The Impact of Falling Rates of Edentulism

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Purpose: The aim of this study was to investigate the impact of both population age changes and falling edentulism rate on the denture market in three European countries. ***Materials and Methods:*** Detailed information on the rate of edentulism for only three European countries (Finland, Sweden, and the UK) was available. For the UK and Sweden, published predicted rates of edentulism for the future decades were used, whereas predictions for Finland were computed using published edentulism rates. Edentulousness in one jaw was also predicted and included in the computation. Demographic projections were taken from government agency websites. ***Results:*** The denture market will decrease in the three countries. Sweden, where edentulism is already low, will experience the largest percentage decrease (60%) over 20 years, but, in absolute number, the change will be of smaller magnitude than that in the UK and Finland. The range of projections for Finland was large, reflecting the difficulty of predicting trends with incomplete information. Within the limitations of this study's design, the impact of population age changes will not increase the denture market in Europe, even with the most pessimistic projections for edentulism rate. ***Conclusion:*** The complete denture market in Europe will fall despite changing age demographics. The falling rates are large enough to markedly affect future patterns of treatment provision and training. *Int J Prosthodont 2004;17:434–440.*

It is widely accepted that the prevalence of edentulism is falling in all age groups in industrialized nations[1]; this has led to widespread acceptance that the denture market will decrease in a similar manner. The denture market can be defined as the number of edentulous jaws that will be eventually restored with a complete denture. Recently, it has been suggested that, far from decreasing, the denture market will actually increase over the first two decades of the 21st century.[2] Those authors predicted the future complete denture market in the United States using a linear annual decline rate and the prevalence of edentulism and single-jaw edentulousness (maxillary or mandibular) recorded during the last available national survey (NHANES III, 1987–1991). The authors demonstrated that although the percentage of edentulous jaws within the population is falling, the maturation of the "baby boomer" generation into the upper age groups will more than compensate for the falling prevalence of edentulism. So, although the percentage of edentulous jaws is likely to continue to fall, the large increase in the number of subjects in the older age cohorts will mean that, in the US, there will actually be an increasing market for complete dentures until 2020.

The aim of the present study was to investigate the impact of the falling incidence of edentulism and population age changes on the denture market in European populations over the next two or more decades. It was

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hypothesized that in countries with a high level of edentulism, the denture market would increase like in the US, whereas in countries with a low level of edentulism, the denture market would fall substantially.

Materials and Methods

Three countries in Europe (Finland, Sweden, and the United Kingdom) have carried out repeated surveys of random samples representative of the national population.[1,3,4] The Finnish data were collected through a national health questionnaire; the Swedish data were collected during health surveys that involved interviewing the participants; and the UK data were collected by means of an oral examination. For Sweden and the UK, predictions of edentulism rate by age group for the near future were available.

UK predictions were presented in the 1998 Adult Dental Health Survey report.[5] The first dental health survey was undertaken in 1968 in England and Wales, and the surveys were repeated at 10-year intervals for the entire UK up to 1998.[5–8] As edentulism is an irreversible state, the future prevalence of edentulism in 10-year age groups was represented by the prevalence of edentulism at the time of the last survey plus a prediction of the new cases that would occur during the period considered (the incidence of the condition). Two scenarios were used: One assumed that the incidence rate observed during the last survey would be stable over the future years, whereas the other projection assumed that no new subjects would be rendered edentulous. The first method provides pessimistic estimates of edentulism, whereas the latter provides the most "optimistic" prediction. Predictions for edentulism in 2008, 2018, and 2028 were presented, and the present authors extended the projection to 2048 as proposed by Walls and Steele.[9]

Projections for edentulism in Sweden were taken from Østerberg et al,[4] who based their estimates on five cross-sectional surveys. Those authors predicted the prevalence of edentulism for 2005 and 2015 by statistical modeling, assuming that the decrease would follow an S-shaped curve as in a logistic regression function. They validated their results by comparing the predicted prevalence with the known prevalence for previous years.

