981 to 1990: 95% CIs do not overlap.

PAPER V

Visits to the dentist and subjective treatment need

In this paper a comparison was made between two 70-year-old cohorts examined in 1981 and 1990 respectively.

A comparison of answers to questions about visits to the dentist showed a higher frequency of visits "at least once a year" (men: p≤0.001; women: p≤0.05) and of the dentist calling for an appointment (men: p≤0.01) for 70-year-olds in 1990 compared with in 1981 (Table 7). A calculation of the 95% CI showed that the increase in dental visits could also be expected among men in the population. In 1981 41.9% of the total sample reported a need for dental treatment compared with 26.7% in the "new" 70-year-old sample in 1990 (n.s.). The difference in
subjective dental treatment need between men and women was very small in both investigations.

**Table 7. Answers to questions about dental visits and subjective treatment need among 70-year old men and women in 1981 and 1990. Per cent of the two 70-year-old cohorts.**

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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you visit a dentist?</td>
<td>At least once a year</td>
<td>31.3</td>
<td>68.8 **#</td>
<td>40.0</td>
<td>67.9 *</td>
</tr>
<tr>
<td></td>
<td>Never or only acute</td>
<td>68.7</td>
<td>31.2</td>
<td>60.0</td>
<td>32.1</td>
</tr>
<tr>
<td>Did the dentist call you for an appointment?</td>
<td>Yes</td>
<td>28.1</td>
<td>65.6 **#</td>
<td>46.7</td>
<td>64.3 n.s.</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>71.9</td>
<td>34.4</td>
<td>53.3</td>
<td>35.7</td>
</tr>
<tr>
<td>Do you think you need treatment now?</td>
<td>Yes</td>
<td>43.8</td>
<td>25.0 n.s.</td>
<td>40.0</td>
<td>28.6 n.s.</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>56.2</td>
<td>75.0</td>
<td>60.0</td>
<td>71.4</td>
</tr>
</tbody>
</table>

No of subjects 32 32 30 28

chi-square test ** p≤0.01, * p≤0.05, # A calculation of the 95% CIs show that a difference could also be expected in the underlying population.

A cross-tabulation of the questions "How often do you visit a dentist?" and "Did the dentist call you for the appointment?" showed that 75% in 1981 and all in 1990 who reported visiting the dentist "at least every second year" were called by the dentist (p≤0.001). In 1990 92.3% of those who were called by their dentist had at least one remaining tooth.

The question "Do you have any problems in your mouth or jaws now?" showed that 68.8% of the men in both 1981 and 1990 reported that they had no oral problems compared with 83.3% and 71.4% of the women in 1981 and 1990 respectively. About 20% of the men stated denture and 10% dental problems in both cohorts compared with a more even distribution of denture and dental problems in the cohorts of women.
Number and distribution of teeth

The mean number of teeth in dentated men and women in 1981/1990 was 17.4±5.4/12.8±6.6 (95% CI) and 16.9±6.3/13.9±8.4 (n.s.) respectively. The 95% CIs indicated a lower mean number of teeth in men in 1990. The range of teeth in the 70-year-old men also changed from 6 - 24 to 1 - 25 teeth and from 7 - 27 to 2 - 25 teeth in dentated women from 1981 to 1990. The frequency of totally edentulous 70-year-old subjects had changed from 31% to 21% in men and from 53% to 36% in women during the 9-year period from 1981 to 1990 (n.s).

The distribution of teeth in the upper and lower jaws in 1981 and 1990 is shown in Fig. 11.

![Fig 11. The distribution of remaining teeth in 70-year-old men and women in two cohorts examined in 1981 and 1990 respectively. Per cent of remaining teeth in dentated subjects.](image)

The figure shows that both the 70-year-old men and women examined in 1981 had a higher percentage of remaining teeth in the front regions than the "new" 70-year-old cohorts examined 9 years later. The frequency of teeth in the front regions in the lower jaws was higher than in the upper jaws in both sexes. In dentated women about 80% of the six upper front teeth persisted compared with almost one hundred percent of the lower front teeth. Dentated men showed a similar picture, however, with a lower frequency of remaining teeth.

A comparison of the Eichner functional index (Eichner 1955) showed only small differences between the two cohorts (Fig. 12). The tendency (n.s) in men, however, was for group A (those with a good functional status) to decrease and
group C (those without supporting zones) to increase over the 9-year period.

Fig. 12. Distribution of the Eichner functional index calculated on remaining teeth and fixed crown-and-bridge restorations. The main groups A (with four supporting zones), B (1-3 zones) and C (without supporting zones) in the two 70-year-old cohorts examined in 1981 and 1990 respectively are shown.

**Dental caries**

The mean value for DMFT in 1981 was almost equal to that calculated in 1990 (Table 8) although the standard deviation differed.

**Table 8. DMFT calculated on 28 teeth in dentated 70-year-old men and women studied in 1981 and in 1990. Mean ± SD of the number of filled (FT), decayed (DT) and missing (MT) teeth in dentated men and women in the two samples.**

<table>
<thead>
<tr>
<th>Study year</th>
<th>Men</th>
<th></th>
<th></th>
<th>Women</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1981</td>
<td></td>
<td></td>
<td>1981</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>DMFT</td>
<td>23.4</td>
<td>3.0</td>
<td>25.3</td>
<td>2.7</td>
<td>25.4</td>
<td>2.6</td>
</tr>
<tr>
<td>FT</td>
<td>12.6</td>
<td>4.7</td>
<td>10.0</td>
<td>6.1</td>
<td>14.3</td>
<td>5.8</td>
</tr>
<tr>
<td>DT</td>
<td>0.2</td>
<td>0.7</td>
<td>0.1</td>
<td>0.3</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>MT</td>
<td>10.6</td>
<td>5.4</td>
<td>15.2</td>
<td>6.6</td>
<td>11.1</td>
<td>6.3</td>
</tr>
</tbody>
</table>

* The 95% CIs do not overlap, indicating a cohort difference in the population.
The most obvious difference in 1990 was a clearly higher number of missing teeth and of teeth with carious lesions in the root cementum. A calculation of the 95% CIs indicated that the difference in the number of missing teeth and of carious lesions in the root cementum could be expected in the population of men. The number of recurrent carious lesions was lower in men as well as in women in 1990 and the 95% CIs calculated for 1981 and 1990 indicated such a difference in the population. In 1981 23.8% of the men and 57.1% of the women were free from carious lesions compared with 60% and 66.7% respectively in 1990. The 95% CIs calculated for the male cohorts indicated such an improvement in the population of men but no change in the female population.

**GBI and AL**

The frequency of bleeding sites was similar in men and women in both 1981 and 1990 (Table 9).

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th></th>
<th></th>
<th>Women</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding sites</td>
<td>30.6</td>
<td>29.4</td>
<td>32.2</td>
<td>28.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachment level &gt; 3 mm</td>
<td>22.1</td>
<td>33.8</td>
<td>9.8</td>
<td>15.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of teeth</td>
<td>22</td>
<td>25</td>
<td>14</td>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both men and women showed a higher frequency of sites with an attachment level > 3 mm in 1990 than in 1981. The male cohorts in 1981 and 1990 showed higher frequencies of an AL > 3 mm than the female cohorts in 1981 and 1990 respectively. The 95% CIs did not overlap, indicating a population difference. The amount of standard deviation was high, indicating an uneven distribution of periodontal diseases.
GENERAL DISCUSSION

A couple of decades into the next century every fifth Swedish inhabitant will be 65 years of age or more, and epidemiologic studies of oral health in the elderly Swedish population show a growing proportion of elderly people with natural teeth left (Österberg & Carlsson 1995). Dietary habits and intakes of essential nutrients are important for general well-being and to satisfy the changing needs of an ageing body (Isaksson 1975). Eating is also said to be the last pleasure left in late life that comforts us for the loss of all the others (Brillat-Savarin 1826). The overall objectives of the present study were to describe oral health (II, III, IV, V) and dietary habits (I, II) in an ageing city population and to estimate the impact of dental status and function on dietary habits and intakes of different food items and nutrients (II).

Epidemiological, statistical and general considerations

There is a distinction between clinical and epidemiological studies. Clinical studies describe patients, and epidemiological studies describe people in relation to the population to which they belong (Barker & Rose 1984). The prevalence rates define the proportion of people in a population who are affected by a disease at one particular time. The number of cases of a disease present in an area - the prevalence - is composed of the frequency with which new cases occur and are diagnosed - the incidence - and the average duration before the disease is terminated by either recovery or death. Prevalence rates can differ greatly in diseases of short-term character such as an epidemic influenza, and the prevalence will be much lower than the monthly incidence. On the other hand, the annual incidence for a chronic disease is often much lower than the prevalence at a certain time. Incidence rates express the rate of occurrence of new cases and may be defined as the frequency of some event related to disease during a specified period of time. Most incidence figures are annual incidences; however, incidence may be estimated over any period of time. Incidence rates have an advantage over prevalence rates in being uninfluenced by the duration of the disease and are thus of interest in longitudinal studies. The age distribution of a disease reflect the influences of many changing biological, behavioural, and life style factors. The elderly manifest the cumulative effects of environmental influences and the life-time experiences of different age cohorts, so-called cohort effects. The age at which a disease occurs and the frequency of a disease in
different age groups not only reflects changes associated with ageing but also the differing experiences of different age cohorts. For instance, dental status has been shown to differ between age groups and rural and densely-populated areas (Lundqvist 1967, Axéll & Öwall 1979, Palmqvist 1986, Salonen 1990, Wigren et al 1993, Österberg et al 1995).

Changes in the prevalence figures as a result of ageing are *age effects*; those associated with the birth cohort examined are *cohort effects*; and those that occur with increasing time are *time effects*. The use of several cohorts and age groups in longitudinal studies sometimes makes it possible to estimate the impact of age, birth cohort, and time. However, the interpretation of what is age, cohort, and time effects is a delicate task, and this must be born in mind when results are evaluated.

One way to estimate the effects of age, cohort, and time is to use all the information available, including the results from those who did not want to or could not participate in all four examinations, and to analyse the total material with multiple regression methods (II, III).

*The U70 sample*

There was no intention in 1981 to make plans for a longitudinal design of the U70 study. The sample sizes of men and women were chosen to be sufficiently large to generate a normal distribution of the prevalence means of the samples in 1981. According to the central limit theorem, sample sizes of at least 20 generate a normal distribution of the means of the samples. To analyse the results and to deal with the statistical problems associated with small samples, the statistical analyses were performed with multifactorial methods in papers II and III. However, the prevalence means in men and women in 1981 and the cohort comparison of 70-year-olds in 1981 and 1990, were sufficiently good estimates of the underlying populations sampled. A larger sample size would probably have increased the possibility of detecting age and gender differences and changes by time, but the multifactorial approach still generated some interesting results. The size of the sample was, however, also determined by the total size of the chosen age cohorts in the city population and by monetary and personal resources available for the examinations.

It should be noted that the proportions of men and women in the samples were not the same as those found naturally in the population for these agegroups. The proportional difference between men and women in the 70-year-old population
was small. In the 79-year-old group, however, there were about twice as many women as men; therefore, to get samples of a similar size, every man and every second woman were selected. In general, the results showed that differences tended to depend more on age than gender. Thus, men and women were not separated in every table. Gender differences were tested continuously and, when interesting, were accounted for in the text. Separate prevalences should not, however, be compared where the gender distribution is unknown or different from the one in this study.

Response and non-response

Non-response rates are usually high in studies of elderly populations and a non-response rate of 15% or more has been reported in other population studies (Axéll 1976, Österberg 1981, Palmqvist 1986). Non-response tended to be higher in women with increasing age (Table 1, p.18) in the present study.

