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Abstract

Objective: The purpose of this review was to study the prevalence and incidence of edentulism and tooth loss in European countries.

Material and method: A literature search was performed by means of Medline/PubMed using various combinations of keywords concerning prevalence and incidence of tooth loss and edentulism, complemented by a hand search. Inclusion criteria were cross-sectional and longitudinal clinical and questionnaire studies of representative or random samples of ≥ 100 subjects at the initial examination. Sixty articles were identified; the hand search gave 13 more references.

Results: This literature review demonstrated that there is a lack of epidemiological studies on edentulism and tooth loss in many countries in Europe. The quality of available data varied considerably. There is a documented decline of edentulism with still great differences in prevalence between countries, between geographical regions within countries and between groups with various backgrounds. The mean number of lost teeth increases with age. In several countries many dentate subjects aged 60 years and over still have reduced dentitions possibly needing prosthodontic treatment. The incidence of tooth loss is low but with geographical variation between age groups, and there is a trend for decreasing incidence over the last decades. A great number of variables are associated with tooth loss, and there is no consensus whether dental disease related or socio-behavioural factors are the most important risk factors. Institutionalised elderly people have, in general, more compromised oral health, including fewer teeth, than those at the same age living freely.

Conclusion: Tooth loss and edentulism are declining at least in those European countries where reliable data are available. However, the WHO goal of retaining at least 20 teeth at the age of 80 years has not yet been met but is being approached in some countries.

For a long time, it was suggested in most textbooks in prosthodontics and taught in dental schools that all lost teeth should be replaced with some form of restorative treatment. The reason given was that the masticatory system needed a complete dentition to remain healthy and provide satisfactory function. The emphasis on this concept in dental education was so strong that many clinicians considered it

a dogma. It took a long time before this concept was questioned by a few bold prosthodontists who observed that numerous patients were quite happy with a reduced dentition and had no wish to get a prosthesis to replace their lost teeth. Some time ago the British prosthodontist Fish made the ironical statement that dentists were often more interested than their patients in replacing lost teeth. In the

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Dutch prosthodontist Käyser (1981) started a research-based campaign against the concept of restoring a full dentition by advocating that shortened dental arches (SDAs) were adequate for many patients without the risk of developing functional disturbances or temporomandibular disorders (TMD). After a long series of studies, his group concluded that there was, in general, no clinically significant differences between subjects with SDA of three to five occlusal units and complete dental arches with regard to variables such as masticatory ability, signs and symptoms of TMD, migration of remaining teeth, periodontal support and oral comfort (for a review see Kanno & Carlsson 2006). The SDA concept and other opinions questioning the necessity to replace all lost teeth have had a strong influence on treatment planning and decision making (Rich & Goldstein 2002; Korduner et al. 2006). This indicates how important the knowledge of tooth loss and its consequences are in clinical dentistry.

Another now refuted concept is that people will lose their teeth with ageing – edentulism and complete dentures were considered the inevitable fate of the elderly. Up to the middle of the 20th century the great majority of old people was edentulous. However, during the last few decades, a dramatic reduction in prevalence of edentulism and incidence of tooth loss has occurred in many industrialised countries (e.g., Ainamo & Österberg 1992; Österberg et al. 2000; Mojon 2003). These changes in dental state, among the elderly, have had a strong influence on dental care. Instead of complete dentures, previously the most common therapy in old people, individuals with remaining natural teeth require other types of restorative and prosthodontic treatment. The rapid development of predictable dental implants has also revolutionised prosthodontic treatment during the last quarter century – for those who can afford this expensive treatment. However, there are also risks and disadvantages associated with most dental restorations. Therefore, a defined aim is to have at least 20 natural teeth at the age of 80 and thus sufficient occlusal units to be able to refrain from the use of any prosthodontic appliance (WHO 1992).

One would expect epidemiological data on prevalence of edentulism and various

types of prosthodontic restorations to be easily accessible. It has, however, been demonstrated that the quality of such data varies considerably, making comparison between countries difficult (Mojon et al. 2004). It is probably even more difficult to find reliable data on incidence of tooth loss, as that requires longitudinal studies, which are even rarer than good cross-sectional investigations.

Prevalence and incidence are synonymous in some dictionaries, but in epidemiological texts they have different meanings. *Prevalence* is defined as the proportion of the population with the disease or condition at a given time. *Incidence* indicates the rate of onset of the condition over time, usually 1 year, i.e., the number of new cases appearing in the specified interval divided by the number of persons at risk of onset (Kleinbaum et al. 1982; Carlsson & LeResche 1995).

There is thus limited knowledge of the rate of ongoing changes in dental state and how it varies between countries. It was, therefore, the purpose of this report to review the prevalence and incidence of tooth loss in the adult and elderly population in Europe, based on available literature. A more specific aim was to define the risk factors of tooth loss. It was hypothesised that both prevalence and incidence of tooth loss are declining in Europe. Other hypotheses were that institutionalised and cognitively impaired individuals would show higher levels of tooth loss than independently living people, and that tobacco smoking, poor general health and poor socio-economic conditions would be important risk factors for tooth loss.

Materials and methods

The literature on tooth loss has been searched up to 30 November 2006 in PubMed. The keywords tooth loss, edentulism, SDA, epidemiology, prevalence, incidence and risk factors were used in various combinations to search the database. PubMed listed about 800 titles for tooth loss and epidemiology. By using the terms tooth loss + epidemiology + Europe, 269 titles were found. When using prevalence or incidence, instead of epidemiology, approximately the same number of articles were listed (277 and 271, respec-

tively). The great majority of the titles were the same in the three searches. Articles were included in the review if they met the following criteria.

1. Clinical and questionnaire cross-sectional or long-term studies of representative population or random samples.
2. Sample size ≥ 100 individuals at initial examination.
3. Articles published in English, French and German.

Two of the authors reviewed all titles against the inclusion criteria, and 60 articles were identified. An additional hand search of references in the articles and in various textbooks, especially those related to dental epidemiology and prosthodontics was also performed. Furthermore, national epidemiological surveys from Germany, Switzerland and the United Kingdom, not available in PubMed, were identified thanks to colleagues in these countries. The hand search gave 13 more references resulting in 73 articles for the review. To cover the additional hypotheses, new searches focused on risk factors for tooth loss. However, no new articles were identified besides those in the original list of references. The selected articles will be presented in the Results section and the reference list.

Statistics

No meta-analysis has been performed because there were no intervention studies included among the reviewed papers. The statistics that will be presented are taken from the reviewed articles, and some caution in comparing results is warranted because of the great variation in design and conduct of the investigations.