No future trends for the prevalence of edentulism were available for Finland, but data on edentulism had been collected from 1978 to 1997 using a representative sample of the working-age groups (15 to 65 years) and were last presented in 1999.[3] So an assessment could be undertaken for the entire adult population, including those over 65 years of age, a linear regression analysis was used to estimate edentulism for five more age bands (66–70 to 80–85) and their respective 95% confidence intervals (CI) for the years 1993 and 1997. This was undertaken using the prevalence of edentulism as the dependent variable and both age bands and years of survey as predictive variables. From this, two predictions, a pessimistic and an optimistic one, were computed for the next 30 years using the method described in the 1998 Adult Dental Health Survey report.[5] The pessimistic prediction assumed that the last observed decline (between 1993 and 1997) for each age band would remain stable thereafter. The optimistic prediction assumed a null incidence, ie, no new subjects would become edentulous after 1999. These optimistic predictions for Finland used the lower limit of the 95% CI for the estimates of the missing older age band prevalences. The pessimistic predictions used the upper 95% CI.

The three data sets for Europe reported edentulism on a patient basis rather than by edentulous jaws. By contrast, the NHANES III study[2] recorded edentulism as both jaws, maxillary jaw only, and mandibular jaw only for about 30,000 Americans. An accurate estimate of a denture market has to take into account the number of edentulous jaws that would require restoration rather than the number of edentulous patients.[2] To facilitate this for the European data, the percentage of completely edentulous subjects was plotted against the percentage of dentate subjects who were edentulous in the maxilla for each age band from the NHANES III study to find a mathematic function that would best describe the relationship between complete edentulism and maxillary edentulism. The parameters of the function were estimated using regression analysis, and the process was repeated with the data for mandibular edentulism. The mathematic formulae were then applied to the UK, Sweden, and Finland data sets to estimate the percentage of persons with an edentulous maxilla only and the percentage with an edentulous mandible only for each age band.

To determine predictions for the absolute number of edentulous subjects for given years, it is necessary to project the estimated prevalence of edentulism onto the estimated population for the specific year. The UK projection was based on the 2000 census.[10] The projections for Finland and Sweden were taken from the international page of the US Census Bureau's website[11] because of the flexibility of the query process. The accuracy of these figures was checked against the projection provided by the European Social Statistics projections[12] and showed only minor variation.

The calculation of the denture market was based on the following formula:

(age-specific population × age-specific edentulous persons × 2) +

(age-specific population ×
age-specific number of persons with an edentulous maxilla) +

(age-specific population ×
age-specific number of persons with an edentulous mandible)

