

# Dental nomograms for benchmarking based on the study of health in Pomerania data set

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#### Abstract

**Aim:** Benchmarking is a means of setting goals or targets. On an oral health level, it denotes retaining more teeth and/or improving the quality of life. The goal of this pilot investigation was to assess whether the data generated by a population-based study (SHIP 0) can be used as a benchmark data set to characterize different practice profiles.

**Material and Methods:** The data collected in the population-based study SHIP (n = 4310) in eastern Germany were used to generate nomograms of tooth loss, attachment loss, and probing depth. The nomograms included twelve 5-year age strata (20–79 years) presented as quartiles, and additional percentiles of the dental parameters for each age group. Cross-sectional data from a conventional dental office (n = 186) and from a periodontology unit (n = 130, Greifswald) in the study region as well as longitudinal data set of a another periodontology unit (n = 135, Kiel) were utilized in order to verify whether the given practice profile was accurately reflected by the nomogram.

**Results:** In terms of tooth loss, the data from the conventional dental office agree with the median from the nomogram. For attachment loss and probing depth, some age groups yielded slight but not uniform deviations from the median. Cross-sectional data from the periodontology unit Greifswald showed attachment loss higher than the median in younger but not in older age groups. The probing depth was uniformly less than the median and tended toward the 25th percentile with increasing age. The longitudinal data of the Unit of Periodontology in Kiel showed a pronounced trend towards higher percentiles of residual teeth, meaning that the patients retained more teeth.

**Conclusion:** The profile of the Pomeranian dental office does not deviate noticeably from the population-based nomograms. The higher attachment loss of the Unit of Periodontology in Greifswald in younger age strata clearly reflects their selection because of periodontal disease; the combination of higher attachment loss and decreased probing depth may reflect the success of the treatment. The tendency of attachment loss towards the median with increasing age may indicate that the Unit of Periodontology in Greifswald does not fulfill its function as a special care unit in the older subjects. The longitudinal data set of the Unit of Periodontology in Kiel impressively reflects the potential of population-based data sets as a means for benchmarking. Thus, nomograms can help to determine the practice profile, potentially yielding benefits for the dentist, health insurance company, or – as in the case of the special care unit – public health research.

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Control instruments have been used in industry for decades as a means of quality management, and are an important part of decision-making to increase efficiency and success. Now, society also expects quality management from its health-care professionals. Physicians and dentists formerly took the view that their performance could solely be assessed on the basis of their technical skills, ethics, and expertise, but are now confronted with a new social imperative from outside the profession (Brothwell, 1998). The dental profession has traditionally attempted to ensure quality and guarantee high educational standards by restricting licensure. The evaluation of quality and efficiency of health care primarily occurs as an outcome assessment. Currently, scientific discussion shows that quality management systems are much superior to the mere observance of quality standards.

Benchmarking is a means of setting goals or targets. As a tool used for continuous quality management, benchmarking compares an organization's performance, product, or process with similar ones outside the organization that are known to be the best. In attempting to emulate or surpass "best practice", an organization must set challenging but attainable goals and reach them with a plan of realistic and efficient actions. Since a "best dental practice" does not exist, we propose to extract a certain statistical data cluster out of populationbased epidemiological studies, which can be used to define the quality of dental office populations. In terms of oral health, it means retaining more teeth and improving the quality of life.

Periodontal disease, caries, or endodontic lesions are seldom so advanced that extraction is the only treatment option. The decision either to treat or to extract a tooth is based on the treatment philosophy and education of the dentist, his/her interaction with the patient, the income and education of the patient, as well on external reasons such as health insurance (Kay & Nuttall 1997). Klock (1995) studied patients' perception of extractions, and reported that 33% of the patients answered that it was their own decision to have the tooth extracted, while about two-thirds said that the dentist had suggested extraction. Findings from landmark studies of well-maintained subjects (Hirschfeld & Wasserman 1978, Axelsson et al. 1991, Rosling et al. 2001) have greatly contributed to our understanding that extractions - because of periodontitis or caries - can be prevented to a large extent in compliant patients with simple preventive measures such as regular prophylaxis sessions, improved oral hygiene regimens, and regular dental visits, whereas erratic or noncompliant patients had a much higher risk of tooth loss (Wilson et al. 1987, Kocher et al.