Results

Edentulism

Prevalence of edentulism

There were considerable differences in prevalence of edentulism between countries (Table 1). For example, a review of studies performed in the 1980s reported a range from 30% to 60% among 65-year-old subjects in six countries (Heath 1992; Öwall et al. 1996, Fig. 1). An extensive review of 55 studies performed from 1960 to 2001 in 14 countries demonstrated a variation in

Table 1. Prevalence and incidence of edentulism in different countries (selected studies only)

Author (et al.)	Year	Country	Study design	Sample (n)	Age (years)	Drop out	Prevalence of edentulism	Incidence of edentulism	Confounding factors	Results/comments
Heath	1992	United Kingdom	3 × cross-sectional	National Surveys 1968, 1978, 1988	65–74 +	NA	1968 → 79% 1978 → 74% 1988 → 57%	1968–78 → 8% 1978–88 → 5% (data taken from figure)		Data for 10 year age cohorts from 15 to 74+
Nitschke	1996	Germany	BASE cross-sectional population based random sample	512	Six stratified groups of equal size from 70 to 95+ (70–103)	NA	70–74 → 32.1% 75–79 → 42.2% 80–84 → 40.2% 85–89 → 57.4% 90–94 → 76.3% 95+ → 64.5%	NA	Socio-economic factors, general health, utilisation	Comprehensive medical examination for each participant
Hescot	1997	France	Cross-sectional	1000	35–44	NA	0%	NA	Gender, rural vs. urban	Mean number of natural teeth 27.1
Nordenyd	1998	Sweden	Cross-sectional	484 (urban = u) 1219 (rural = r)	30–70	NA	30: u0% r0.4% 40: u0% r0.4% 50: u0% r2.1and 60: u9.8% r5.1% 70: u23% r18.5%	NA	Urban vs. rural	No important differences between urban and rural population
Ahliquist	1999	Sweden	Longitudinal 24 years	Only women 1968: 1417 1980: 1198 1992: 994	1968: 38–60 1980: 38–72 1992: 38–84	Filled up with new participants	50-year-olds 1968:18.2% 1980: 4% 1992: 1%	50-year-olds 1968–80 → 6.1% 1980–92 → 1.1%		The incidence of edentulism decreases in later age cohorts
Suominen-Taipale	1999	Finland	20 × cross-sectional mailed questionnaire	Between 3418 and 5037 in the years 1978 to 1997	15–64	NA	1978: 9.9% men 17.2% women 1997: 7.1% men, 5.7% women	NA		Difference between women and men levelled nearly out from 1978 to 1997
Kelly	2000	United Kingdom	Adult Dental Health Surveys 1968–1998 4 × cross-sectional	1968: 2658 1978: 4639 1988: 3583 1998: 3817	1968/1978: five, 1988: six and 1998: eight stratified groups from 16 to 85 +	NA	1968: 1–63% 1978: 0–56% 1988: 0–57% 1998: 0–81%	In age groups: 1968–78 → 3–10% 1978–88 → 0–5% 1988–98 → 0–3%		Incidence increased with age but decreased in younger age-cohorts
Närhi	2000	Finland	Helsinki ageing study longitudinal for 5 years	103 out of initial 293, followed up for 5 years	Baseline: 76, 81 and 86	Only persons with both examinations	28.1% 5-year follow-up 32%	1990–95 → 3.9%	Selection bias: X-ray had to be accepted	Only few changes on radiographic parameters of natural teeth (oral infections)
Österberg	2000	Sweden	5 × cross-sectional 1975–1997 interview	> 11,582	16–74 after 1980 16–84	22% or less of original sample	25–74 years: 1975 → 19% 1989 → 8% 1997 → 3%	65–75 years 1975–80 → 7% 1980–88 → 6% 1988–96 → 2%	Utilisation of dental services, chewing ability	Prevalence in women > 75 years significantly higher than in men (P < 0.001); gender difference below 65 years disappeared 49.5% of the participants had fixed and/or removable prosthesis, 19% had at least one
Zitzmann	2001	Switzerland	Swiss Health Survey 1992/1993 tel. interview and questionnaires	14,326 in population based stratified samples	15–74	NA	15–24 years: 0.3% 25–34 years: 0.5% 35–44 years: 1.1% 45–54 years: 4.9% 55–64 years: 12.6% 65–74 years: 26.8%	NA		

Author	Year	Country	Study Design	Sample Size	Age Group	NA	Total %	Notes
Mack	2003	Germany	SHIP cross-sectional	1877	55-79	NA	5.7%	removable prosthesis 28.9% had 20 or more natural teeth
Nevalainen	2004	Finland	Helsinki ageing study longitudinal 5 years	113 out of initial sample of 364	At baseline: 76, 81 and 86 years	Only persons with both examinations	26.2%	Socio-economic, health, smoking, alcohol Salivary flow rate
Nitschke	2004	Germany	Baseline data from BASE longitudinal: 8.6-year follow-up	84	85.2 (78-97) at follow-up in 2000	84% less than original sample of 512	33.3%	1990-95 → 4% 1990/1993 → 2000 → 2.4%
Kerschbaum	2006	Germany	DMS III and IV 2 × cross-sectional	DMS III: 1367 DMS IV: 1040	65-74	NA	24.8% 2006: 22.6%	More root caries and increased prevalence of periodontal disease
Zitzmann	In preparation	Switzerland	Swiss Health Survey 2002 written questionnaires	16,141	15 (no upper age limit)	86%	15-24 years: 0.2% 25-34 years: 0.1% 35-44 years: 0.4% 45-54 years: 2.2% 55-64 years: 5.5% 65-74 years: 13.8% 75-84 years: 27.1% 85+ years: 38%	Sex, age, living area, nationality
							Total 5%	From 1992/1993 to 2002/2003 the mean number of lost teeth (maximum 28) dropped in the 65-74-year-olds from 15.4 to 10.4

BASE, Berlin Ageing Study; NA, not applicable.

prevalence of edentulism from 3% to 80% among people aged 60 or more. When limited to the eight European countries in the review, the figures were between 11% and 80% (Nitschke 2004). Also in countries with seemingly similar economic and social conditions, such as the Nordic countries, the differences are notable (Ainamo & Österberg 1992). In the 1990s, the prevalence of edentulism among 75-year-old subjects in a Swedish, Danish and Finnish city were 27%, 45% and 58%, respectively (Österberg et al. 1995). In a global perspective, a range of prevalence from 0% to 72% has been reported for the 65- to 74-year age group, and in Europe this range was 15-72% (Mojon 2003). A remarkable finding of that survey was that the rate of edentulism was neither associated with a country's economic situation nor with the number of dentists per capita.