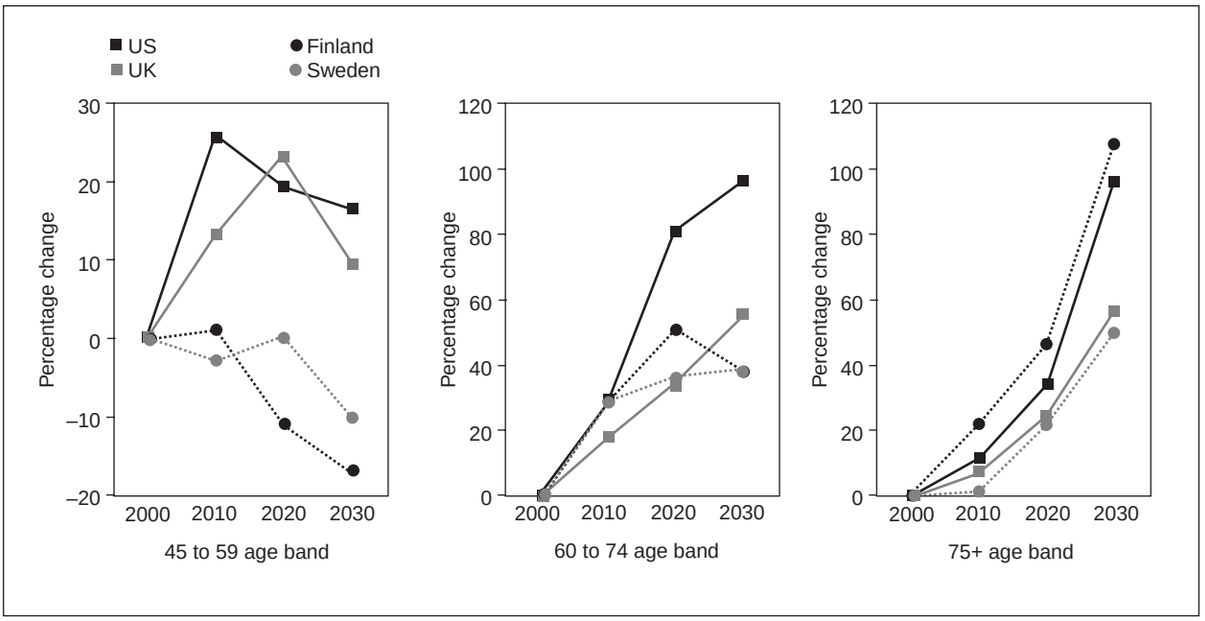

Fig 1 Demographic projections after 2000.

Table 1 Prevalence of Edentulism (%) According to Latest Nationwide Surveys

Age group (y)	UK (1998)	Sweden (1997)	Finland (1997)	US (1991)
35–44	1	0	1	4
45–54	6	2	9	10
55–64	20	5	23	21
65–74	36	15	—	29
75+	58	35	—	44

The sum of these estimates for all age bands provided the total number of edentulous jaws for a specific year. Only age bands higher than 44 years were considered, as edentulism has almost been eradicated in the younger age groups in Europe. To compare the projections for the three countries, the percentage change in total edentulous jaws since the last data available was computed (1998 for the UK; 1997 for Sweden; and 1997 for Finland). The same percentage change was computed for the US using the data presented by Douglass et al.[2]

Results

The three countries had different demographic profiles. The UK (59,000,000 inhabitants) had almost 7 times the population of Sweden (almost 9,000,000), and Finland had the smallest population, with only about 5,000,000 inhabitants. Their demographic projections were also quite different, and each was very different from the US projections. Figure 1 presents the projected percentage change in three age groups for the four countries from 2000 to 2030. Sweden and Finland will have a decrease in the youngest group (45 to 59 years old), whereas this age group will grow in the UK and US. With the exception of the oldest age group in Finland, which will double by the year 2030, the other European countries will see their oldest age groups increasing moderately. By contrast, the US will have a steady and large increase among the oldest groups that will double the number of persons both between 60 and 74 years of age and those over 75 by the year 2030.

The prevalence of edentulism varied from one country to another (Table 1).[1–4] Sweden had the lowest prevalence, while Finland and the UK had similar edentulism rates. The oldest UK age group had the largest proportion of edentulous people by far, whereas the US figures reported an unexpectedly low level of edentulism compared with the younger age groups. The two youngest US age groups had a higher prevalence than their European counterparts. In 1998, the prevalence of edentulism was 20% for the age band 55 to 64 in the UK, versus 36% in 1988, a decrease of about 1.5% per year. In Finland, the decrease in edentulism rate from 1988 to 1997 for this age band was 15%. Hence, the annual overall decrease rate was also around 1.5%, and the prevalence of edentulism in 1998 for this age band would have been around 22%. The values for Sweden

Table 2 Last Available Estimates and Predicted No. of Edentulous Jaws (in Thousands): UK*

Age group (y)	1998	2008	2018	2028	2038	2048
45–54	1,654	676	729	593	670	619
55–64	3,096	2,057	1,408	1,465	1,203	1,299
65–74	4,379	3,043	2,270	1,834	1,953	1,559
75+	5,898	4,982	4,110	2,137	3,229	3,471
Total	15,028	10,758	8,517	6,029	7,055	6,948

*Based on the pessimistic prediction of the 1998 National Dental Health Survey.[6]

were much lower: In 1997, the prevalence of edentulism in the age band 55 to 64 was around 5%, and the decrease for the last 10 years was around 10%.

Estimating Edentulism Rate in Older Age Groups for Finland

The linear regression analysis of the age-specific prevalence data demonstrated that the regression model was significant ($P < .001$). The two independent variables, age group and year of survey, were significant ($P < .001$ for both). The 95% CIs around the predicted prevalence for the older age bands were at most ± 10%.