2000). Kressin et al. (2003) concluded that adherence to recommendations for preventive care, especially receiving regular dental prophylaxis, leads to higher tooth retention rates in the long run, in the general population as well.

Data for benchmarking procedures can be extracted from the most important indices used in epidemiological studies. Different indicators have been used to measure oral health (Marcus & Spolsky 1998). Marcus et al. (1983) developed the oral health status index (OHSI), which is a composite index with one numerical composite score, assessing decayed, missing, replaced teeth, free ends, and attachment loss. Spolsky et al. (2000) validated the OHSI by its correlation with epidemiological measures and with demographic variables in a minority group. They concluded that this composite index can be acceptably explained by the number of decayed, missing and filled teeth (DMFT), the number of replaced teeth, and attachment loss. Another proposal is simply to use epidemiological measures such as DMFT or attachment loss (Unell et al. 1998, 1999).

In other areas of medicine, nomograms are commonly used to estimate certain variables in comparison with a reference population. In pediatrics, for example, there are nomograms for the growth and weight of a child. Nomograms are usually constructed from the representative data sets of several longitudinal studies, and the information is given in percentiles. Because there are no longitudinal, large-scale, populationbased dental studies for Germany, we used the epidemiological data of the representative cross-sectional study (SHIP) 0 to construct dental nomograms. The degree to which patients of different practices correspond to the median dental health status of the SHIP subjects was estimated (dental-practice profile). The nomograms presented here are based on the variables tooth loss, attachment loss, and probing depth. The variable tooth loss results from the summation of untreatable (dentist's/ patient's opinion) carious and periodontal lesions, traumata, and extractions performed for prosthetic and orthodontic reasons. The variable attachment loss identifies the periodontal tissue lost over the years, and the variable probing depth characterizes the current status of periodontal disease/treatment. Periodontal treatment reduces probing depth, but the attachment loss remains virtually unchanged.

In this pilot investigation, we assessed whether the data generated by SHIP 0 can be used as a benchmark data set to characterize different practice profiles.

#### Material and Methods Subjects

#### Ship 0

Subjects were randomly selected from a population of 210,000 inhabitants of the German part of Pomerania, designated as "SHIP population". SHIP is a cross-sectional, multistage random sample with 4310 males and females, aged 20–79 years (response rate 69%). The design of the study, recruiting of participants, and the scope of this population-based cross-sectional health survey were outlined by Hensel et al. (2003) and John et al. (2001).

## Unit of Periodontology, Dental School, Greifswald

A sample of 130 Caucasian subjects (age  $50.4 \pm 15.2$  years (median and inter-quartile range), range 35.6-64.6 years, 57 males) were included (Table 1). They were compliant patients who were treated for moderate-to-advanced periodontitis at the Unit of Periodontology, University of Greifswald, and had been in regular maintenance for at least 2 years. For detailed information on the subjects, see Kocher et al. (2002).

#### Pomeranian dental office

On the German island of Hiddensee, located in the Baltic Sea, live 1250 permanent inhabitants who regularly visit the island's dentist (Table 1). The dentist has worked on this island since 1983. One hundred and eighty six subjects from 20 to 79 years of age (98 males/88 females, age  $49.0 \pm 25.25$ years, range 22–80 years) were included in the study.