In many countries, women had a higher prevalence of edentulism a few decades ago (Rise 1982; Palmqvist 1986; Salonen et al. 1990), but this difference between the sexes has tended to level out with time in many countries (Suominen-Taipale et al. 1999, Fig. 2; Österberg et al. 2000; Mack et al. 2003a, 2003b; Nitschke 2004), but not in all of them (Walter et al. 1999).

The rate of edentulism has decreased rapidly over the last few decades in many countries (Suominen-Taipale et al. 1999; Kelly et al. 2000, Fig. 3; Österberg et al. 2000). In an extensive review of the literature, it was found that there were reliable data from only four countries (Finland, Sweden, the United Kingdom and the USA) that made it possible to predict the trends in edentulism for the next few decades (Mojon et al. 2004, Fig. 4).

The proportion of adult Scots without teeth fell from 44% in 1972 to 18% in 1998, but was still higher than the UK average (Nuttall 2001). Based on the 1998 Adult Dental Health Survey, it has been estimated that the prevalence of edentulism will fall to only 4% of the UK population over the next three decades (Steele et al. 2000). In two cohorts of 70-year-old Swedes, the prevalence of edentulism was 16% in 1990/1991 and 7% in 2000/2001 (Österberg & Carlsson 2007). In 40-70-year-old people in a Swedish city (Jönköping), the prevalence of edentulism fell dramatically from 16% in 1973 to 1% in 2003 (Hugoson et al. 1995, 2005). At the latest

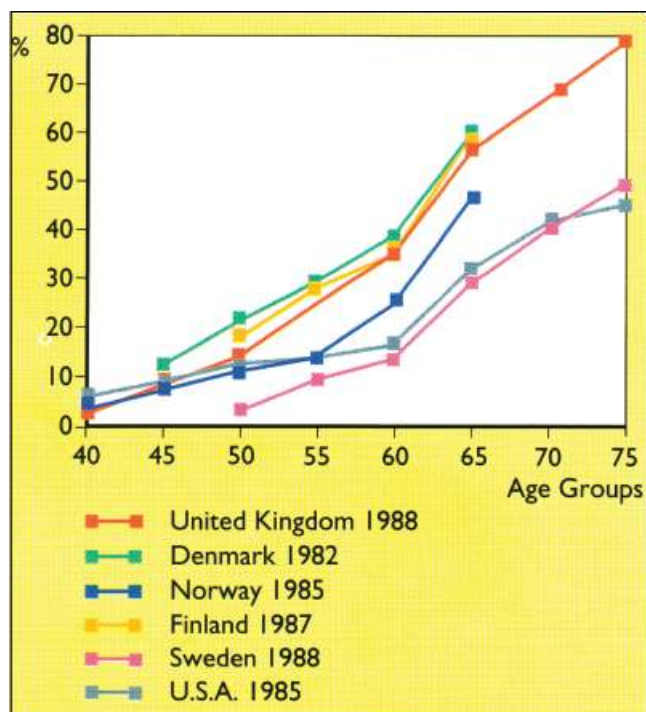


Fig. 1. National differences in six countries in edentulism in various age groups in the 1980s (Öwall et al. 1996).

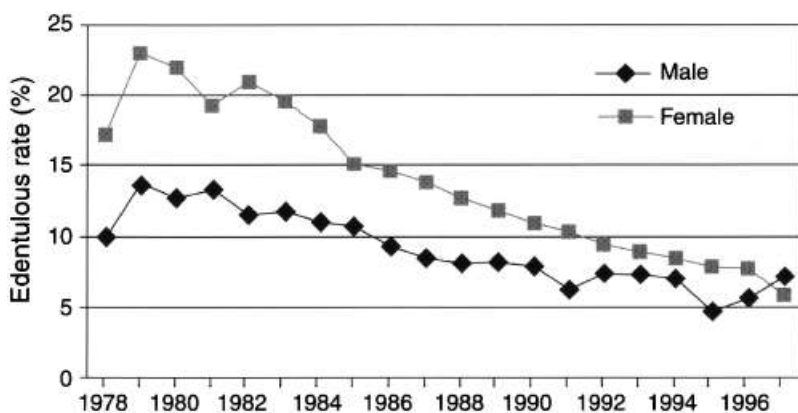


Fig. 2. The decline in edentulism in Finland by sex (Mojon 2003, data from Suominen-Taipale et al. 1999).

turn of the century, edentulism was rare among people in working age according to studies in several European countries. For example, the prevalence of edentulism in Finns aged 15–64 years decreased from 14% to 6% from 1978 to 1997 (Suominen-Taipale et al. 1999). In Sweden, the rate of edentulism among 50-year-old subjects was 1.9% in 1992 and 0.3% in 2002 (Unell et al. 2006). Hugoson et al. (2005) recorded 0% prevalence for edentulism in people below the age of 60 in one Swedish city in 2003. Edentulism was observed in 0.8% of 30–39-year-old subjects in Finland

in 1989 (Hiidenkari et al. 1997), whereas no edentulism was found in a sample of 35–44-year-old French subjects in 1994 (Hescot et al. 1997), and similar was the case in 35-year-old Swedes (Axelsson et al. 1998). Sixteen percent of the 65–74-year-old French population were edentulous (Bourgeois et al. 1995).

Despite the rapid decline in edentulism, there are still differences between countries and between geographical regions within countries, as well as between groups with various background characteristics, e.g., education, urbanisation, occupation, perso-

nal economic circumstances, attitudes to dental care and lifestyle factors such as smoking, etc. (Österberg et al. 1995, Fig. 5). These confounding variables make direct comparison between national samples difficult as they are beyond control for in data reports.