Estimating Maxillary and Mandibular Edentulism for European Populations

When the percentage of completely edentulous US subjects was plotted against the percentage of dentate subjects with edentulous maxillae for each age group, a logarithmic increase was observed. When complete edentulism is low, edentulism in the maxilla is of the same magnitude or higher, whereas when complete edentulism is high, edentulism in the maxilla is much lower, at around 20%. The Pearson correlation between the log-transformed edentulism rate and percentage of edentulous maxillary jaws was .961 ($P = .002$). The formula used to estimate the prevalence of maxillary edentulousness among the dentate had the form:

$$a \times \text{Ln}(\%\ \text{edentulism in the age band}) + b$$

where $a = 3.79$ and $b = 1.40$, as derived from the linear regression analysis.

For the prevalence of edentulousness in the mandible, the relationship was linear, and the correlation coefficient was also significant (Pearson correlation coefficient .980, $P = .001$). The mathematic formula had the form:

$$c \times \%\ \text{edentulism in age band} + d$$

where $c = 2.95 \times 10^{-2}$ and $d = 0.152$, as derived from the linear regression analysis.

The accuracy of these formulae was evaluated by applying them to data obtained from the Study of Health in Pomerania (SHIP),[13] which examined a representative sample (about 5,000 subjects) of Germans living in Pomerania. The estimated mandibular and maxillary edentulousness rates were compared to the observed prevalence values recorded during the study and showed that the estimates were slightly lower than the observed figures, by 3% on average for edentulousness in the maxilla and by 1% for the mandible, and may thus represent a slightly conservative estimate.

Comparing the Denture Market over the Next 30 Years

The denture market will decrease for all age bands in the three countries (Tables 2 to 4). In the UK, the decrease will occur mainly during the next 20 years and among the younger age bands. In Sweden, similar trends were found for the next 10 years, but the decreases were less marked. In Finland, the 45 to 54 age band will be the one most affected by the decrease. The numbers in the age band 75+ will basically remain stable for the next 30 years.

The percentage change in the denture market since the last survey for the three European countries and the US is presented in Fig 2. According to Douglass et al,[2] the US denture market will expand for the next few decades. However, in Europe, the denture market will decrease. Sweden, which already has the lowest edentulism rate, will experience the largest percentage drop (60%) in 20 years. This corresponded to the lower limit of the Finnish projection. In the UK, the denture market will be reduced by 60% over 30 years, but will remain stable thereafter. The average projection for Finland closely followed that of the UK; however, the upper limit (pessimistic prediction) and lower limit (no new edentulous subjects) were far apart, reflecting the difficulty of predicting trends with incomplete information. However, even the pessimistic prediction did not predict an increase in the denture market.

Table 3 Last Available Estimates and Predicted No. of Edentulous Jaws (in Thousands): Sweden*

Age group (y)	1997	2005	2015
45–54	54	0	0
55–64	141	113	29
65–74	345	218	162
75+	614	457	288
Total	1,154	789	480

*Based on the prediction of Østerberg et al.[4]

Table 4 Last Available Estimates and Predicted No. of Edentulous Jaws (in Thousands): Finland*

Age group (y)	1997	2007	2017	2027
45–54	210	55	39	34
55–64	314	251	112	92
65–74	412†	318	287	168
75+	404†	420	385	372
Total	1,340	1,044	823	666

*Mean values of the two extreme projections.
†Estimated through regression analysis.