A major cause of non-response in a longitudinal study of old people is that many persons die during the study. The prevalence of oral diseases could be changed due to the oral status of the deceased persons. A higher mortality rate among edentulous than dentate subjects has been reported from the H70 study (Österberg et al 1990) and medically healthy elderly people were found to have better dental status than edentulous or partially dentate patients (Loesche et al. 1995). One interesting question in this context was whether there was a correlation between general and oral health in U70. If not, changes in prevalence figures in oral health would occur only by chance as a result of people dying. One way to avoid this problem is to concentrate on intra-individual incidence rates of oral diseases in those persons examined in 1981 which could be re-examined in 1990 (III). However, in a longitudinal study general dental status is also known in persons who have attended the study and later died. There were no statistically significant differences in edentulousness or in the number of teeth between the survivors and the deceased in the U70 study.

From a study of non-response on estimates derived from an oral health survey of older adults in Ontario, Canada ( Locker 1993), it was concluded that response rates lower than those conventionally regarded as acceptable do not necessarily compromise the results of epidemiologic studies. Evaluation of a loss of 1/3 of the subjects in a longitudinal 3-year follow-up study of elderly (Payne et al 1995) showed some differences between the retained and the lost, but it was concluded that the magnitude of the differences was small and not likely to seriously bias the results. Non-response bias is, however, a possibility whatever
the response rate, and the design of all surveys should thus include some mechanism to make an analyse of non-response rate possible.

Patterns of non-response are likely to vary with different populations and different types of diseases and it was found in the U70 investigation in 1981 that there was a tendency, not statistically significant, for edentulous persons not to want to participate, "because they did not think that the dentist would be interested in people without teeth". However, most non-responders in 1981 could be reached by telephone or letter, and we could explain that denture wearers were just as interesting for the dentist as were persons with natural teeth. The general oral status in the non-responders in 1981 and in the follow-ups was registered by telephone interview and in 1984, -87, and -90 it was already known from previous examinations which were confirmed by telephone interviews.

**Dental status and migration**

Investigations of oral health in the middle and southern parts of Sweden during the last decade (Palmqvist 1986, Salonen 1990) have shown evident differences in dental status between rural and denselypopulated parts of the country, with a lower prevalence of edentulousness in denselypopulated areas. In an recent study in Västerbotten County (Wigren et al. 1993), where Umeå is the largest city, it was found that 26% of the 65-year-olds living in the denselypopulated areas by the coast were totally edentulous compared with 40% of the age group in rural parts. Thus, it seemed important to investigate whether migration could explain differences in dental status between the 70-year-old cohorts examined in 1981 and 1990. A comparison of some characteristics of the 70-year-old cohorts was performed. It showed that 87% of the men and 73% of the women in the study in 1981 and 75% of both genders in 1990 had been living in the central district of Umeå for more than 20 years, many of them for their whole life. A comparison of the level of education, the frequency of subjective oral problems, edentulousness, the mean number of teeth, and the distribution of the different Eichner index groups between those persons who had been living in the central district for more than and for less than 20 years showed the same pattern in 1981 and in 1990. Thus, migration had not influenced the results in any significant way.
The impact of the study on the study itself

Many subjective oral problems such as mucosal lesions, dental caries, "bad" dentures, functional impairments, and symptoms and signs of CMD have been reported and/or registered in the clinical examinations during the 9-year period. The probands were informed about their oral status and given advice about adequate treatment measures. Many subjects normally consulted a dentist only for emergency treatment and the study itself has probably increased their awareness of oral health and thus increased the frequency of dental treatment. This has naturally changed the number of, for instance, dental visits (IV, V). Some participants, however, did not follow our advice, and others should have visited a dentist anyway. Thus, the longitudinal results have no doubt been affected by the study itself. The effect of this was probably less important than what would be expected, and the prevalence figures from 1981 and the cohort comparison of 70-year-olds in 1981 and 1990 were not biased by the study design.

Interview validity and reliability

Some similar questions were asked both in the socio-medical and dental interviews (discussed in Materials and Methods, p. 20) to assess validity and reliability in the interview. The congruence in the answers from the different interviews was far from complete. It is my belief that this is not only a problem in dental surveys of the elderly, and if analysed, it is very seldom discussed. An extensive and comprehensive study such as the U70 study, however, may be very tiring for any person, and elderly people with a lowered physical capacity, with an increasing amount of diseases and medications, with a deteriorated visual acuity and hearing can not be expected to give one hundred per cent consistent answers. On top of this there were some subjects that were, or became demented during the course of the study. This is a methodological problem that cannot be entirely avoided or solved. The examiners were aware of these problems and for this reason some questions and examinations that were used in the 1981 survey were excluded in the following surveys. Answers or clinical examinations that were ambiguous or not possible to perform were excluded in the follow-up surveys. Uncertain or inadequate answers were confirmed with relatives or accompanying medical personnel, in order to come as close to the "truth" as possible. It should also be noted that the number of don't know/blank answers increased with increasing time and age and that the number of participants was not entirely consistent in the different investigations for this reason.
Clinical examination validity and reproducibility

A total number of five different examiners were involved in the U70 study during the 9-year-period. The examiners all worked in the field of prosthetic dentistry as teachers and also treated patients referred for specialist treatment to the Department for Prosthetic Dentistry, Umeå University. As teachers in the student's clinic they discussed diagnoses and therapy daily with the students and each other and judged details in the treatments made by the students. This meant a continuous calibration of the examiners and this calibration was further improved and confirmed by the simultaneous examination of a number of subjects at the start of each follow-up in the longitudinal study. The person responsible for the design and performance of the U70 study, Göran Nordström, participated in all four surveys and made this calibration.

In a paper discussing the validity and reproducibility of epidemiological methods commonly used (Carlos & Wolfe 1989) it was concluded that reproducibility of coronal and rootsurface caries and of gingivitis was high and that reproducibility of periodontal attachment loss was satisfactory. The assessment of validity (i.e. whether a parameter provided unambiguous evidence of the occurrence of disease) corresponded with the judgement of reproducibility for all parameters but gingivitis, which was uncertain.

Carlsson et al (1980) investigated intra- and interobserver variation in functional examination of CMD and concluded that intra-observer constancy is larger than that between different observers, and repeated registrations in longitudinal studies should be done by the same observer. Observer variability has been reported to be low in measurement of maximal mouth opening but increases in non-parametric variables (Kopp & Wenneberg 1983, Dworkin et al. 1990) Intra-observer variability of the non-parametric clinical dysfunction score and clinical dysfunction index (Helkimo 1974), however was within acceptable limits (Kopp & Wenneberg 1983) In a review of the reliability and validity of methods used to register temporomandibular disorders, it was concluded that "traditional clinical measurements of muscle palpation and mandibular range of motion can be achieved with acceptable reliabilities" and that "reliabilities may be improved by retraining experienced examiners" (Dworkin & LeResche 1992). Thus, the results in this study ought to be reasonably reliable as all the examiners had the same clinical training and the same calibration method was used.

In a review (Carlsson 1984) of epidemiologic studies the author writes, "it is quite obvious that definitions differ and that application of method varies between examiners, making detailed comparison between studies difficult. This does,
however, not undermine the value of epidemiology". The author concludes" Past studies have been cross-sectional but modern epidemiological principles offer superior study designs. The field of TMJ dysfunction with its many controversies demands such designs in both basic research and treatment studies".

A nationwide Swedish population study (SOU 1977) showed that 83% of the population aged 70-79 had received six years of schooling or less and 13% junior high school education or more. The corresponding figures in Umeå in 1981 were 83% and 16%. Thus, the educational level of the population sample in Umeå seemed to correspond to that of the country as a whole, and since educational level and sociomedical behaviour are closely connected, such factors as the pattern of oral diseases, age-related changes, age and gender differences, and attitudes to and knowledge about dental care were probably very much like those in the rest of the country. Civil status, educational level, and living conditions in 1981 were similar to those reported in the H70 study in Göteborg (Österberg 1981). As in the H70 study, a strong correlation between educational level and Eichner index was seen in the U70 study in 1981 (chi-square test, p<0.001).

Comparisons with other studies must be in made with caution because of different investigators, sampling methods, statistical inferences, and, in many variables, a lack of universally accepted definitions of symptoms, diseases, or dysfunctions. These problems and the play of pure chance should be born in mind when interpreting the results of this study.

Dietary habits in the elderly

General dietary aspects

The term diet is derived from the Greek word diaita and can be translated as life pattern, has a meaning of ration, compulsion, and control in every culture (Schlettwein-Gsell 1992). The variation in dietary habits, meal patterns, choice of food items, cooking and storing methods, and facilities are influenced by many background factors of different origin. Cultural, religious, geographical, and economic parameters affect the nutritional status in a population. In all cultures and in all decades of life, eating constitutes an important part of social life and is necessary for the maintenance of social and physiological well-being (Wahlqvist & Kouris 1990). Ageing entails losses: relatives and old friends die; retirement
means losing workmates, business contacts and the luncheon bar. There are also socioeconomic, psychological, and educational aspects of nutrition in old age (Davies 1990).

Visual acuity and hearing deteriorate with ageing and the matter of how food is perceived is also influenced by medication, nutritional status, oral care and the state of the central nervous system (Russell 1992). The taste thresholds for recognition and detection of flavors are elevated with ageing (Stevens et al. 1984, Busse 1987), which means that a higher concentration of a tastant must be present for an elderly person to be able to detect or recognize it. The use of antihypertensive medications has also been reported to elevate the thresholds for sour and salt acuity in elderly men (Spitzer 1988). Many elderly, especially subjects on anticholinergic drugs, antihistamines, sedatives, hypnotics, phenothiazines, and diuretics, also suffer from mouth dryness (Carlos & Wolfe 1989) which makes it difficult to chew and to swallow food. Taste and smell of foods may stimulate salivary flow, thereby increasing the concentrations of salivary lactoferrin, lactoperoxidase, and immunoglobulin all of which may be host protective (Fox et al. 1987, Cole et al. 1981). It is not clear whether smell is affected by ageing because definite studies in humans are lacking.

At the same time there is an increasing number of factors which influence the availability of, the need for, and the resorption of nutrients. Increasing movement disabilities, health disorders, and less physical activity set new demands upon the composition and frequency of meals. Resorption from the gastrointestinal tract may be disturbed by diseases or impaired by ageing (Bowman & Rosenberg 1983, Russell 1992). Loneliness and depression may reduce appetite and the interest in cooking (Davis et al. 1985, Burr et al. 1982. Also the educational level has been reported to correlate with dietary intake (Colasanti & Hendricks 1986, Mac Lennan 1986).

**Longevity and nutrition**

Until quite recently, population ageing was driven primarily by declining fertility and only secondarily by declining mortality (Kinsella 1992). We can now speak of having entered a new era of reduced gerimortality that has given a more rectangular shape to the national population pyramid in developed countries. This has led to the assumption that the health of elderly populations is improving. Recent health surveys in developed countries, however, suggest that the average duration of sickness is inversely proportional to the death rate and
the risk of being sick increases with increasing age. This increase in morbidity with increasing age has also been reported in the medical part of the U70 study (Österlind 1993) where the average number of medical drugs increased with age. Nearly all specialists agree that improved nutrition is one factor responsible for the 20th century decline in mortality. Analysis of historical stature and body mass indices (Kinsella 1992) suggests that improvements in average nutritional status explain a major proportion of declining mortality in England, France, and Sweden between the 1700s and 1875 and about one-half of the decline in the subsequent 100 years. Thus, both longevity and morbidity are increasing in the elderly.

**Medical aspects on nutrition**

There is a common interest in general health among people, and a central question is whether the choice of food can support and increase general health and thus longevity? This public interest in food choice versus health and longevity is taken care of by the media and the market and many daily and weekly papers, and radio and TV shows. Pills and bio-dynamic cultivated carrots are produced and delivered by the market.

Nutrition is considered to be a science of the twentieth century (Kreutler 1980) and many age-related medical problems and diseases such as obesity, diabetes, heart diseases, hypertension, osteoporosis, osteomalacia, diseases of the gastrointestinal tract, cancer, and renal diseases have nutritional aspects (Isaksson 1975). The conditions are often chronic, which means long-term dietary management. It is also increasingly recognized that a proper diet during disease is important if the specific therapy is going to have optimal effect, and interactions between food items and drugs must also be taken into consideration. Another factor of utmost importance for avoiding acute and fatal diseases such as infections and cancers is maintenance of a properly functioning immune system.