Incidence of edentulism

According to a 24-year longitudinal population study of Swedish women, the rate of edentulism was 15% among 54-year-olds examined in 1969, 22% in 1981 at age 62 and 26% in 1993 at age 78 (an estimated annualised incidence of 0.46 percentage points). The corresponding figures for 46-year-olds were 8%, 12% and 15% (an estimated annualised incidence of 0.29 percentage points). It was concluded that there was a decrease with time in incidence of edentulism (Ahlqwist et al. 1999). In a random sample of Swedes aged 55–79 years, examined in 1989 and again after 10 years, the prevalence of edentulism was 5% at both examinations, indicating 0% incidence. However, the authors recommended some caution with this conclusion as ‘the distribution of non-response should be considered in this context’ (Kronström et al. 2001). It was, at any rate, concluded that only small changes in dental conditions had occurred during the decade studied. In a sample of 70- and 79-year-old Swedes, most dentate subjects had lost only one or two teeth and only one subject (2%) became edentulous during a 9-year follow-up (Nordström et al. 1998). In a large sample of 50-year-old Swedes, first examined in 1992, the proportion of edentulous subjects increased from 1.2% to 1.7% when examined again in 2002, suggesting a 10-year incidence of 0.5 percentage points (Unell et al. 2006). This is much lower than those data reported by Ahlqwist some 17 years previously. In a longitudinal Finnish study of 103 elderly subjects (aged 75–85), seven of 77 dentate participants lost all their natural teeth during the 5-year follow-up, which implies an incidence of edentulism of 2%/year (Närhi et al. 2000). In another paper, it was reported that 4% of the participants became edentulous during the 5-year follow-up, indicating an annual incidence of 0.8% (Nevalainen 2004; Nevalainen et al. 2004). Only a few longitudinal studies have reported the proportion of dentate subjects

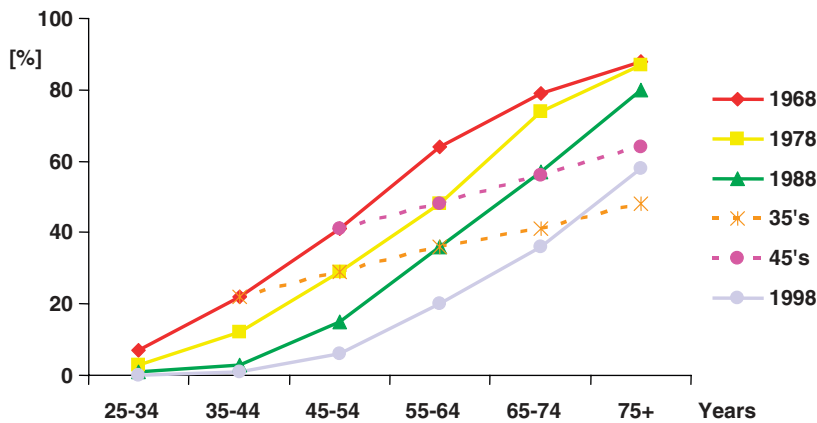


Fig. 3. Decline of edentulism in the United Kingdom from 1968, 1978, 1988 and 1998. From this repeated cross-sectional survey, cohort trends for change in edentulism in the 35- and 45-year-olds are depicted by the dotted lines (Kelly et al. 2000).

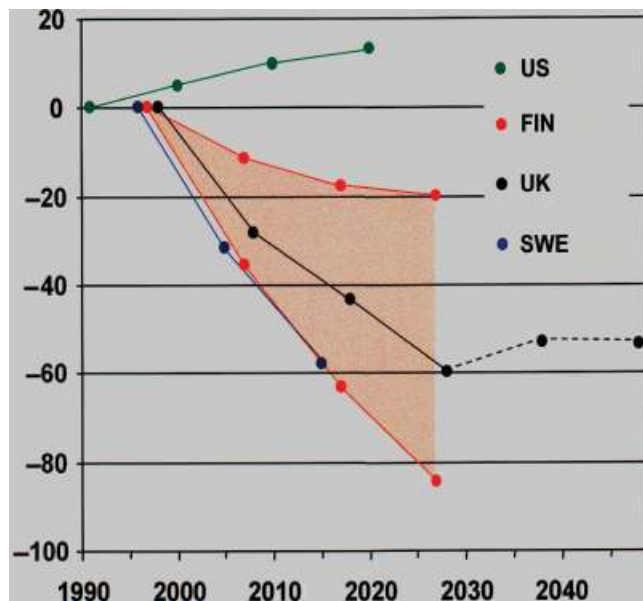


Fig. 4. Prediction of the prevalence of edentulism in four countries with reliable epidemiological data available for a prognosis (Mojon et al. 2004).

who became edentulous during specified periods. The available results indicate that the incidence is low but with geographical variation (0–2%/year); it varies between age groups and there is a trend towards decreasing incidence with time.

Natural dentitions

Prevalence of complete natural dentitions
Few studies have reported the prevalence of complete dentitions, but several studies indicate that the great majority of adolescents and young adults have all or almost all teeth remaining. In Sweden, the mean number of remaining teeth in 2003 was

approximately 27 in all groups of 15, 20, 30 and 40-year-old dentate subjects; the number only became lower above the age of 50 and fell to 18 at age 80 (Hugoson et al. 2005). In a German study performed in 1990–1992, nobody had a complete natural dentition in the age group 65–74 years (Borutta et al. 1994). In 1999, in a German population based sample of 12-year-olds, 41.8% had a full and sound dentition, but this percentage decreased to 0.3% in the 65–74-year-old population (Micheelis & Reich 1999).

In a representative sample of 35–44-year-olds in a French region, examined in 1994, the mean number of teeth was 27.1, in-

dicating that the great majority had all teeth remaining (Hescot et al. 1997). The proportion of 30–39-year-old Finns with a complete natural dentition (28–32 teeth) was 40% in 1978/1979 and 63% in 1989 (Hiidenkari et al. 1996). In a longitudinal Swedish study, 23% of 50-year-old subjects reported in 1992 that they had all teeth remaining, but 10 years later, at age 60, that figure had diminished to 17% (Johansson et al. 2006). Among 55–79-year-old subjects, the proportion of those reporting all teeth remaining in 1989 was 27%, a figure that fell to 17% 10 years later (Kronström et al. 2001).

Tooth loss

Prevalence of remaining teeth

Many studies demonstrate that the prevalence of tooth loss increases with age (Battistuzzi et al. 1987a, 1987b; Salonen et al. 1990 Fig 6; Borutta et al. 1994; Nitschke & Hopfenmüller 1996; Walter et al. 2001). According to recent German National Surveys on oral health (DMS III and IV), the most frequently lost teeth are the molars followed by the maxillary premolar and front teeth. Mandibular canines are retained longest (Micheelis & Reich 1999; Kerschbaum 2006) (Fig. 6).