#### Unit of Periodontology, Dental School, Kiel

The investigation was conducted as a longitudinal retrospective study based on compliant patients (Table 1). Data were obtained from charts of 135 (63 males/72 females) Caucasian patients (age  $46.0 \pm 10.0$  years, range 30-62 years) who were treated for moderate-

to-advanced periodontal disease at the Unit of Periodontology, University of Kiel, Germany. They had received cause-related and regular supportive periodontal therapy over a period of at least 10 years (for details, see König et al. 2002). Of the Kiel data, only the variable "number of teeth" was used in this study.

The data of SHIP were recorded from 1997 to 2001, and the data from Greifswald and Hiddensee were recorded in 1998. The data of the Unit of Periodontology in Kiel were retrospectively collected from patient charts in 1995. The local ethics committee approved the study.

#### Variables

Probing depth and clinical attachment loss were measured to the nearest millimeters from the gingival margin or the cemento-enamel junction, respectively, to the base of the pocket at four sites per tooth (Hu-Friedy PCP11, Chicago, IL, USA, disto-, mid-, and mesiobuccal and midlingual), in either the first and fourth or second and third quadrant. The number of teeth was registered; wisdom teeth were excluded.

#### Statistical analysis

For each subject, the extent of attachment level and probing depth  $\geq 4$  mm were expressed as percentage of the total number of sites examined. Subjects were divided into twelve 5-year strata. For each stratum, the fifth, 25th, 50th, 75th, and 95th percentiles for the dental variables (extent of attachment loss and probing depth, number of teeth) were calculated for SHIP data. For the other data sets (practice, units of periodontology), only the median was calculated.

#### Results

#### Attachment loss

The values of attachment loss  $\ge 4 \text{ mm}$  of the Pomeranian office population do not deviate uniformly from the median values of the SHIP 0 subjects. In the 35–39 and 65–69 years age strata, the Pomeranian office median lies above the SHIP 55th percentile; in the age groups 40–44, 45–49, and 70–74 years, the Pomeranian office median lies under the 45th percentile of SHIP. This deviation is within the nearest 25th

Table 1.	Distribution	of	subjects	in	the	different	study	populations

	SHIP 0		Unive Grei	ersity of fswald	Hido	lensee	University of Kiel	
	n	%	n	%	n	%	n	%
20-24	268	6.3			15	8.1		
25–29	324	7.6			4	2.2		
30-34	375	8.8			10	5.4	9	6.7
35–39	385	9.0	21	16.2	30	16.1	16	11.9
40–44	370	8.7	20	15.4	25	13.4	35	25.9
45–49	378	8.9	23	17.7	19	10.2	31	23.0
50-54	366	8.6	21	16.2	11	5.9	21	15.6
55–59	423	9.9	26	20.0	19	10.2	14	10.4
60–64	419	9.8	19	14.6	13	7.0	9	6.7
65–69	370	8.7			17	9.1		
70–74	312	7.3			10	5.4		
75–79	275	6.4			13	7.0		
20–79	4265	100.0	130	100.0	186	100.0	135	100.0

SHIP, study of health in Pomerania.

Attachment loss in the office on Hiddensee and in the Dental School Greifswald in relation to the SHIP population



*Fig. 1.* Median with fifth, 25th, 45th, 55th, 75th, and 95th percentile of the percentage of subjects with attachment loss  $\ge 4$  mm for the study of health in Pomerania (SHIP) population in each stratum. The blue rectangles represent the patients from the office on Hiddensee and the red dots represent those from the Unit of Periodontology in Greifswald.

percentile and, thus, the deviation is small to moderate. The variation of the deviation is small, and no trend can be observed over several age groups (Fig. 1).

The periodontally treated subjects at the Greifswald Dental School had higher attachment loss than the SHIP population for the age groups 35–59 years; the medians were within the 55th and 95th percentiles. The range of deviation is small, e.g., all median values are above the SHIP median in each age stratum. The deviation becomes smaller with increasing age. Higher age groups tend to have the same extent of attachment loss as the SHIP population.