The quality of life of ageing individuals depends greatly on their capacity for physical mobility, mental alertness, and cognitive function (Rosenberg & Miller 1992). Independence and self-esteem are strongly determined by physical and mental capacities. Growing evidence supports the view that continued physical activity and good nutritional status are important determinants of physical and cognitive function. It was concluded that it is possible that some of the decline in cognitive function associated with ageing is preventable or reversible with improved vitamin nutrition, especially vitamins B12, B6, and folate. In a review of
nutritional aspects of dementia (Bucht & Sandman 1990), eating and feeding problems in demented nursing home residents were discussed. In later stages of the disease, the patient has difficulties recognizing the meal situation and the food and handling the utensils and may develop difficulties in transporting food to the mouth, in chewing and swallowing.

Many physiological functions decline in old age and the immune system is no exception. The interactions between nutrition and immunity have been the subjects of recent interest and investigation, and it is generally accepted that protein-energy malnutrition impairs several aspects of the immune system (Chandra 1990). The most dramatic effect is on cell-mediated immunity. Defective cell-mediated immunity is associated with infectious diseases caused by certain pathogenic bacteria, mycobacteria, viruses, fungi, and parasites. Studies of healthy elderly subjects in whom dietary intake data and blood concentrations of nutrients have been examined show that approximately 30-35% of the subjects have evidence of one or more deficiencies (Chandra 1989).

In a study of the nutrition and immunological status of a group of subjects who had no evidence of underlying systemic disease it was demonstrated that nutritional advice and supplements given for 8 weeks resulted in improved skin-test response and an increased number of T-cells among those with clinical and haematological evidence of nutritional deficiency (Chandra et al 1982). This improvement in immunological function was associated with evidence of improved nutritional status, mainly in terms of levels of albumin, prealbumin, transferrin, retinolbinding protein, zinc, and iron. In a series of studies reviewed by Chandra (1990), it was concluded that the provision of protein-energy supplement and correction of deficiencies of iron, zinc, and vitamins C, E, and B complex all are associated with improved immune responses. Nutritional support also improves antibody response to influenza virus vaccine and to pneumococcal and tetanus immunization in the elderly (Chandra & Puri 1985). In a study of long-stay patients that were randomly allocated to receive either placebo or supplementation with vitamins A, C, and E for 28 days it was found that the supplementation of vitamins improved the cell-mediated immune function in the long-stay patients (Penn et al. 1991). Immune response to a 6 month supplementation period was studied in subjects deemed to be deficient in at least one of the monitored nutrients iron, zinc, folacin, vitamin $B_{12}$ and protein-energy (Roebottan & Chandra 1994). Improved immune function with a significant increase in mature T-cells was found.
Diet is one aspect of nutrition. Resorption is another, perhaps important aspect. It is important to understand how ageing affects the gastrointestinal tract, because changes in this organ due to ageing and disease could affect the nutritional requirements and medical needs of elderly people (Russell 1992). It has been reported that both basal and maximal gastric acid output decrease in ageing human populations (Holt et al 1989). This decrease in gastric acid is most likely due to the inclusion of a subpopulation of elderly people with atrophic gastritis. Atrophic gastritis has been reported to increase in prevalence with ageing and more than 40% of Bostonians over the age of 80 years have been reported to have this condition (Krasinski et al 1986).

As a result of atrophic gastritis, a decreased secretion of gastric acid and intrinsic factor has been found (Suter et al 1991), and vitamin B$_{12}$ has been shown to be malabsorbed because of the inability to dissociate the vitamin from food proteins, and/or because of bacterial uptake of B$_{12}$ in the stomach and proximal small intestine. Atrophic gastritis may also affect calcium bioavailability by limiting its ability to dissociate from food complexes. Calcium has to be in solution for absorption to take place and this process depends on acid (Suter et al 1991). Furthermore, calcium absorption has been reported to decline with age per se (Bullamore et al 1990). Also the absorption of ferric iron is diminished in achlorhydric subjects (Jacobs et al 1964) and like calcium, ferric iron must be in acid solution for absorption to take place. Thus, both calcium and iron absorption are influenced by the presence of gastric atrophy. In addition, the elderly human small intestine appears to be less able to increase the efficiency of calcium absorption when exposed to a low-calcium diet compared with younger persons (Ireland & Fordtran 1973). It has been mentioned before that studies of healthy elderly subjects in whom dietary intake data and blood concentrations of nutrients have been examined show that 30-35% of the subjects have evidence of one or more deficiencies (Chandra 1989). It is likely that many of these deficiencies are due to impaired resorption because of gastrointestinal diseases and/or ageing.

Dietary allowances are probably more valid on the population level in studies of young and middle-aged people with a lower disease prevalence and a smaller range in physical and psychological functions. In the perspective of increased differences in physical and psychological performance with increasing age and the amount of diseases found also in the U70 study (Österlind 1993), it seems less relevant to compare the results with allowances for healthy elderly
populations. In an extensive review of nutrition in the elderly Sandstead (1987) concludes that 'subclinical or marginal nutrition status for certain micronutrients appears to be much more frequent than generally recognized. The functional significance of marginal status is a topic of current research'.

The, in most respects, satisfactory results in the U70 study were based on a comparison with an allowance set for healthy people. In the 1981 U70 study, however, 61% of the sample were considered not healthy and an additional 27% required further consideration.

**Oral health and nutrition**

Oral and dental diseases including angular stomatitis, denture stomatitis, glossitis and bone resorption may be related to insufficient or inadequate dietary intake (Steen 1986). Insufficient vitamin A intake may give rise to atrophy of the oral mucosa and has been reported to correlate with the prevalence of periodontal disease (Russell 1963). Persons with a vitamin C deficiency have been reported to have more extensive gingival bleeding compared with those with adequate vitamin C intake (Legott et al. 1986, Jacob et al. 1987), but whether this increases the risk of subsequent attachment or bone loss has not yet been demonstrated. The etiology of many oral pathologies in elderly subjects is still not completely understood (Carlos & Wolfe 1989). In some cases, nutrition plays a clear role, as in the protective effect of ingested fluoride against dental caries, and there are a variety of nutrients, when seriously deficient, that influence the soft tissues of the oral cavity (Baxter 1983) (Table 10).

Some nutritional deficiencies result in uncomfortable or painful oral lesions and may complicate treatment and oral hygiene procedures and interfere with wearing dentures and with eating. In contrast, it is not yet known whether the same factors related to sugar content and adhesiveness of foods are important in the etiology of root-surface caries. To my knowledge, there are no studies of the relationship of periodontal disease to osteoporosis that at the same time monitor parameters such as age, gender, smoking, genetic predisposition, and oral hygiene. The possible correlations between nutrition and oral health are further discussed in relation to the results in the U70 study.
Table 10. Oral manifestations of nutrient deficiencies.*

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Oral manifestations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>Decreased salivary flow, drying and keratosis of oral mucosa, decreased taste acuity</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Increased clotting time from dental procedures or surgery, spontaneous hemorrhage of gingival tissues</td>
</tr>
<tr>
<td>Niacin</td>
<td>Exfoliation of the filiform papillae with a red sore tongue. Burning sensations of the tongue and the oral mucosa</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>Angular cheilosis, red 'pebbly' tongue</td>
</tr>
<tr>
<td>Folic acid</td>
<td>Smooth red tongue, gingival tissues may be inflamed. Erosions may occur on the tongue or buccal mucosa</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Easily abraded tissues, delayed healing times</td>
</tr>
<tr>
<td>Water</td>
<td>Dehydration of oral tissues with resulting xerostomia and related problems (root-surface caries, fragile tissues, burning sensations and intolerance to dental prostheses)</td>
</tr>
</tbody>
</table>

* according to Baxter 1983.

The dietary interview method use in U70 (I, II)

One objective with the dietary study in Umeå (U70) was to make a comparison with the gerontological and geriatric population studies in Gothenburg (H70) to find out whether there were any differences in dietary habits between elderly people living in the North-Eastern and the South-Western parts of Sweden. Thus the same dietary interview method used in Gothenburg (Burke 1947) was also used in Umeå. The interviews followed a questionnaire adapted to elderly people (Steen et al 1977) and were carried out by dietician students supported by their teacher. The dietician in charge of the H70 study instructed the local team in Umeå in the fine points of the methods.

The intake of energy and nutrients was compared with the recommendations given by the Swedish National Food Administration in 1981. The Swedish recommendations are in figures and text known as the RDA-S value (Recommended Dietary Allowances for Sweden). These standards are almost identical with the recommendations given by the Food and Nutrition Board and the Committee on Dietary Allowances in 1980. However, the American recommendations apply to men and women aged 51 years and over, while the Swedish recommendations are meant to be used for subjects aged 70 years and over.

The intake of energy and nutrients was calculated using a computer
program based primarily on data published by Abramson (1971) and further
developed at the Department of Clinical Nutrition, University of Göteborg

The dietary history method

In the H70 study the dietary history interview method was used and, compared
with the 24-hour recall interview method, found to be more reliable (Steen et al
1977). For this reason and because we aimed at making comparisons with H70, the
dietary history method was used also in the U70 study. The validity of the dietary
history interview was kept under control by a continuous cross-checking of the
replies during the interview. An attempt was also made to validate the results of
the interview against a study of 24-hour nitrogen excretion. This validation was,
however, not possible to carry through for practical reasons.

Some studies on the validity and reproducibility of dietary assessment
methods in elderly people have been published, but it is difficult to make general
conclusions because of differences in purpose, design, reference method and
target population (Staveren 1994). It appears, however, that decline in short-term
memory with age makes the 24-hour recall method in elderly people particularly
unreliable. Better results have been obtained with the dietary history method,
which have been validated against a 24-hour nitrogen excretion and a 7-day
weight record (Steen et al 1977). As the team in Umeå were calibrated with the
personnel in Göteborg and the same design and protocols were used in both
studies, it is most likely that the validity of the studies was reasonably
comparable.

The dietary allowance used in U70 (I, II)

The Recommended Dietary Allowance in Sweden 1981, RDA-S, was mainly based
on the recommended values of the Food and Nutrition Board in 1980 which
were "considered to be adequate to meet the known nutritional needs of
practically all healthy persons". It should also be noted that the recommended
daily allowance is meant to be used on the population level. Thus, individual
needs for nutrients arising from metabolic disorders, infections, chronic diseases,
and the use of medications were not covered by the RDA. In the U70 sample, 61%
of the responders were considered not healthy and an additional 27% had
symptoms/and or signs which required further treatment or investigation.
Seventy-two per cent of the men and 84% of the women were taking
pharmaceutical drugs (Österlind et al. 1986). Thus, despite an in most respects satisfactory intake on the populational level, it was most likely that not only the individuals who had intakes below, but also several people with intakes above the RDA-S, were in reality suffering from under- or malnutrition.

The American recommended dietary allowances (Food and Nutrition Board 1980), which are in most respects identical with the RDA-S, are calculated to meet the nutritional needs of a healthy 70kg man and a 55kg woman, aged 51 years and over. This is based upon the surveys of the American population made by the National Center for Health Statistics (1979). The female person in the present sample was, on the average, 20% heavier (65.8kg) and the male person 4% heavier (73kg) than the American reference. A calculation of the average Body Mass Index (weight in kilograms divided by the square of height in meters) in U70 showed a BMI of 26.1 for the women. According to Bray (1978) the normal BMI interval is 20-24 for women, but, on the average, this mild obesity in women could not by itself explain their "overweight" in comparison to the reference woman. In the H70 study (Bengtsson et al 1981) the 75-year-old women were also, on the average, 20% heavier (mean weight 65.6kg) than the American reference. A calculation of the BMI for the reference woman gives a score of 20.7. This is close to the lower limit of the "normal" BMI interval. It seems that elderly women in Umeå and Göteborg have a body constitution that differs from that of the American reference woman. Men in U70 (BMI=24.4) were also rather close to the upper limit for mild overweight (normal BMI interval 20-25), despite a mean weight close to the reference man. The BMI for the reference man was 22.1 also indicating a slightly slimmer ideal in men in northern America. However, the American recommendation was set for people aged 51 years and above and the probands in U70 were 70, 75, or 79 years old. Age difference in itself explains to some extent the BMI difference as height decreases with increasing age, thus giving another weight/height ratio. For example, a man weighing 80kg and 1.80m tall has a BMI score of 24.7. Supposing that he loses 4 cm in height while his weight remains unchanged, his BMI will then increase to 25.8.