In the same way as for edentulism, there are obvious differences in tooth loss between countries as well as between regions within countries, e.g., between rural and urban areas (Österberg et al. 2000; Henriksen 2003; Henriksen et al. 2003). In a county in the middle of Sweden (Dalarna), cross-sectional studies have been performed at 5-year intervals. The mean number of remaining teeth in 50-year-old subjects was 23 in 1988, 25 in 1993 and 26 in 1998 (reported in Unell 1999). The corresponding figures in two neighbour counties (Örebro and Östergötland) were 24 in 1992, and 26 in 2002. In a Swedish city (Göteborg), the mean numbers of teeth in 60-, 70- and 80-year-old subjects, examined in 1992, were 22, 18 and 15, respectively (Fure & Zickert 1997). In another Swedish city (Jönköping), the corresponding figures for the same age groups examined in 2003 were 23, 21 and 18, respectively (Hugoson et al. 2005). In a French population sample of 65–74-year-old dentate subjects examined in 1990–1992, the mean number of remaining

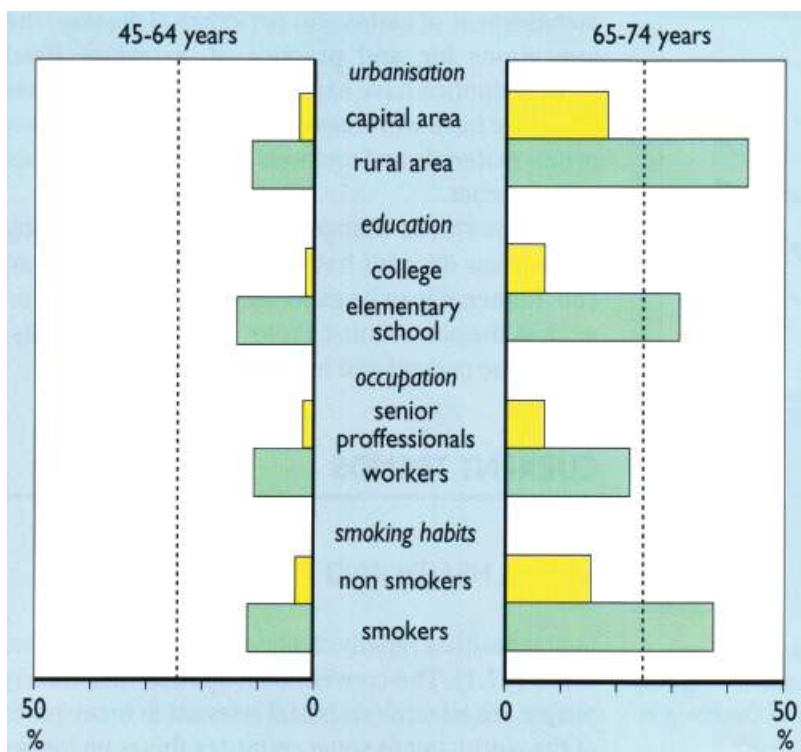


Fig. 5. Prevalence of edentulism in two age groups of Swedish men with different characteristics, examined in 1988–1989 (Österberg et al. 1995).

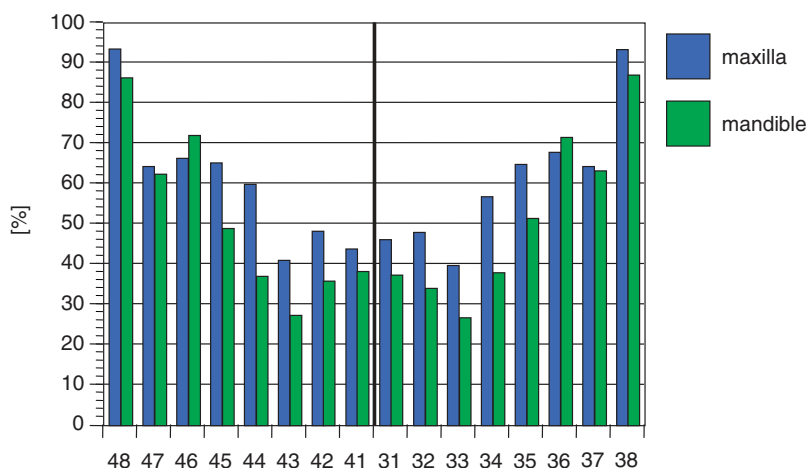


Fig. 6. Topography of tooth loss according to the fourth German National Oral Health Survey (DMS IV) (Kerschbaum 2006).

teeth was 17 (Bourgeois et al. 1995). In the DMS III, a population-based study performed in 1999, the 35–44-year-olds had on average 3.9 teeth missing (based on 28 teeth). This number increased to 17.6 in the 65–74-year-olds (Micheelis & Reich 1999). In the DMS IV, these numbers have dropped to 2.4 and 14.1, respectively (Micheelis & Schiffner 2006). The Swiss Health questionnaires revealed in 1992/

1993 1.7 missing teeth in the 35–44-year-olds and 16.3 missing teeth in the 65–74-year age cohort (Zitzmann et al. 2001). The next survey, conducted in 2002/2003, showed a reduction of missing teeth to 1.7 and 10.4, respectively (Zitzmann et al. 2007).

In a Swedish county (Jönköping), no great differences in tooth loss were found between individuals living in the city and

in the surrounding area, but there were marked differences between age groups: there were on average one, two, three, seven and 10 missing teeth in 30-, 40-, 50-, 60 and 70-year-olds, respectively, examined in 1993 (Norderyd & Hugoson 1998). In 2003, 10 years later, the corresponding figures were one, two, two, five and seven (Hugoson et al. 2005).

Besides geographical differences, the dental state also changes with time. For example, the mean numbers of teeth in three cohorts of 38-year-old Swedish women examined in 1968–1969, 1980–1981 and 1992–1993 were 23, 26 and 28, respectively (Ahlqwist et al. 1999). In cohorts of 55-, 65- and 75-year-old subjects examined in 1987 and 1997, there was a significant increase in the mean numbers of remaining teeth in the 65-year-old group, from 19 to 23, whereas the changes in the 55- (from 23 to 24) and 75-year-old (from 17 to 17) groups were non-significant (Fure 2003). In a 30-year perspective, the mean number of teeth in a Swedish county increased in 60- and 70-year-old subjects from 18 and 13 in 1973 to 23 and 21 in 2005, respectively (Hugoson et al. 2005, Fig. 7). Within the context of the Berlin Ageing Study, (Nitschke & Hopfenmüller 1996, Fig. 8) described the tooth loss in the old and very old population. Their oldest participant was 103 years old. They confirmed the increasing number of missing teeth in the older age cohorts, yet in the group 95+ years the number of remaining teeth was again higher. They attributed this phenomenon to the lower life expectancy of edentulous subjects. A recent study showed, in men, an almost linear relationship between the number of teeth at age 70 years and the 7-year mortality (Österberg et al. 2007, Fig. 9).