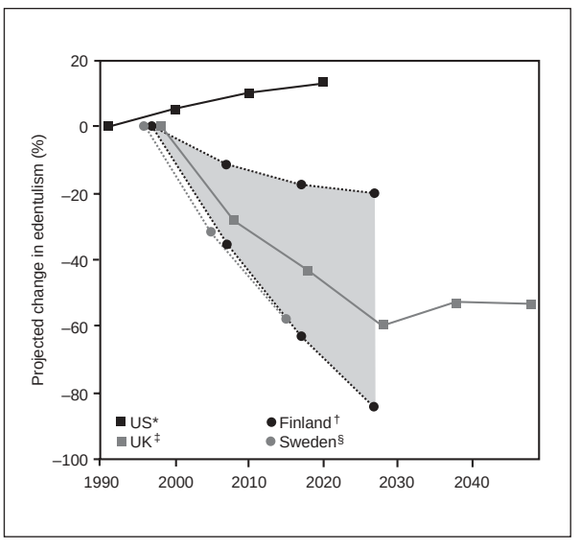

Fig 2 Projected changes in proportion of edentulous jaws (denture market).
*US data taken from Douglass et al.[2]
†Finnish projection depicted as an area representing the upper and lower limits of the prediction.
‡UK projection based on the pessimistic prediction of the 1998 National Dental Health Survey.[6]
§Swedish projection based on prediction by Østerberg et al.[4]

Discussion

Edentulism is considered a handicap[14] with consequences on quality of life and nutrition. It is an effective marker of population oral health and is therefore monitored in many countries. However, only a few countries worldwide have surveyed edentulism on a national scale, and even fewer have done so several times.

Consequently, our study's limitations are self-evident given the fact that we could find only three countries in Europe that had carried out nationwide surveys on edentulism. Furthermore, projections for national edentulism are available for only two of these countries (Sweden and the UK), and we attempted to predict trends for Finland based on the edentulism rate of the working-age group. In terms of denture market, an estimate would be incomplete if it was based solely on complete edentulism. As demonstrated by the US data, maxillary edentulousness may represent up to a third of the denture market, whereas mandibular edentulousness is rare.[2] The data we used for the three European countries did not identify the dentate who had one edentulous jaw. We estimated the prevalence of maxillary and mandibular edentulousness by modeling the US data. The mathematic models predicted these prevalences from the rate of complete edentulism for each age band. The models (one for maxillary, one for mandibular edentulousness) seemed quite accurate, as demonstrated by the small difference between the predicted prevalences and the true values when the models were applied to the data from SHIP. The accuracy of our models could be easily verified if true prevalence of edentulousness in each jaw were obtained in future surveys.

We did not include a utilization rate in our evaluation of the denture market. A utilization rate takes into account the proportion of edentulous subjects who chose to not wear prostheses. Data on this proportion are scarce and seem to vary according to age, socioeconomic level, living environment, region, and country.[15–17] The inclusion of a utilization rate would lower the figures presented in Tables 2 to 4. However, the percentage changes, as reported in Fig 1, would not be affected by the inclusion of a utilization rate, provided it remains constant, which seems a reasonable assumption.

The data presented for Finland are the least reliable, as we extrapolated the edentulism rate for the older age group and then determined incidence rate based on the last two surveys. This was reflected quite clearly by the area of prediction seen in Fig 2. However, it should be noted that even with the most pessimistic projection, where the edentulism decrease was set at a minimum, the denture market will still contract.

Sweden will experience the largest percentage change (–60% in 20 years) in the denture market.

However, since the edentulism rate is already low, the decline in number of edentulous jaws to restore was of smaller magnitude than that for the two other European countries. It seems that Sweden has already experienced its revolution in the complete denture market, thanks to the dental care system implemented in 1974.[18]

All three European countries will experience a contraction of their denture market, and our working hypothesis was not confirmed. Douglass et al[2] predict an expansion in the US. The difference may be explained by a combination of three factors. First, the oldest part of the population will grow much more in the US than in Europe because the baby boom was more pronounced in the US. More important, the decline in edentulism rate, used by Douglass et al[2] to calculate the prediction for the US, was significantly lower than those used in the European countries. Douglass et al used a 1% annual decline rate predicted by Weintraub and Burt,[19] who based their estimates on various national US surveys from 1958 to 1974 that probably no longer reflect the present situation. Also, the NHANES III study used as baseline was conducted between 1987 and 1991 and is somewhat dated compared with those used for Europe. It should also be noted that the projected prevalences for the US are based on an overall (across age bands) linear decrease that does not take into account the effect of cohorts, which create an S curve, as can be observed in the European surveys. This all resulted in an extremely pessimistic projection for the US compared with our pessimistic projection used for the UK or Finland.