It seems that the reference woman used to calculate the American recommendation is about 10 kg too light for Swedish use. In most respects the American and Swedish recommendations are identical, but in the Swedish recommendation the daily intake of protein is increased by 25%, and of calcium decreased by 25%. Considering the BMI in the studied population, the recommended daily intake in Sweden of nutrients, minerals and vitamins, especially for the women, might be a little too low to cover the intentions behind
the recommendations.

Energy intake in U70 (I, II)

Ageing and retirement entail a decrease in physical activity. Biological ageing leads to a loss of metabolizing tissue and a decreasing number of cells in the organs (Shock 1972). Energy expenditure has been found to be one-third lower in 80-year-old men than in 30-year-old men (McGandy et al. 1966) and here the decrease in basal metabolic rate seems to be less important than the decrease in physical activity. The correlation coefficient (r) was strong between energy on the one hand and protein, fat, and carbohydrates (r=0.88-0.92); iron, potassium, and calcium (r=0.69-0.89); and vitamins B1 and B2 (r=0.77-0.85) on the other. As the need for essential nutrients is about the same in old age, it is inappropriate to simply reduce the energy intake to adjust it to the decreased physical activity. This problem is pronounced among women as they in general have a lower energy need than men and at the same time need the same amounts of calcium, iron, and vitamins C and D. Thus, women run a greater risk of being malnourished, undernourished in order not to become obese, overnourished in order to get enough essential nutrients. Western diets contain too much fat and refined sugar and have a low nutrient density, which makes it impossible to simply reduce the energy intake and still maintain essential nutrients at a satisfactory level. Thus, energy reduction must be combined with an increased nutrient density.

Fat intake in U70 (I, II)

It was difficult to find a specific explanation for the age-related overconsumption of fat. Part of the explanation is probably a cohort difference in that 31% of the 79-year-old men compared with 3% of the 70-year-olds had worked in forestry, farming, and papermills, all occupations consuming much muscle energy. Dietary habits are known to be stable, and women did the cooking and still have the same food and dietary habits as their men. An overconsumption of fat has also been reported from the Glostrup survey in Denmark (Mørch-Jørgensen et al. 1991), Norway (Nes & Thoner 1990), Finland (Uusitalo et al. 1982) and in Sweden (Steen et al. 1977). Coronary heart disease increases with age and dietary and lifestyle factors, such as a high fat intake and cigarette smoking, are established risk factors (Schaefer et al. 1995). From a recent population study within the framework of the MONICA-project study (Multinational Monitoring of Trends
and Determinants in Cardiovascular Disease 1987) made in the provinces of Norrbotten and Västerbotten in northern Sweden it was reported that edentulous persons were more obese and had lower serum HDL-cholesterol concentrations than those who had not lost all their teeth (Johansson et al 1994). Edentulous women also had higher concentrations of total cholesterol and triglycerides in serum than dentate women and edentulous subjects were more often regular smokers, than dentate of the same age and sex.

Protein in U70 (I, II)

In a review of past and present allowances of protein (Scrimshaw 1976), it was suggested that the "safe allowance of protein of FAO/WHO (0.57 and 0.52g/kg body weight for men and women respectively) is too low (FAO/WHO 1973). There seems to be no need for different allowances for healthy elderly people and for younger individuals (Cheng et al 1978), but dietary protein requirements during disease is often increased and nitrogen balance studies on hospital patients showed a negative nitrogen balance in half the sample even with a protein intake above 0.9g/kg body weight (Isaksson 1973). The American allowance, RDA 1980, recommends 0.8g/kg in the 51+ age group. Calculated on the body weight of the reference persons, this gives 56g protein per day for men and 44g for women.

The RDA-S is higher at 70g/day for men and 55g for women. In our sample this would give a mean protein intake of 0.96g/kg body weight in men (mean body weight 73kg) and 0.84g/kg in women (mean body weight 65.8kg). It has been found that a positive nitrogen balance was obtained with a daily intake of 0.9g/kg body weight (Albanese 1957). In U70 the mean intake of protein was 76g for men and 61g for women. This gave an average intake of 1.04g/kg body weight in men (mean body weight 73kg) and 0.93g/kg in women (mean weight 65.8kg). According to the present knowledge, this should be sufficient for healthy elderly individuals. However, 61% of the probands in U70 were considered not healthy, but receiving adequate treatment, and 27% had symptoms and/or signs which required further treatment or investigation. Seventy-two per cent of the men and 84% of the women were taking pharmaceutical drugs (Österlind et al 1986). From this perspective, it seems likely that several individuals, not only below but also above the RDA-S due to chronic diseases, have a negative nitrogen balance.
Both men and women who had 3 cooked meals per day had a satisfactory daily intake according to the RDA-S apart from a vitamin D intake below 5μg and a fat intake above the Swedish recommendations. Overconsumption of fat was, however, even higher in group eating 2 cooked meals. Analysis of variance showed that nutrient density, in general, was higher in the group eating 3 cooked meals. This increased nutrient density, with a lower energy intake from fat and more energy derived from protein and carbohydrates, is of importance in the elderly for reducing energy intake to maintain weight and at the same time still provide ample quantities of the various essential nutrients necessary to maintain a healthy life.

**Intake of calcium/vitamin D in U70 (I, II)**

The incidence of hip fractures is increasing in many countries, and a collum femoris fracture is the most usual background factor to accidents indirectly causing death among patients aged 75 years and over (Cummings et al. 1985). An epidemiological study in Göteborg, Sweden, showed a 10% yearly increase of the incidence of such fractures during the last decade (Zetterberg & Andersson 1980). Environmental and life style factors are of importance in this context (Rundgren & Mellström 1984). Even moderate physical activity, such as walking, has been proven to prevent involutional bone loss in elderly women (Smith et al 1981).

Bone mineral density (BMD) was reported to be positively associated with weight in both men and women (May et al.1994) and one-third of the decline in BMD with age could be explained by the age-related loss of bone. Postmenopausal women have a higher prevalence of osteoporosis and incidence of hip fractures than men of the same age. This is partly explained by decreasing estrogen levels in postmenopausal women. Sex-hormone replacement and calcium supplements have proved to decrease age-related bone loss in women (Recker et al. 1977). Osteoporosis in females is widely publicized; osteoporosis is, however, a problem which also afflicts elderly men (Drinka & Bauwens 1987).

Fluoride plays an established role in the prevention of coronal caries and has also been under debate whether it may prevent hip fractures. A recent review concludes that scientific reports show inconsistent results (Raheb 1995). Some surveys suggest that exposure to fluoridated water is associated with an increased risk of hip fracture, and others found no association or a decreased risk of hip fracture.
fracture associated with exposure to fluoridated water.

Histological studies have shown that low bone mineral content (BMC) of the mandible was associated with low BMC of the femoral neck (Dyer & Ball 1980) and the iliac crest (Habets et al. 1988a, 1988b). Alveolar bone porosity increased with age and at a given age, alveolar samples from men tended to be less porous than those from women (Dryer & Ball 1980). Tooth loss increases with age and it has been reported that postmenopausal women have a higher than expected number of dentures and fewer teeth (Groen et al. 1968, Kribbs 1990). An increased tooth loss with age was also associated with increased risk of hip fracture (Åström et al. 1990) and associated with lower body mineral density in older men (May et al. 1994). Residual ridge and alveolar bone density has been shown to be correlated to total bone calcium (TBC) and to the bone density of the distal radius in women. However, no statistically significant correlation was found between the dietary intake of calcium and residual ridge and alveolar bone density or TBC (Kribbs et al. 1983). In another investigation it was demonstrated that a dietary supplement of calcium and vitamin D given to 46 immediate denture patients decreased the postextractional alveolar bone resorption by 36% compared with a control group in a 1-year double-blind study (Wical & Brusse 1979). In a review of the roles of calcium, vitamin D, and other factors of importance for bone density and formation, it was pointed out that there is a growing body of evidence that inadequate calcium intake may contribute to decreased bone density in the elderly (Heaney et al. 1982).

Two sources of vitamin D are available; the diet and the action of ultraviolet light on 7-dehydro-cholesterol in the skin. The latter is more important: especially among homebound or long-term geriatric patients; with little or no access to sunlight, there is a risk of developing an unsatisfactory intake of vitamin D (Corless et al. 1979). In hospitalized patients it has been shown that exposure to daylight for 30 min a day increased the levels of 25-hydroxyvitamin D (25(OH) D) significantly, and an increase in strontium absorption indicated a similar effect in calcium absorption (Reid et al. 1986). A seasonal variation of 25(OH) D and parathyroid hormone (PTH) has recently been reported. In a survey of 96 community-dwelling men and women aged 65-74 years (Hegarty et al. 1994) increased levels of PTH and lowered levels of 25(OH) D were found during winter. Even in the summer, mean 25(OH) D concentrations were low, especially among women. It was concluded that more optimal vitamin D levels in general would have clinical and public health benefits. Another recent study of community-dwelling elderly volunteers concluded that body vitamin D levels in
elderly people during winter are related to diet and overseas holidays within the last 6 months (Scragg et al. 1995). An oral supplement of vitamin D twice a year has also been found to maintain serum levels above the threshold associated with osteomalacia (Davies et al. 1985).

The U70 study shows that about 10% of the probands had intakes of calcium below the Swedish recommendation of 600 mg/day, and if the American standard of 800 mg was used this proportion would increase to approximately 20% among men and 40% among women; 14% of the men and 35% of the women would simultaneously have intakes below the RDA-S for Ca/vitamin D. There were no differences between the age groups. There are investigators who have suggested that the recommendation for calcium be increased to between 1000 and 1500 mg/day in menopausal women and elderly men (Heaney et al 1982, Marcus 1982, Pogrund et al 1986, NIH 1994). The cumulative frequency of the intake of calcium in Fig. 1 in paper (I) shows that almost 50% of the men and 70% of the women in U70 would have insufficient intakes of calcium if the RDA-S was 1000mg/day.

Excessive intake of calcium, within the range of probable calcium intake, produces very few effects that could be considered toxic. The principal side effects of an excessive intake are hypercalcemia, hypercalciuria, urinary tract calculi, and calcification in a variety of soft tissues. Calcium intakes of up to 2500mg/day do not result in hypercalcemia or produce other side effects in healthy adults including the elderly (Heaney et al 1982). In some diseases like hyperparathyroidism, tuberculosis, and sarcoidosis, however, hypercalcemia may occur because of an increased intestinal absorption.

The mean intake of vitamin D was satisfactory for men but below the RDA-S (5µg) for women. However, the cumulative frequency of the intake of vitamin D in Fig. 1 in paper (I) shows that nearly 60% and 80% of men and women respectively had intakes of vitamin D below 5 µg. In winter, many elderly people stay inside because of the cold and a fear of slipping and fracturing a bone. This often generates a vicious circle, not only because they get too little sunlight, but also because the decrease in physical activity reduces energy expenditure and thus the appetite and the dietary intake of essential nutrients. The etiology of osteoporosis and hip fractures and what constitutes adequate calcium and vitamin D intakes are still under debate. The possible consequences of the fact that a lot of women in U70 simultaneously had a calcium and a vitamin D intake below the RDA-S cannot be judged from this cross-sectional study. The question of calcium recommendations for the elderly is, however, far from settled.
Intake of Iron/vitamin C in U70 (i, II)

The RDA-S for the intake of iron is the same for men and menopausal women. The absorption in the elderly does not seem to be different from that in younger individuals (Frieman et al. 1963). The effect of ascorbic acid on non-heme iron absorption has been tested in a number of dietary settings, and in each case has been shown to be profound. It should be born in mind that losses in vitamin C content of up to 50% because of inadequate storage and preparation of food are not uncommon.