Incidence of tooth loss

According to a review of 15 longitudinal studies from seven countries regarding tooth extractions during varying observation periods (2–28 years), the annual incidence of persons losing one or more teeth varied from 1% to 14%. The mean number of teeth lost varied from 3 to 24/100 subjects/year, and the proportion of baseline teeth lost varied from 0.1% to 28.5% (Haugejorden et al. 2003). An extreme value of 38 teeth lost/100 persons/year was reported for a group of patients with periodontal disease (Papapanou et al. 1989).

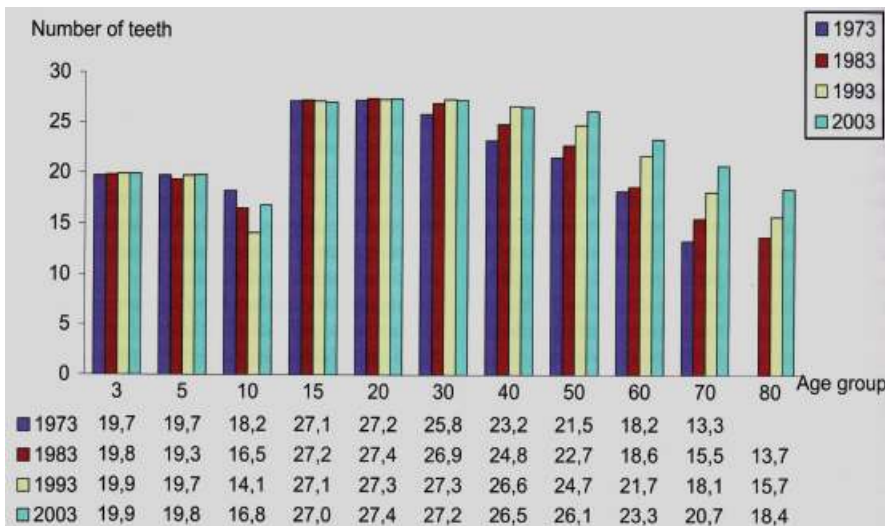


Fig. 7. Number of existing teeth (excluding edentulous individuals). Means in the different age groups in 1973, 1983, 1993 and 2003 (Hugoson et al. 2005).

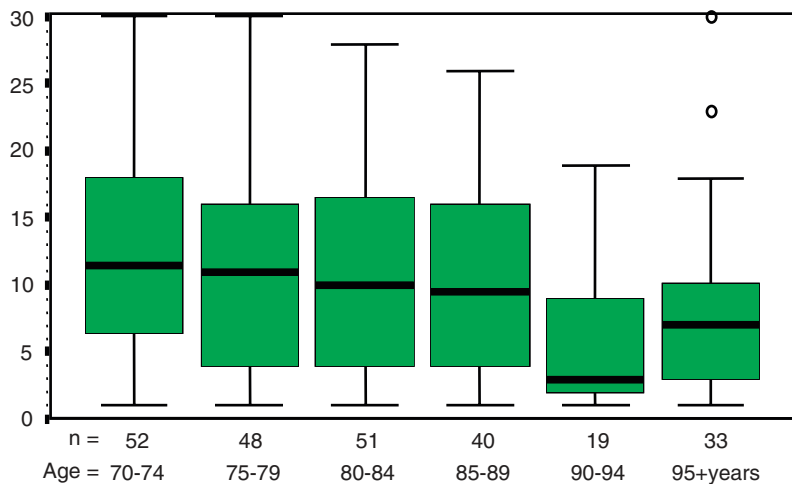


Fig. 8. Number of natural teeth in the Berlin Ageing Study (BASE) in age cohorts up to 95+ years (Nitschke & Hopfenmüller 1996).

Studies using regression analyses to assess predictors have generally shown that oral disease-related factors were the most important, but demographic, behavioural and attitudinal factors and education also made small contributions to variation in tooth loss in some studies. There will inevitably be some confounding factor between these groups. In a representative sample of adult Norwegians, the proportion of respondents who reported losing one or more teeth during the last 12 months was 6.5%. Those who reported tooth extractions had lost, on average, 1.5 (range 1–9) teeth (Haugejorden et al. 2003). In a random sample of 60-, 70- and 80-year-old subjects in a Swedish city, the mean number of

teeth lost during a 5-year period was 0.4, 0.8 and 1.4, respectively (Fure & Zickert 1997). The mean numbers of teeth lost during a 10-year period among 65-, 75- and 85-year-old subjects were 0.9, 1.5 and 3.1; men had lost more teeth than women (mean 1.5 and 1, respectively; Fure 2003).

The incidence of tooth loss is at present low, but exhibits fairly great age and geographical variations. It is associated with a multiplicity of background factors of which many, but not all, studies reported dental disease related ones to be most important.

Prevalence of SDA

In the 1980s, Käyser and his group conducted epidemiological surveys in the

Netherlands (Battistuzzi et al. 1987a, 1987b). The number of teeth and occluding tooth contacts decreased with increasing age and more so in the lower socio-economic group than in the higher socio-economic group. An average of 60% of all open tooth spaces was not restored prosthetically. The proportion of subjects with SDA was already high in middle-aged people. The results showed no significant correlation between missing teeth or number of contacting pairs of teeth and the functioning of the dentition.

In a Canadian study of dentate adults aged 65 and over (Hawkins 1998), only 6.3% of nursing home subjects and 7.5% of independently living subjects were classified as having 'good' upper and lower arches (a 'good' quadrant was defined as one that contained all premolar and anterior teeth, a 'good' arch contained two 'good' quadrants, based on the SDA concept). Using the same definition in the 1988 adult dental health survey in the United Kingdom, the proportion of people with four 'good' quadrants was 90% at 16–24 years falling to 2% at 65–74 years (Gordon et al. 1994). In a Swedish county, the proportion of subjects without molars increased with age, but it was lower in the city than in the rest of the county: 5% cf. 11% and 16% cf. 22% of the 60- and 70-year-olds, respectively (Norderyd & Hugoson 1998). The mean number of molars in these age groups was five and three, respectively, in 1993, and six and four in 2003 (Hugoson et al. 2005).