The variation among European countries reporting on edentulism is great.[20] For example, in France, the latest survey[21] was conducted in 1995 in the region Rhone-Alpes, which was considered representative of the French population.[22] The edentulism rate for the 65 to 74 age band was 16%, versus 36% for the UK. In Germany, the corresponding figure was 34% for the region of Pomerania (Mack F, personal communication, 2002). Several factors have been shown to influence edentulism; among them, economic wealth, education, availability and use of professional and preventive services, oral health care systems, third-party payment, dental awareness, and social beliefs are the most frequently cited. Even if we could obtain accurate, recent figures on edentulism, it seems difficult to extrapolate the prediction presented for Finland, Sweden, and the UK to other countries, as the disparities even among these three countries were large. However, in light of the results presented here and the latest prevalence of edentulism, it seems unlikely that European countries will experience an expansion of their denture markets.

Within the limits of our analyzed database, it appears that changing age demographics will mean that the complete denture market will not fall as far or as fast as might have been suggested by a simple interpretation of the projected prevalence of edentulism. Nevertheless, the market will fall by up to 50% to 60% over the next 20 years; this will undoubtedly markedly affect dental education and denture care providers.

Acknowledgments

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Literature Abstracts

Speech with maxillary implant prostheses: Ratings of articulation

Speech is often perturbed after placement of maxillary implant-retained prostheses and may affect patient satisfaction with the prostheses. This study tested the hypothesis that the rate of speech errors varies with prosthetic design. Thirty edentulous French-speaking subjects with mandibular implant prostheses entered two within-subject crossover trials. Subjects wore maxillary fixed prostheses and removable long-bar overdentures (Trial 1) or overdentures with and without palates (Trial 2). The criterion for assigment was the presence of bone for six (Trial 1) or four implants (Trial 2). Test words from a French-language speech battery were recorded after each prosthesis had been worn for 2 months. The percentages of stops, fricatives, and vowels correctly perceived by lay judges were calculated. Subjects produced a higher percentage of sounds correctly with overdentures than with fixed prostheses. Between-treatment differences were significant for stops and fricatives but not for vowels. There were no significant differences in error rates between the two overdentures. Patient self-assessment produced similar results. In conclusion, maxillary implant overdentures with and without palates enable patients to produce more intelligible speech than fixed prostheses.

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Influence of tobacco smoking on periodontal bone height. Long-term observations and a hypothesis

Tobacco smoking is known to influence periodontal health. This study was performed to determine the long-term effect of smoking on periodontal bone height. The study population included 19 continuous smokers over the 10 years, 28 former smokers, and 44 nonsmokers. The height of the interdental periodontal bone of the individual was determined from the original radiographs of the first and second premolars of the maxilla and the mandible. The distance from the cemento-enamel junction (CEJ) to the periodontal bone crest (PBC) was measured. Multiple regression analysis was performed with variables for smoking and former smoking. Logistic regression was used to estimate the relative risk associated with smoking, expressed odds ratio, and 95% confidence level. There were significant differences between smoking groups. The overall mean CEJ-PBC distance was 1.82 mm for smokers, 1.65 mm for former smokers, and 1.16 mm for nonsmokers. The post-hoc difference between smokers and nonsmokers was statistically significant, whereas the difference between smokers and former smokers and between former smokers and nonsmokers, were not significant. The overall mean 10-year bone height reduction was 0.74 mm for smokers, 0.26 mm for former smokers, and 0.27 mm for nonsmokers. Multiple linear regression analysis revealed that continuous smoking was the most important and only significant variable. Former smoking was not a significant factor. The author hypothesized that smoking induces an acceleration of the periodontal bone height reduction rate and that smoking cessation results in a return toward the nonsmoker rate.

Bergström J. *J Clin Periodontol* 2004;31:260–266. **Reference:** 12. **Reprints:** Dr Jan Bergström, Karolinska Institutet, Stockholm, Alfred Nobels Allé 8, Box 4064, 141 04 Huddinge, Sweden—*Myung W. Brian Chang, Lincoln, NE*