The uneven distribution of vitamin C in the studied U70 population, with a huge standard deviation and approximately 60% of the 79-year-olds below the RDA-S, is not satisfactory. Although a mean iron intake above the RDA-S for both sexes was found, the mean intake in the first quartile of the 79-year-old women was below the RDA-S and the mean intake of vitamin C in this group was extremely low, 32.9 mg. This is an important finding and must be studied further.

Comparison of the dietary intake between U70 and H70

In general it could be stated that, within the frame of a similar mean intake of energy, the diet of the 70-year-old in Umeå seemed to have a slightly higher nutrient density. The greatest difference was found in retinol intake. There are problems involved in the calculation of retinol because of incomplete information about how much there is in many food products. This could be part of the explanation for the big difference.

A comparison of the per cent of energy intake derived from fat, protein, and carbohydrates confirmed the general picture of similarity, but also of a somewhat higher nutrient density in the diet among the 70-year-olds in Umeå. The difference between women in U70/H70 concerning the intake of energy from fat and carbohydrates was significant at the 5% level (t-test). This might be a result of the propaganda during the last decade for less fat and more fiber in the diet.

A dietary interview may give a good picture of the choice of food items, meal patterns, and the intakes of different nutrients. The social part of eating is increasingly important for the quality of life in the ageing person. Environmental factors have also proven to be important for the daily intake. In an experimental setting a long-term care ward was redecorated in a way similar to what was common during the 1940s (Elmståhl et al. 1987). During the experimental period
energy and protein intake increased by 25% and blood chemistry variables such as blood folate, serum creatinine, and retinol showed significantly increased levels.

Chewing, dental status, and dietary intake in U70 (II)

In the U70 study, as in H70 in Göteborg (Österberg 1981), there was an obvious correlation between the Eichner index and chewing problems. Dental status (represented by the single variable, the Eichner index, and by the principal component, upper denture status/Eichner index), was chosen as a predictor for a reduced intake of the principal component vitamin C in analyses 1 and 2. Although the regression coefficients were not significant (p=0.13 and p=0.06 respectively) these findings correspond with the problems in masticating fruit and raw vegetables reported by subjects belonging to Eichner group C. It has also been found that bite force in complete denture wearers is 5-6 times lower than in dentate subjects (Haraldsson et al. 1979), and that there was no difference in bite force between clinically satisfactory and unsatisfactory complete denture wearers in this respect. The reduced bite force is probably an important cause of the higher frequency of subjective chewing problems among the complete denture wearers and their problems in masticating raw vegetables and fruit. In a large Finnish study (n=7190), however, it was found that adequate prosthetic rehabilitation increased the probability of eating roots, vegetables, and fruits (Ranta et al. 1988).

In a recent paper from the on-going longitudinal gerontologic population study in Göteborg, it was reported that despite a reduced bite force, none of 35 the randomly selected 90-year old subjects claimed poor masticatory ability (Tzakis et al. 1994). Forty per cent were edentulous, 29% were partially edentulous and wore removable partial dentures, and the others were dentate without removable dentures.

It is most interesting to note that chewing problems, together with education, are the second strongest single predicting variable for the first very broad and important principal component (A) in analysis I. In analysis III, where the effect of sex differences is eliminated because of different RDA-S values for the energy intake between men and women, chewing problems show the strongest standardized regression coefficient of all the background factors studied for the dominating principal component (A). It should be noted, however, that about 90% of the men and 70% of the women in Eichner group B and about 60 % of both sexes in group C did not report any chewing problems. Correlation between
dietary intake and self-perceived chewing problems have been found in elderly veterans (Gordon et al. 1985). Recent reports of comparisons between dietary intake in edentulous and dentate elderly show a better diet composition in dentate elderly (Johansson et al. 1994, Greksa et al. 1995). However, persons who claimed that they had trouble chewing their food were not more likely to select easy-to-chew food (Greksa et al. 1995). In a study of the correlation between masticatory performance, chewing experience, denture quality, and oral conditions in edentulous subjects, a relationship between ability to masticate and experience of performance was found (Slagter et al. 1992). Slagter, however, concluded that dentists should not rely on asking denture wearers about subjective chewing ability. In the representative sample of elderly men and women in the U70 study, reported chewing disabilities turned out to be one of the strongest clinical predictors for a reduced dietary intake.

Nutritional inadequacies often have a slow and insidious onset, and the atypical presentation nutritional deficiencies may have in old age could easily lead to a delay of the diagnoses (Gupta et al. 1988). The present study shows that only when a question addresses chewing problems directly are disabilities in masticatory performance reported. This indicates the importance of asking elderly patients questions about their chewing ability in order to discover those who might need a closer examination of oral status and function, from a masticatory point of view, and a more detailed dietary interview and advice.

It has been reported (Gunne & Wall 1985) that masticatory efficiency and the subjective experience of masticatory performance increased significantly when patients were treated with a new complete denture and that there was a strong correlation between masticatory efficiency and the subjective experience of chewing performance. The increased chewing efficiency was measured using a method which showed that the surface of the test material was increased (Gunne 1983). If a person who says he has chewing problems not only has a decreased dietary intake but also a reduced ability to break up the food items so that they are effectively exposed to the gastrointestinal juices, a decreased resorption of the different nutrient components might result. This could be the subject of an interesting and important study.
Oral health in the elderly

Craniomandibular dysfunction

The first comprehensive description of symptoms involving the temporomandibular joint (TMJ) was presented in 1934 by an otorhinolaryngologist named Costen. Based on eleven subjects he identified a number of symptoms including: impaired hearing, dizziness, tinnitus, headache, popping noise in the TMJ, stuffiness, ear-ache, dryness of the mouth, and burning sensation of the tongue and throat (Costen 1934). This constellation of symptoms became known as "Costens syndrome". He attributed the symptoms to irritation of the auriculo-temporal and chorda tympani nerves due to erosion of the glenoid fossa by the condyle. The subjects were described to be without posterior teeth or edentulous, and tenderness to palpation in the TMJ area was found.

Since Costen, different names have been introduced in the literature. Some of the names given refer to the etiologic factors involved in the processes, like "the TMJ dysfunction syndrome" and "functional TMJ disturbances or disorders". Others stress the factor "pain" among the symptoms and propose "pain-dysfunction syndrome" "myofacial pain dysfunction" or a combination, "temporo-mandibular joint pain-dysfunction syndrome" (De Boever 1979). Today mainly four terms are synonymously used in literature to describe a group of patients with similar symptoms of multifactorial etiology: Mandibular dysfunction, temporomandibular joint (TMJ) pain dysfunction syndrome, myofacial pain dysfunction syndrome (MPD), and craniomandibular disorders (CMD). In 1985 the editorial council of the Journal of Prosthetic Dentistry changed the section title from "Temporomandibular Joint and Occlusion" to "Craniomandibular Occlusion" (Zarb 1985) (today the section title is: Craniomandibular Function and Dysfunction) and it was in 1986 decided at the Nordic biennal meeting in stomatognatic physiology to use the term craniomandibular disorders in Scandinavia. Thus, in this thesis the term CMD was used.

Etiology of CMD

The etiology of functional disorders is still under debate and both central and local factors have been proposed and discussed (Rugh & Solberg 1979, Carlsson & Droukas 1984, Iacopino & Wathen 1993). The main view is that the etiology is multifactorial and that local structures and craniomandibular function are
affected by the general social, medical and psychological health status (De Boever 1979, Iacopino & Wathen 1993). The symptoms described are still mainly in accordance with what Costen defined in 1934; pain in the TMJ region, TMJ clicking and crepitation, mandibular deviation, stiffness or fatigue in the jaws, locking of the jaw or limitation of the opening, and tenderness to palpation in the TMJs and masticatory muscles. Other symptoms frequently reported in patients with CMD are headache, migraine, vertigo, tinnitus, tongue pain, extensive wear of teeth, chewing problems, psoriasis and psycho-somatic diseases (De Boever 1979, Carlsson et al. 1982, Iacopino & Wathen 1993). CMD also appears to be a problem affecting musicians, and symptoms appear to be significant in trombone, trumpet, tuba, violin and viola players (Taddey 1992). There appear to be a number of significant etiologic factors related to the mechanics of the instrument, the environment, habit patterns, and emotional sensitivities.

The TMJ, like other joints, may also be affected by acute trauma, followed by obstinate or irreversible sequelae, such as interference with joint movement and to changes in occlusion, articulation and functional load (Carlsson et al. 1979). Other diseases which can affect the TMJ are osteoarthrosis, rheumatoid arthritis, chrystal deposition diseases and arthritis and infections. Radiographic changes were found more often in subjects with rheumatoid arthritis (66%), psoriatic arthritis (38%), and ankylosing spondylitis (30%) than in controls (12%) (Wenneberg et al. 1990). Crepitation may be the most reproducible clinical sign of TMJ OA. The pathologic changes of the joint tissues are capable of giving rise to different symptoms such as swelling, resting pain and pain on movement of the joint and associated muscles as well as limitation of mandibular movements (Carlsson et al. 1979).

The number of teeth have been reported to affect CMD and it has been reported that subjects with the largest number of occluding teeth had the highest prevalence of subjective symptoms (Swanljung & Rantanen 1979). Other studies report that a decrease in the number of occluding teeth results in a higher degree of CMD prevalence (Helkimo 1974, Harriman et al. 1990). There is however studies that have reported that adequate oral function can be maintained in shortened dental aches provided they include at least four posterior occlusal contacts (Käyser 1990). According to Käyser, the minimum size of a functional dental arch differs between individuals and important factors are the age, the quality (periodontal) of the remaining dentition, the spatial relationship between the lower and upper teeth, the occlusal activity and the adaptive capacity. Complete denture wearers have also been reported to have CMD symptoms (Carlsson & Swärdström 1971, Bergman & Carlsson 1972, Carlsson 1976, Choi &
Furthermore, there are studies that report no correlation between the number of teeth and CMD signs and symptoms. Also in a study of 48 crania from the Middle Ages a lot of remodelling of the TMJs was found in the condyles (90%), tubercles (80%) and fossae (25%) (Wedel et al 1978). Surface changes indicating a osteoarthrosis were found in one third of the tubercles and one fourth of the condyles. Form and surface changes of the TMJ-components, especially those on the tubercles, were correlated to dental attrition.

**Differential diagnoses of CMD**

There are a variety of local pathologies that can confuse the picture of TMJ. Osteoarthroses, rheumatoid arthritis and neoplasms may produce symptoms difficult to distinguish from pain and dysfunction referable to masticatory musculature. The parotid gland is closely related to both the TMJ and the masticatory muscles and initial symptoms of TMJ pain dysfunction and parotid gland affections might be confused (Jagger & Carlsson 1978). The differential diagnoses between CMD signs and of neuralgias and myalgias ca be very difficult and may require the cooperation of several disciplines (De Boever 1979). Also psoriatic arthritis (PA) can involve the TMJ and in a study of PA patients, 32% reported pain from the TMJ and the TMJ pain correlated with both the number of joints affected by PA and the severity of PA (Könönen 1986).

In a review of CMD in the geriatric patient (Iacopino & Wathen 1993) it was concluded that the following factors should be considered when formulating the differential diagnoses:

1) normal age-related changes in the craniomandibular apparatus and their impact on function as well as on responses to stress
2) the impact of present dental and denture status
3) the contribution of general and local diseases to the pathosis of CMD
4) the various implications of the psychologic, sociologic, and biologic aspects of ageing to the development of headache and atypical facial pain as components of CMD in the geriatric patient.