Risk factors for tooth loss

A number of reasons have been associated with tooth extraction, such as caries, periodontal disease, prosthetic and orthodontic reasons, trauma, pain (endodontic and periapical disease), wisdom teeth and patient request (Reich & Hiller 1993; Spalj et al. 2004; Richards et al. 2005). Most studies indicate that caries is a more important reason than periodontal disease for extraction (McCaul et al. 2001; Fure 2003). Demographic, behavioural and attitudinal factors make small but statistically significant contributions to variation in tooth loss (Haugejorden et al. 2003). An earlier study concluded that total tooth loss is a social-behavioural issue as much as it is disease-related. On the other hand, social-behavioural factors were less clearly related to

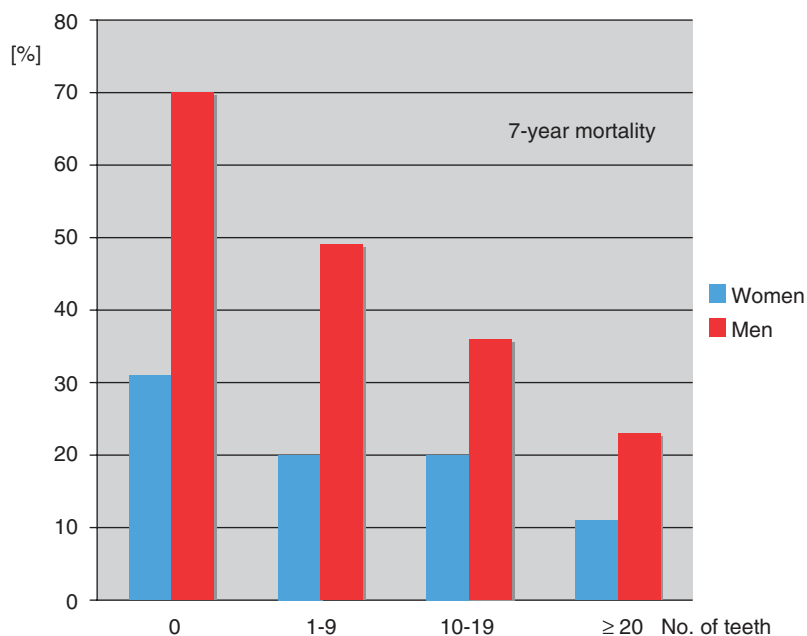


Fig. 9. Relationship between number of teeth at age 70 and 7-year mortality (diagram drawn after data in Österberg et al. 2007).

partial tooth loss in dentate persons, in whom oral disease characteristics were the most prominent risk factors (Burt et al. 1990).

Institutionalised vs. independently living people

Over the years, a great number of studies have reported poor dental health among institutionalised elderly people (Lemasney & Murphy 1984; Tobias & Smith 1990; Merelie & Heyman 1992; Frenkel et al. 2000) (Table 2). It has often been concluded that there is a need to improve dental health service programmes for older people living in institutions (Angelillo et al. 1990; Nitschke et al. 2000; Steele et al. 2000). The results of recent articles suggest that this situation has not improved much up to now (Peltola et al. 2004; Simunkovic et al. 2005; Adam & Preston 2006). Further, the prevalence of edentulism is known to increase in the institutionalised population and was reported to be over 50% in Spanish nursing home inhabitants over the age of 65 years (Baciero et al. 1998). This situation is particularly delicate as denture use is very difficult and thus rare in demented patients (Taji et al. 2005). In a group of 115 mentally retarded individuals (mean age 41, range 19–83 years), the 10-year incidence of tooth loss was 3.7 teeth, most of which were lost due to periodontal

disease, in spite of the fact that they had received regular dental care (Gabre et al. 1999).

A related observation was that a group of homeless adults in Stockholm had fewer teeth than the general population, a consequence of the fact that extraction was common instead of expensive and time-consuming conservative treatment (De Palma et al. 2005).

Discussion

To give a simple answer to the question in the title was difficult even if many articles were found in a literature search on the prevalence and incidence of tooth loss in Europe. The quality of the studies varied considerably making direct comparisons uncertain. The literature suggests that there are great differences between countries, as well as between regions within countries and between rural areas and cities. Furthermore, dental health is changing rapidly with time, adding further complexity to comparison of data between countries when the dates of data collection are separated chronologically. However, the greatest difficulty was that trustworthy data were only available from a few countries. In fact, a recent review found nationwide surveys on edentulism in only three

European countries (Finland, Sweden and the United Kingdom), and only two of them were repeated to allow projections for the next one to two decades (Mojon et al. 2004). Within the limits of that analysis, the authors concluded that the prevalence of edentulism will fall by up to 50–60% over the next 20 years in these countries, which will markedly affect dental education and dental care providers.

Within the limits of comparability between surveys it is possible to conclude that, despite the rapid decline in edentulism, there are still differences between countries and between geographical regions within countries, as well as between groups with various background characteristics, e.g., education, occupation, personal economic situation, attitudes to dental care and lifestyle factors such as smoking, etc. In many European countries, edentulism is already rare among people of working age or up to 60 years of age, whereas there are still many edentulous subjects in the age group above 65 – in studies from the 1990s, the prevalence varied between 15% and 72%.

Estimation of the future treatment needs for edentulous jaws is complicated by two problems. First, the decline of edentulism may be counteracted by the growth of the older part of the population with projected future demographic change. Projections in the USA have shown that the demographic growth will outpace the decline in edentulism as the 'Baby Boomers' enter this phase of their lives. Thus, the need for treatment of edentulous jaws in the United States is likely to increase over the next 20 years despite reductions in the prevalence of the condition. With the limited evidence available, this confounding of demography and change in oral health status does not appear to be as strong in Europe. However, the decline in demand for care for people who are edentulous will not fall as rapidly as might be anticipated, because the age groups where edentulism will still be highly prevalent are getting larger.

The second confounding issue is that about 25% of dentate older people only have teeth in one jaw. They still require the skills for managing an edentulous jaw, and indeed often pose considerable problems in terms of stability of their complete prosthesis functioning against natural teeth.