**Temporomandibular joint (TMJ) sounds**

The mechanism behind clicking of the TMJ has been the subject of many studies and still is not fully understood. There seems however to be a consensus on the

There is some evidence that crepitus is frequently associated with degenerative joint disease, with perforations in the disc, and with reduced joint space (Öberg et al. 1971). Åkerman et al (1986) reported from an autopsy study of 42 joints in elderly individuals that anterior disc position and structural changes such as disc perforation were common findings. It has been proposed that crepitus may be regarded as the best clinical sign of TMJ osteoarthrosis (Carlsson 1980), that tenderness to palpation of the masticatory muscles is a common finding in osteoarthrosis of the TMJ (Kopp 1977), that deviation of the mandible is towards the affected side (Agerberg & Österberg 1974), and that clicking sounds are associated with lateral deviation (Isberg-Holm 1980). In accordance with these reports the high prevalence and incidence of clicking and crepitus in the present study corresponds with the increasing frequency of muscle pain and the high frequency of mandibular deviation seems to be a summary of these CMD signs.

**CMD examination methods in U70 (II, III)**

The anamnestical ($A_i$) and clinical dysfunction ($D_i$) indices introduced by Helkimo (1974) were used in the first study in 1981 (II). These indices, however, were considered to be too extensive and tiring to for elderly patients to be useful in the long run. Similar problems have been reported by Salonen (1990) in a cross-sectional study, who reported a dropout rate of 24% for $D_i$ in the age group 70-79-year-olds and 47% in persons over 80. Before the first follow-up in 1984, all questions and examination methods in the social, medical, psychological, dietary, and odontological parts of the health investigation were validated in order to reduce the total examination time and while still maintaining a high quality in the study as a whole. Questions about clicking and crepitus and TMJ locking / luxation had shown very low correlation with the clinical findings (II) and were then excluded from the 1984 re-examination. Also, the clinical examination of jaw muscles performed in 1981 to complete the Helkimo $D_i$ were excluded because it was found to exhaust the subjects. The examination of the jaw muscles was however performed again in the 1987 and 1990 investigations with the difference that it concentrated to the three "main" jaw muscles. The question about TMJ locking/luxation was asked again in the 1990 investigation.
CMD signs and symptoms in the U70 study (II, III)

A retrospective comparison of the results from the 1981 study showed no statistically significant differences in the parameters used in the regression analysis between persons who could be followed up throughout the whole 9-year period and the persons who were later registered as dropouts. The question, "Do you feel well?" showed the greatest difference (12.4%) between the responders and the drop-outs as 31.8% of the responders and 44.2% of the drop-outs in 1981 answered they were not feeling healthy. It seems normal that the answer "Not feeling well" would be overrepresented in the dropout group as the main part of this group had died by 1990. Subjective health problems increased during the longitudinal study, and in 1990, 93.9% reported such problems. Poor medical health might influence the different signs and symptoms of CMD and was also one of the predictors for chewing problems in the regression analysis in 1990.

In general, reported symptoms, apart from chewing problems, decreased and clinical findings increased during the 9-year observation period. A similar discrepancy between signs and symptoms has been reported from Norwegian (Heloe & Heloe 1978), Dutch (Serfaty et al. 1989), and Swedish cross-sectional studies (Österberg & Carlsson, Salonen et al. 1990) in elderly populations, but was not found in studies in younger populations (Swanljung & Rantanen 1979, Nilner 1981, Wänman 1987).

The discrepancy between CMD signs and symptoms in elderly people could be explained by the increasing presence of other, more disabling, painful, or frightening medical symptoms and diseases that leave little room for worries about CMD conditions. For instance, the 79-year-olds increased their mean drug intake from 2,5 to 5,2 drugs during the 9-year study, and the proportion of subjects regularly taking drugs increased from 82% at 79 years to 95% at 88 years of age (Österlind & Bucht 1991). The use of analgesics increased with age, and paracetamol was the most common preparation used by 25-30% of the 88-year-olds. This explanation for the decreasing reports of CMD problems does, however, not fit in with the high and increasing prevalence of reported chewing problems. Use of analgesics, diseases and age-related changes in the nervous system might decrease pain sensitivity in the elderly. This probably does not influence chewing problems but might reduce the frequency of reported symptoms and clinical signs. Despite a lower age-related sensitivity, an increased use of analgesics, and contradictory to the decrease in reported symptoms, the regression analysis showed that muscle pain on palpation increased with age and time.
An impaired dental status as estimated by the Eichner index, muscle pain, and the feeling of illness were the most important background factors in explaining chewing problems. Increasing chewing problems is an important finding as subjective chewing problems in the 1981 (II) study had been found to be the strongest single background factor for explaining the variation in energy intake associated with a low intake of most nutrients, minerals, and vitamins. There were also data in the U70 study that pointed to the fact that neither the Eichner index nor subjective chewing problems was improved in the "new" 70-year-old cohort that was examined in 1990 compared with the 70-year-olds examined in 1981 (V). A report from a study on functional ageing in the gerontological population study in Gothenburg (Österberg et al. 1990) concluded that a deterioration in dental state and dental function, measured by the Eichner index, was significantly associated with a lower capacity in cognition, visual ability, hearing ability, lung volume, heart volume muscle strength and bone mineral content as well as a lower self-assessment of health. These associations were more marked in men and the survival rate between 70 and 79 years of age was higher among men with a well preserved dental state at the age of 70 (Österberg et al. 1990).

Joint sounds can be examined by the use of a stethoscope, and with this method Hansson & Nilner (1975) found a prevalence of 65% in workers in a shipyard. The other method is to "listen with the fingers" giving prevalence figures between 29% and 37% in elderly populations (Agerberg & Österberg 1974, Österberg & Carlsson 1979, Swanljung & Rantanen 1979). Helöe & Helöe (1978) concluded that CMD tended to increase with age and was evenly distributed between the sexes, but women were more likely to report symptoms of CMD. Österberg & Carlsson (1979) reported that all CMD signs except deviation showed higher frequencies among women. In an epidemiological cross-sectional investigation of 65-year-old people living in Västerbotten County, where Umeå is the largest city, Agerberg & Bergholm (1989) reported that crepitus was more often observed in women and increased with age and that jaw muscles were more frequently tender to palpation in women.

There are both similarities and differences between the results in this paper and the findings reported by Österberg et al. (1992) in the longitudinal population study in Göteborg. Reported symptoms decreased in both studies and in both sexes and the decrease was greater among men. Clinical signs of severe CMD are rare in both studies. Another similar result is the stable situation in and the mean values for maximal mouth opening. In the U70 study, however, most clinical
signs of CMD increased during the 9-year observation period, whereas the conclusion in the Göteborg study was that there is no increased risk of CMD with ageing. There are differences in the methods used in the two studies. For instance, the present paper does not use the Helkimo classification and also uses another method for the statistical analysis. The sample in Umeå had a higher mean age. The difference in approach, analysis and material could explain most differences in and interpretation of the results.

*Individual CMD changes in U70 (III)*

About half of the joints with clicking/crepitus in 1981 were still registered for clicking/crepitus in 1990. It has been stated (Eriksson 1985, Lundh 1987) that clicking may indicate a possible degeneration into joint diseases such as osteoarthrosis and will transform into crepitus. One-third of the new crepitating joints in 1990 had been registered for clicking sounds in 1981.

The preponderance of leftward deviations is in agreement with the findings by Gross & Gale (1983) in an investigation of a 1000 patients in a general dental practice. Deviation to the left has been reported previously in investigations of young persons (Nilner 1981, Grosfeld & Czarnecka 1977) and has been suggested to be the result of the greater number of right-handed people with stronger right-side lateral pterygoid muscles. It has also been proposed that left-sided deviation is the result of having the examiner seated on the patient’s right which would make the patient turn his head to the right and thus activate the infrahyoid muscles on his left side (Halbert 1958). In the present study, however, all clinical examinations of CMD signs were performed with the patient in an upright position and the examiner standing in front, and the TMJs were examined simultaneously on both sides. Deviation was recorded in the same examining sequence as the palpation of the TMJ. This might increase and improve sensitivity and reliability, but could also increase the risk of overregistration. No former records were at hand when the follow-ups were performed.

*Cohort comparison of dental visits (V)*

There were two major changes in dental care consumption between the 70-year-olds examined in 1981 and 1990: the frequencies of dental visits and of being called to an appointment by the dentist were higher among the 70-year-olds examined in 1990. The main reason for the higher frequency of dental visits was undoubtedly the higher frequency of dentated subjects in 1990. The cross-
tabulation of dental status and visits showed that more than 90% of the dentated and less than 10% of the edentulous were recalled by the dentist. Both the dentated patients and the dentists seemed to be more interested to meet regularly in order to maintain the last tooth or teeth than to examine problems associated with complete dentures. However, despite the higher frequency of dental visits in 1990, the number of oral problems was similar to what was reported in 1981. At the same time people claimed less subjective treatment need in 1990. The wording of the questions was identical in the two studies, but the question is, was the patients subjective value scale was the same in the two cohorts? The high frequency of reported oral problems might be the result of a higher awareness of oral health because of more frequent dental appointments. Consequently, the lower frequency of reported subjective treatment need might also be explained by the feeling of having a dentist to turn to, if needed.

Longitudinal comparison of dental visits (IV)

In the longitudinal study the 88-year-olds showed the lowest consumption of dental services. In men this could partly be explained by the fact that more men in the oldest cohort had complete dentures and were thus not recalled by the dentist. In the cohorts of women no such difference in edentulousness could explain the difference in dental service consumption between the 79- and 88-year-old. It has been shown, however, that there is a wide discrepancy among the elderly between, on the one hand, identifying symptoms of illness and, on the other hand, deciding whether or not to seek professional care (Holzman & Akiyama 1985). For example, of those who considered "chest pain during light exercise or at rest" serious or very serious, 75% considered seeking professional care to be the most appropriate response. However, only half of those who had experienced such pain reported actually visiting a health care professional and only 30% of those with painful teeth or gums and 11% of those reporting an irritated tongue or mouth had actually responded to professional service.

The longitudinal U70 study also showed an increasing amount of medical disease with increasing age (Österlind et al. 1984); this might be another reason for the low consumption of dental services among the oldest and corresponds to the increasing number of home visits in this group in 1990. The low consumption of dental services in the oldest cohort may partly also be a pure cohort effect, at least among men, as they showed low figures even in the first study in 1981.

In a qualitative study of oral health norms and behaviour in representative groups of 65-year-olds and over in Scotland (Schou & Eadie 1991) it was found
that tooth loss was expected and accepted as part of a natural ageing process; dental visits were regarded as problem-solving behaviour; non-attendance was explained by no perceived need, low interest, fear or expected high cost. Oral health was perceived as unrelated to general health. A study of the relative importance of tooth loss and denture wearing was conducted as a mailed questionnaire to 311 Swedish adults aged 20-70 years in the community of Jönköping (Bergendal 1989). The Social Readjustment Rating Queationnaire (Lundberg & Theorell 1976), comprising 46 life events, was supplemented with two events concerning tooth loss and denture-wearing. The majority of the respondents perceived loosing teeth and being provided with dentures as more important in terms of adjustment than events such as "marriage", "retirement" and "changing work". "Getting dentures" was ranked as the 16th and "lose one or more teeth" as the 21st most important life event. "Death of a son/daughter" was ranked first of the 48 life events.

Experienced dentists know that regular dental appointments, once or twice a year in most patients, are a suitable way of maintaining good oral health and keeping in contact with the patient. The latter is probably of special importance with the elderly since in higher ages it is more and more laborious to make new friends and to find a new dentist. One commonly heard explanation for why the most recent dental appointment had been so long ago was that the dentist had retired or died. The results in the U70 study show that a reliable way of getting old people to attend regular treatment appointments is to have a recall system.

Cohort comparison of dental status (V)

Compared with the 70-year-old cohort in 1981, the frequency of totally edentulous 70-year-olds in 1990 was almost 20% lower in women and 10% lower in men. A similar difference was reported by Österberg & Mellström (1986) in 70-year-old cohorts examined in the H70 studies in 1971 and 1981. However, the lower frequency of total edentulousness in Umeå in 1990 did not seem to be accompanied by an improved functional status according to the Eichner index. Moreover, in 1981 a total of 62 persons had 619 teeth (an average of 10 teeth/person) and in 1990 60 persons had 569 teeth (an average of 9.5 teeth/person). Thus, the lower prevalence of total edentulousness in 1990 could mainly be considered to be the effect of another distribution of about the same number of teeth on more people, rather than of an improved functional dental status. It has also been demonstrated that the CMD status did not improve from 1981 to 1990 (III).
The reason why fewer teeth were observed in more people may be that the treatment philosophy among dentists changed during the 1970s and 80s. Scientific results and the development of new diagnostic tools, strategies and treatment plans in periodontology, cariology and prosthetic dentistry have encouraged dentists to save teeth which before had been extracted. This investment in treatment time and money is probably another explanation for the high number of recalled dentulous patients.

Longitudinal comparison of dental status (IV)

The general pattern of tooth distribution was similar in the 70- and 79-year-old cohorts in 1981 with more teeth in the anterior segments of the maxilla and mandible, even though the frequency of anterior teeth was lower in the older cohort at the start in 1981. In Fig. 10 (p. 42) it can be seen that the front region of the older cohort also showed a higher reduction of teeth during the 9-year observation period. A similar pattern of tooth distribution in elderly cohorts has been reported in other Swedish studies (Österberg et al. 1983, Palmqvist 1986, Salonen 1990). In a nationwide study in the Netherlands (Willemsen et al. 1991) it was found that the oldest age group (65-74 years) had fewer teeth in the posterior segments and a higher percentage of teeth with coronal caries in the anterior segments. In accordance with our study Chauncey et al (1987) measured caries prevalence at 3-year intervals over an elapsed time of approximately 10 years. Chauncey et al reported that the anterior segments of the maxilla and the mandible in the 55+ group had the highest caries rate.

Dental caries and periodontal disease

The DMFT index was once constructed to estimate changes in caries rate in young and adult subjects with a few tooth losses, mainly correlated with caries. It has been reported that tooth losses in subjects older than 25 were mainly correlated with periodontal disease (Murray 1971), but recent studies (Niessen & Weyant 1989, Chauncey et al. 1989) have indicated that dental caries is also of importance for tooth loss in the elderly. Consequently, the M part of the DMFT index used in elderly subjects should be considered as an indicator both of previous periodontal disease and of caries.

The DMFS index is well known and easy to register. However, the changed distribution of teeth in the elderly with more edentulous molar and premolar regions make the anterior segments more important for masticatory function. In
consequence, the incisal part of the front teeth in many dentate U70 subjects either were restored with crowns or fillings or formed a mastication surface caused by increased occlusal wear. Decayed incisal surfaces were also found and it is our opinion that a DMFS index based on 140 (5x28) surfaces would better reflect the changed pattern of tooth distribution, the increased importance for mastication in the anterior segments and the increased frequency and changed pattern of dental diseases in elderly subjects.

It has been reported that periodontal destruction occurs in short bursts rather than in linear progression (Haffajee et al. 1983). Periodontal sites are considered as existing in 2 states, either disease active or inactive. Since periodontal pockets once formed do not spontaneously disappear, recurrent bursts of activity result in more periodontal lesions in the elderly than in individuals who have not lived as long. Clinical measurements of periodontitis have been evaluated (Goodson 1986), and clinical measurements which have failed to exhibit associations with episodic attachment loss include gingival redness, bleeding on probing (BOP), suppuration, supragingival plaque, and darkfield microscopic counts. Detection of disease activity appears central to the clinical measurement of periodontitis and the only practical means of detecting active disease is from differences between repeated attachment level measurements. Other authors (Lang et al. 1991) have also pointed out that BOP depends on the force used and that uncontrolled forces may result in a proportion of false positive readings. However, absence of bleeding on probing was concluded a reliable predictor for maintenance of periodontal health (Lang et al. 1990). In a follow-up study of 39 patients incorporated in a program of supportive periodontal therapy for a period of 53 months (Joss et al 1994), it was found that 2/3 of all sites which lost attachment were found in a group of patients which presented a mean BOP ≥30%. In a group of patients with a mean BOP≤20% only 1/5 of the loser sites were found. In a paper by Van der Velden (1991) the onset of periodontal destruction was discussed. The author claims that longitudinal epidemiological studies have shown that periodontitis increases with ageing and that data show that after the age of 40, the per cent of the population affected by periodontitis remains rather constant. If the incidence after the age of 40 was zero, then extractions due to periodontitis should lead to a decrease of the prevalence of periodontitis. However, the prevalence of periodontitis remains about the same after the age of 40, which suggests that even at a relatively old age, the onset of periodontatis may occur. It has also been shown by Holm-Pedersen et al. (1975) in a controlled study of experimental gingivitis that gingival inflammation developed more rapidly and was more intense in elderly (65-78 years) than in
young (20-24) subjects. Plaque accumulations was also enhanced in the older age group. However, when oral hygiene measures were resumed, there were no differences in the rate of healing of the inflamed gingiva and restitution of gingival health in the two groups. The greater amount of plaque recovered in the elderly subjects were supposed to be, in part, the result of a larger root surface area available for plaque retention because of gingival recession in the elderly subjects.

Cohort differences in periodontal status and caries lesion (V)

A significant decrease in PLI and GI was reported in 70-year-old cohorts examined in 1973 and 1983 in Jönköping, in the southern part of Sweden (Hugoson et al. 1986). A corresponding improvement in BOP could not be found in the present study in northern Sweden. BOP was almost equal in the two 70-year-old cohorts in Umeå. Interestingly, the per cent of sites with an attachment level exceeding 3 mm was higher in the cohort examined in 1990. This may indicate a larger area of exposed root surface in 1990 and might be the most important factor behind the increased frequency of lesions in the root cementum. It could be questioned whether a registration of attachment level is a relevant method to compare two different samples. The distribution of crowns and fillings is not the same in the two 70-year-old cohort samples which means that more registrations may have been done from the cervical border of a filling or crown, rather than from the E-C border, in one sample or the other. However, a comparison of attachment level may still give some useful information. A calculation of the ratio between the number of filled teeth (FT) and the total number of teeth in men and women in 1981 and 1990 showed a ratio of 0.72 and 0.79 in men and 0.84 and 0.82 in women respectively. Thus, the trend was that men had a higher portion of their teeth with fillings or crowns in 1990. If a filling extended below the E-C border, the cervical border of that filling or crown was used for the registration and the measure of the pocket depth would have a lower value than if the registration had been done from the E-C border. Despite the FT/teeth ratio in men, the frequency of an attachment level >3 mm was higher in the 70-year-old cohort in 1990, which probably reflects a lower alveolar bone level and a larger exposed root surface area (Table 9). This might explain some of the significant increase of root caries lesions in men (Table 8). Women showed in general a lower frequency of attachment level > 3 mm than men, and thus less exposed root surface area. Consequently the tendency towards more root surface lesions in women did not reach a statistically significant level in 1990.
There was a high and increasing frequency of root caries during the 9-year period in the younger cohort. It has been reported in a study in Göteborg that root caries increased with age (Fure & Zickert 1990). In another epidemiological study in southern Sweden (Salonen 1990) 95% of the lesions in the oldest age group (>79 years of age) were found to be root caries. An 8-year long-term study was conducted to evaluate a number of variables presumed to influence root caries development on exposed root surfaces (Ravald et al. 1981). It was concluded that root caries was far more prevalent when risk values of the variables were present and that the important variables differed considerably between the subjects; no single variable was found to be discriminative in all subjects.

In the present study the increased frequency of an attachment level exceeding 3 mm indicated a larger area of exposed root cement in 1990 which was considered to be the main explanation of the high frequency of lesions in the root cementum. In order to compare the results during the 9-year period, all results were calculated as per cent of the remaining teeth or surfaces. In the longitudinal study attachment level increased significantly in the older cohort while bleeding was unchanged during the 9-year period (Table 5). In the younger cohort bleeding was significantly decreased and the attachment level unchanged during the same period. Bleeding and attachment level showed significantly higher frequencies in the older cohort compared with the younger cohort in 1981 and in 1990.

The bleeding frequency seems be correlated with the changes in attachment level in the present study which may support the reports by Joss et al (1994) of a correlation between BOP and loss of attachment level and by Van der Velden (1991) that periodontal disease may start also in old age. The increased attachment level and the root caries incidence in the oldest cohort also support the opinion that periodontal disease, caries and tooth loss in the elderly are correlated (Murray 1971, Niessen & Weyant 1989, Chauncey et al. 1989).

Knowledge of dental insurance in 1981 (IV)

Although the financial rules for dental insurance were very simple in 1981, few of the elderly knew that the patient and the insurance shared the total costs for material and work equally. However, the rules for the insurance had been changed several times since the introduction in 1974, which might partly explain the low frequency of correct answers. When the insurance was begun it was the regular patients who were given the opportunity to obtain more and cheaper
dental care, and the results of the present study indicated that it was mainly the regular customers that knew of the insurance. Furthermore, many of the elderly in this study were complete denture wearers and had not seen a dentist for many years. It was not considered meaningful to repeat the question about dental insurance in the follow-up studies because the rules became more and more complicated with time.

_Fear and uneasy feelings before a dental visit in 1981 (IV)_

More than 20% of the sample in 1981 felt uneasy or scared before a dental appointment, irrespective of age, gender, dental status, or earlier consumption of dental care. Investigations of dental anxiety in representative populations in Sweden have shown a prevalence of 10-15% in adult populations (SIFO 1962, Håkansson 1970). In general, phobias are found to be more common in women, and in clinical materials of people with dental phobias, women also dominate (Berggren 1984). Dental anxiety has also been related to poorer dental status with fewer natural teeth and more dentures (Hällström & Halling 1984). The reasons for fear and uneasy feelings before a dental appointment in the U70 study appear to be of complex origin. For instance, there was no difference between those who visited their dentist regularly or only for emergency treatment, and complete denture wearers and dentate subjects felt equally uneasy at the prospect of a visit to a dentist. The latter was in accordance with the findings in Jönköping (Hugosson & Koch 1979) but contradictory to Locker & Liddell (1992) who reported that dentally anxious subjects were more likely to be edentulous, to need prosthodontic treatment, and if dentate, had more missing and fewer filled teeth.

_Removable denture problems in U70 (IV)_

There is a reported gap between the demand and need for denture treatment; in general, about two-thirds of the denture wearers have been reported to have a clinical treatment need but only one-third ask for treatment (Grabowski & Bertram 1975, Österberg 1981, Rise 1982). In one recent investigation, no significant association was observed between the need for complete denture treatment and complaints (Mojon & MacEntee 1992), which was in accordance with our findings in U70. Adjustments of new complete dentures are often required; this is especially frequent in mandibular dentures, and patients may attempt to guide such adjustments. Results of a recent study, however, indicate
that patient-perceived locations rarely coincide with the actual area on the denture that required adjustment as determined with the use of a dye-transfer indicating method (Yeoman & Beyak 1995).

Clinical studies of patients' evaluation of complete dentures one (Bergman & Carlsson 1972), and five years (Magnusson 1986) after receiving new dentures, showed that a great majority of the patients were satisfied with their dentures. The patients had been told to contact the clinic at least every two years for a clinical check-up (Magnusson 1986) but more than 50% of the patients did not contact a dentist during the 5-year period, and 60% of the dentures were judged to be in need of correction or replacement. Both studies stressed the importance of a regular recall system.

One reason for the discrepancy between need and demand in the U70 study may be the increase in medical diseases with increasing age discussed above (Österlind 1993). Another reason reported by (Schou & Eadie 1991) was the opinion among the elderly that tooth loss was expected and part of the ageing process and that oral health was unrelated to general health. Furthermore, some general problems encountered in the assessment of complete dentures (Pinsent & Laird 1989a) may lead to validity problems. When a study was undertaken to develop criteria of proven reliability for the assessment of complete dentures (Pinsent & Laird 1989b) an acceptable level of reliability was not attained. The criteria presented by Bergman et al. (1964) used in the present study have, however, been considered to have long-term consistency (Pinsent & Laird 1989b).