Table 2. Prevalence of edentulism and number of remaining teeth in particular populations (institutionalised, homeless, mentally retarded, demented)

Author (et al.)	Year	Country	Study design	Sample (n)	Age (years)	Drop out	Prevalence of edentulism	Remaining teeth (n) in dentates	Incidence of tooth loss (n)/year	Results/comments
Lesmasney	1984	Ireland	Cross-sectional	368 institutionalised persons	77 (58–99)	NA	78%	5	NA	27% of edentulous persons used complete dentures
Angelilo	1990	Italy	Cross-sectional	234 institutionalised	81.4	NA	59.8%	9.9	NA	44.3% of edentulous persons wore complete dentures; 68.1% of dentate subjects needed on average 3.9 extractions
Tobias	1990	United Kingdom	Cross-sectional	151 institutionalised	81	NA	71%	No data	NA	24% of edentulous persons did not own complete dentures
Merelie	1992	United Kingdom	Cross-sectional interview	379 institutionalised	<75 (n = 68) 75 + (n = 379)	NA	89%	No data	NA	96% stated that they would only see a dentist if they had trouble with their teeth
Baciero	1998	Spain	Cross-sectional	3282 institutionalised	65–95 +	NA	52.4%	3.4	NA	Data from 17 different institutions
Gabre	1999	Sweden	Prospective 1984–1994	147 mentally retarded institutionalised	41 (19–83)	14% (115 dentate persons followed up)	7.5% (excluded from re-examination in 1994)	20.7 (1984) 17 (1994)	0.37	Decreased incidence of tooth loss if patient cooperates less teeth if medication with neuroleptics
Frenkel	2000	United Kingdom	Cross-sectional	412 institutionalised	84.5 (42–102)	NA	71.4%	11.6	NA	70% had not seen a dentist in the last 5 years
Nitschke	2000	Germany, rural	Cross-sectional	170 institutionalised	79.4 (51–99)	NA	68.3%	3.3	NA	2.4% had neither teeth nor dentures
Chalmers	2003	Australia	Prospective 1-year observation	232; 116 demented (D) and 116 non-demented (ND) community dwelling	21% over 80 years	11.2% (D) 2.6% (ND)	Excluded from study	18 (D) 17.2 (ND)	0.4 (D) 0.3 (ND)	Caries prevalence and incidence significantly higher in demented persons
Peltola	2004	Finland	Cross-sectional	260 institutionalised	83.3 ± 8.1	NA	42%	12.4 ± 8.6	NA	42% of persons in need of extractions
De Palma	2005	Sweden	Cross-sectional	147 homeless	48 (22–77)	NA	5.4%	18 (9–24)	NA	Deplorable oral status compared with general population
Simunkovic	2005	Croatia	Cross-sectional	139 institutionalised	58–99	NA	45.3%	21.1	NA	30.9% had decayed teeth requiring treatment
Adam	2006	United Kingdom	Cross-sectional	135 institutionalised with (81) /without (54) dementia	85.5 (D) 80.8 (ND) (65–100)	NA	65.9% 70% (ND) 63% (D)	11.7 (D) 11.7 (ND) out of 32	NA	Denture use rare among demented edentulous persons (40%D vs. 90%ND)

D, demented; NA, not applicable; ND, not demented.

It is even more difficult to estimate the incidence of edentulism. Only a few longitudinal studies have reported the proportion of dentate subjects who became edentulous during specified periods. The available results indicate that the incidence is low but with geographical variation (0–2%/year); it varies between age groups and there is a trend towards decreasing incidence with time. When judging the incidence of edentulism of the different cohorts, their historical context has to be taken into consideration. Those Europeans who are aged now have lived through two world wars and have experienced limited access to oral health care associated with high rates of extractions. Younger cohorts will have benefited from preventive programmes and advanced dental restorative techniques, and are thus unlikely to experience the same incidence of tooth loss. However, one risk factor will remain unchanged and that is declining mental and physical health, namely institutionalisation. An increased incidence in caries and poor oral hygiene are common in the institutionalised population (Chalmers et al. 2003). A further reason for an increased incidence in tooth loss in the fragile and demented elderly population is restriction in restorative treatment options due to the ability of the individual to tolerate protracted periods of care. Even if the incidence is low, the afflicted subjects are in need of complete dentures or implant prostheses.

A few studies reported the prevalence of complete dentitions, but several studies indicate that the great majority of adolescents and young adults have all or almost all teeth remaining. Problems in reviewing and comparing the literature on this question are e.g., the varying use of the 32- or 28-teeth dentition and self-reported or clinical examination as a base for reports on the number of remaining teeth. The rapidly changing dental health during the last few decades indicates that new data are required regularly. For example, the very high prevalence of tooth loss and open

tooth spaces reported for Dutch populations in the 1980s are not seen today in many European countries, including in the Netherlands.

Studies on SDAs have shown that dentitions comprising anterior and premolar teeth, in general, fulfil the requirements of a functional dentition including patient-assessed oral comfort and chewing ability. A review of the literature on SDA concluded that the concept deserves serious consideration in treatment planning for partially edentulous patients. However, with ongoing changes, e.g., in dental health and economy, the concept requires continuing research, evaluation and discussion (Kanno & Carlsson 2006).

Even if the most recent studies demonstrate ongoing improvement of dental health, subjects in recently examined cohorts seem to be less satisfied with their chewing ability than those in earlier cohorts (Johansson et al. 2006; Unell et al. 2006; Österberg & Carlsson 2007). One explanation for this may be that there is an increasing expectation of good masticatory function among younger people associated with good oral health, which are perpetuated as they age and some teeth are lost.

In analyses of risk factors for tooth loss, both dental diseases (caries, periodontitis) and socio-economic and life-style factors (e.g., smoking, attitude to dental care, dental anxiety) have been found to be significant. A great number of variables are associated with oral health and there is no consensus whether dental disease-related or socio-behavioural factors are the most important risk indicators for tooth loss (Burt et al. 1990; Haugejorden et al. 2003).

Conclusions

This literature review demonstrated that there is a lack of epidemiological studies of tooth loss in many countries in Europe. Furthermore, the quality of available studies varied considerably, and the lack

of relevant randomised-controlled trials (RCTs) made statistical comparisons impractical. Considering these limitations, the following conclusions are warranted.

- There is a documented decline in edentulism but still great difference between countries and between geographical regions within countries, as well as between groups with various backgrounds.
- The mean number of lost teeth increase with age, and many dentate subjects aged 60 and over have reduced dentitions possibly needing prosthodontic treatment.
- Recently examined cohorts of elderly subjects tend to be less satisfied with their chewing ability than those in earlier cohorts irrespective of dental state, which may indicate increasing expectation for masticatory function and an associated demand for replacement of lost teeth with time.
- The incidence of tooth loss is low but with geographical variation (0–2%/year); it varies between age groups, and there is a trend for decreasing incidence with time.
- A great number of variables are associated with tooth loss, and there is no consensus whether dental-disease-related or socio-behavioural factors are the most important risk factors.
- Institutionalised elderly people have in general more compromised oral health, including fewer teeth, than those of the same age living in their own homes. They are thus likely to have a higher incidence of tooth loss.

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