Longitudinal studies of caries and periodontal, and prosthetic findings in 30 patients fitted with removable partial dentures after 10 and 25 years were reported by Bergman et al. (1982, 1995). After the initial 10 years, the patients were advised to continue to have yearly controls on their own initiative. During the follow-up period, the patients were examined at yearly intervals, at which time remotivation and reinstruction regarding oral hygiene was given, and scalings, operative restorations, and prosthetic and other treatment procedures were performed as required. The 10-year study, where 27 patients could be re-examined, showed that patient cooperation was excellent, and no significant deterioration of periodontal status was found. In addition, there was only a minor increase in the number of decayed and filled tooth surfaces. The dentures, however, showed damage and several changes. This indicated the need for various corrective prosthetic procedures. Of the initial 30 patients from 1969, 23 were still alive in 1994, all of whom were re-examined. In 18 patients wearing a total of 20 RPDs, 13 (65%) of the original RPDs were still functioning. Among these 18 patients the numbers of lost teeth, of new DF surfaces, and of new endodontically treated teeth...
were few. No apparent changes took place regarding the periodontal condition during the 25 year period. Seven RPDs were new with principally the same design as the original ones. In five patients the original RPD situation had changed more or less due to general illness and/or change to other therapies. It was concluded that an RPD is a valuable treatment procedure for patients with a markedly reduced number of teeth.

The number of lost teeth, of new DF surfaces and of periodontal changes reported by Bergman et al. (1982, 1995) were few. The patients were reinstructed and remotivated once a year during the first ten years which can explain some of the excellent results of the longitudinal RPD study. The participants in the U70 study were not motivated or instructed only informed about the results of the examinations, which can explain the higher amount of tooth loss, caries lesions, and the increasing attachment loss found in U70. The characteristics of the samples differed a lot because of different aims and sampling methods. However, also in the longitudinal RPD study a lot of prosthetic treatment was reported, which was in accordance with the findings in the U70 study.

**Denture stomatitis in U70**

The chronic inflammation of the denture bearing mucosa is known under the name of *stomatitis prosthética* or *denture stomatitis*. Various factors have been reported to be associated with this denture related inflammation, i.e. trauma due to poor fit, instability, unsatisfactory occlusion and articulation (Nyquist 1952, Bergman et al. 1964). Toxic irritation and/or hypersensitivity to the base material (Nyquist 1952), infections with *Candida albicans* and poor hygiene (Butz-Jørgensen & Bertram 1970, Bergendal 1982), and systemic diseases (Bergendal 1982) such as kidney and urinary tract diseases are other factors associated with denture stomatitis. In a clinical random study in 60 patients divided into two equally large groups, the effects of habitual use (day only *versus* day and night) of complete dentures on underlying tissues were investigated (Bergman et al. 1971). Clinical examination of 54 of the patients one year later revealed no significant differences in the frequency of denture stomatitis between the two groups. Bergendal (1982), however, reported a higher prevalence of stomatitis among nightly denture wearers. Ambjörnsen (1985) investigated denture stomatitis in a sample of 430 persons 65 years old and over including 249 persons with complete upper dentures. In a multivariate analysis of 12 selected predictors the quality of the fitting surface of the denture and the occlusal contact relation were the most important predictors for stomatitis. In addition, the number of years with the
current maxillary denture, denture cleanliness and mouth dryness had a significant effect on the prevalence of denture stomatitis.

Denture stomatitis was a common finding in U70, and the frequency was similar to that reported by Österberg (1981) in the H70 study in Göteborg. The frequency of denture stomatitis tended to decrease in the longitudinal study, and the frequency of discomfort or pain caused by denture-related wounds, painful redness, or impressions in the denture-bearing mucosa tended to increase. There was also an association between denture stomatitis and angular cheilitis, and a similar observation was previously reported (Bergendal 1982).

A clinical denture treatment need was registered only when the examiner considered the prognosis for denture treatment to be good. In consequence, there was a higher frequency of treatment with new dentures in the younger agecohorts and the high and increased frequency of adjustments among the 88-year-olds reflects a poor prognosis due to more severely resorbed residual ridges and more medical diseases in the oldest agegroup. There were many good reasons to re-line or re-base or otherwise maintain an existing complete denture, the main one being the avoidance of adaptive problems that occur with new dentures and increase with age of the patient. It has previously been discussed that subjective chewing problems were highly correlated with dental status and removable dentures and that chewing problems influence the variation in dietary intake (II).

Dry mouth in U70 (IV)

Saliva is produced principally to protect the oral cavity (Mandel 1980) and contains lubricatory proteins to keep the oral mucosa pliable and hydrated. Antibacterial factors regulate the distribution and numbers of oral microorganisms, and inorganic and organic buffers neutralize proton production by cariogenic bacteria (Baum 1986). Furthermore, saliva dissolves tastants, contributes to food bolus formation, and lubricates the bolus in preparation for the swallowing process. There is no generalized diminution in salivary gland performance with increased age (Bertram 1967, Baum 1986). Diseases and drug therapy may, however, decrease the saliva flow.

A sufficient layer of mucous saliva is essential to obtain an adequate retention of complete dentures (Östlund 1960, Kawazoe & Hamada 1978), and the importance of minor salivary glands has been pointed out (Kawazoe & Hamada 1978, Edgerton et al. 1987). Hyposecretion of minor salivary glands is significantly associated with complaints of "dry mouth" and "burning sensations" of the mucosa especially in complete denture wearers (Niedermeier & Krämer 1992). In
a study of correlations between the retention of complete dentures and flow rates of the palatal and parotid glands in 86 complete denture wearers (Niedermeier & Krämer 1992), no correlation between parotid saliva flow and denture retention was found, while a narrow correlation between maxillary denture retention and the secretion of the palatal glands was reported.

Prevalence data suggest that dry mouth is a common problem in the segment 50+ in the population (Locker 1995), and rates ranging from 18% to 61% have been reported. In a longitudinal 3 year study Locker (1995) found the dry mouth was more likely to develop with increasing age, in subjects with more chronic medical conditions and in persons reporting a poor general health. The onset of xerostomia was also associated with an increase in other oral problems and with chewing problems. The prevalence of subjective dry mouth problems in the U70 study was ranging from 26% among the 88-year old and to 45% in the 79-year-olds both in 1981 and 1990. Whether the decrease in number of complaints of dry mouth in the oldest age cohort in the U70 study was due to an increase in other problems and diseases or, on the other hand, to the fact that was the healthiest persons were still alive cannot be judged from the present results. This question, however, among others, will be analyzed in a forthcoming paper.
SUMMARY AND CONCLUSIONS

A number of conclusions might be drawn from the results of the present study. Some of the most apparent are the following:

(I) Mean intakes of energy and nutrients were satisfactory in most respects according to Swedish recommendations (RDA-S) in 1981. The energy intake from fat, however, was above the RDA-S and the intake of fat increased with increasing age. Vitamin D intake among women was below the RDA-S, and although the RDA-S was the same for men and women, women had lower intakes than men of calcium, iron and vitamins C and D. In light of current research, the RDA-S for calcium set in 1981 seems low. Even though this recommendation is low, about 10% of the sample had intakes of both calcium and vitamin D below the Swedish standards.

It should also be noted that the analysis of dietary intake in the U70 study was based on a comparison with an allowance set for healthy people. In the 1981 U70 study, however, 61% of the people in the population sample were not considered healthy, and an additional 27% required further consideration. Diseases and medications affect absorption, and malnutrition may also occur as a result of metabolic requirements that are altered by chronic disease. It thus seems less useful to use the RDA-S in studies of elderly populations than in young and adult populations with a more homogeneous health profile.

In comparison with the H70 study, the U70 study showed a similar or slightly higher intakes of energy and most nutrients, minerals, and vitamins. The overconsumption of fat in Göteborg was, however, even higher than in Umeå.

(II) In the sample, more women than men felt lonely, lived alone, and felt ill. Women also had more signs and symptoms of CMD. A multivariate analysis showed that sex, age, education, general living conditions, anamnestical and clinical dysfunction indices, and dental status all influenced dietary intake. Subjective chewing problems were strongly correlated to dental status and constituted one of the most important single variables explaining the differences in dietary intake.

The study shows the importance of investigating elderly patients about their living conditions and chewing problems, as well as evaluating dental status and function from a "masticatory performance perspective" and offering adequate dietary advice.
Although the frequency of reported CMD symptoms decreased, many clinical signs of CMD increased during the 9-year observation period. Women reported more symptoms and showed more signs of CMD than men, and a great many of the clinical signs registered in 1981 persisted in 1990. Another interesting finding was that one-third of the new crepitating joints in 1990 had been registered for clicking sounds in 1981.

The new 70-year-old cohort studied in 1990 showed a lower prevalence of reported symptoms of CMD and of TMJ pain on palpation but a higher frequency of muscle pain and mandibular deviation compared with the 70-year-olds examined in 1981.

Thus, no general improvement in CMD status could be found in the new 70-year-old cohort in 1990 compared with the 70-year-olds examined in 1981.

The longitudinal study shows a high and in many cases increasing amount of tooth loss, root caries, and periodontal disease with increasing age. Reported denture-related problems were common, but less common than and not correlated with the clinical findings. Between 29 and 54% of the cohorts reported a removable denture treatment need with the lowest frequency among the oldest subjects. The oldest individuals also reported fewer dry mouth problems than younger elderly. Also the clinically estimated need for new complete dentures decreased with increasing age but the need for adjustment increased with ageing.

A cohort comparison between 70-year-olds examined in 1981 and 70-year-olds examined in 1990 showed a lower denture treatment need in 1990. Subjects with annual dental visits had, in general, fewer oral problems.

A comparison of oral health in the two different samples of 70-year-old men and women examined in 1981 and 1990 showed that a higher frequency of dental visits among men could be expected in the city population in 1990. The prevalence and pattern of reported oral problems was similar in 1981 and 1990. Total edentulousness was more common in 1981 than in 1990, but the lower frequency in 1990 was not statistically significant on the population level. The mean number of teeth was, however, significantly lower in dentated men in 1990 and the tendency was the same among women. The functional index according to Eichner showed no difference in the two 70-year-old cohorts. Thus, the lower frequency of edentulousness in 1990 mainly seemed to be the result of a different distribution of approximately the same number of teeth on more people. The bleeding index showed values of about 30% in both cohorts, but both men and
women showed significantly less recurrent caries in 1990. Men showed a higher number of missing teeth and of decayed root surfaces in 1990. The latter might be explained by a larger exposed root surface area which was indicated by a higher frequency of surfaces with an attachment level >3 mm in the cohort examined in 1990. Although, the new 70-year-old city cohort examined in 1990 showed a higher frequency of dental visits and of dentated subjects compared with the 70-year-olds examined in 1981, no improvement in reported oral health or dental status could be found in the 70-year-olds in Umeå in 1990.

Future research

The present thesis describes cohort differences and longitudinal changes in oral health in representative samples of an elderly city population. The high and, with age increasing prevalence of chewing problems associated with an impaired dental status affects dietary intake and emphasises the importance of improving dental status while the elderly patient is still able to adapt to a new situation and thereafter maintain the oral function for life. This thesis may answer some questions but raises many new and interesting ones. Among these are:

* How relevant is the use of recommended dietary standards in the analysis of dietary interviews in elderly populations? A study of estimated dietary intakes in a representative population compared with blood concentrations and urinary excretion of nutrients in the same persons would perhaps be one way to approach this important question.

* To what degree can the discrepancy between dietary intake and blood component concentrations be explained by dental status and oral function parameters? This is another question of interest not only to dentists.

* What changes may occur in the quality and quantity of saliva during aging and disease? A prospective study of a group of healthy 70-year-olds followed longitudinally to study the impact of pure aging in persons who stay healthy, and the impact of aging plus different diseases and medications in those subjects who become ill during the course of the study.
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