#### Probing depth

The deviation of the median of Pomeranian office patients from the median of SHIP is moderate. The range of the deviation is also moderate. The subjects of the Greifswald Unit of Periodontology had fewer pockets  $\ge 4$  mm than did the SHIP population for the age groups 40–64 years. The variation of deviation is very small. The deviation becomes somewhat greater with increasing age. Higher age groups tend to the 25th percentile (Fig. 2).

#### Number of teeth

The deviation of the median of the Pomeranian office from the median of SHIP is small. The range of variation is also small. A trend for several age groups cannot be observed. The deviation of the subjects in Greifswald from SHIP is not uniform. In the younger age strata, they tend to have fewer teeth than the SHIP population, while the older age groups (>55 years) have more teeth (Fig. 3).

The median number of teeth of the Kiel Unit of Periodontology patients in (baseline) is higher in the age strata 35–64 years than in SHIP. After 10 years of maintenance, the 45–64-year-old Kiel population moved from the third to the fourth quartile (Fig. 4).

#### Discussion

Benchmarking is a method of measuring performance against established standards of best practice. An example is the study published by Middleton & Donnelly (2002), who assessed mortality as the outcome of carotid endarterectomy in some Australian state hospitals and compared them to international benchmarks during a certain time frame. The authors concluded that Australian surgeons achieve outcomes comparable with the international benchmark. Instead of using standards of best outcome, we propose percentiles/median values as benchmarks, based on a representative population-based study, to assess the "performance" of a dental office. Using these nomograms constructed from the SHIP data, it was our intent to examine whether it was possible to create individual practice profiles to assess their preventive impact. A dental goal may be to longitudinally shift the median of the practice population into a higher population-based percentile, as was done in the Kiel population (Fig. 4). In the current public debate on health care, the term "treatment quality" appears regularly. One facette of this is the outcome quality, the aspect that is of immediate interest to the patient. The patient (often) wants to know why a particular treatment must be performed and how it will influence the longevity of the restoration, bridge, tooth, etc. Although the nomograms cannot answer the

Probing depth in the office on Hiddensee and in the Dental School Greifswald in relation to the SHIP population



*Fig.* 2. Median with fifth, 25th, 45th, 55th, 75th, and 95th percentile of percentage of subjects with probing depth  $\ge 4$  mm age for the study of health in Pomerania (SHIP) population in each stratum. The blue rectangles represent the patients from the office on Hiddensee and the red dots represent those from the Unit of Periodontology in Greifswald.



*Fig. 3.* Median with fifth, 25th, 45th, 55th, 75th, and 95th percentile of the number of teeth for each age stratum of the study of health in Pomerania (SHIP) population. The blue rectangles represent the median of tooth number of the patients from the office on Hiddensee and the red dots represent those from the Unit of Periodontology in Greifswald.

questions of the individual patient, they can provide a practice profile, i.e., the dental outcome quality of a given practice.

Although the practice population of Pomeranian office was not randomly selected, the deviation for tooth loss, attachment loss, and probing depth from the SHIP data was, on the whole, low. Furthermore, the prevalence of smoking and diabetes – both accepted risk factors for periodontitis (data not shown) – were comparable in the Pomeranian office and in SHIP. Since the dental indices of the Pomeranian office population are equal to those of SHIP, it seems that the dentist's preventive effectiveness is comparable with other dental offices in



*Fig. 4.* Median with fifth, 25th, 45th, 55th, 75th,and 95th percentile of number of teeth in each stratum for the study of health in Pomerania (SHIP) population. The blue rectangles represent the median number of teeth of the Dental School Kiel at treatment begin, the red dot represents that 10 years later.

this area. The preventive measures performed in his office are not more effective, and/or the island population is not more interested in adopting preventive measures – such as regularly attending the dental practice and performing measures to improve oral hygiene – than the SHIP population was.

The dental school population of Greifswald is highly selected: most patients were referred for periodontal treatment to the dental school. The higher attachment loss of this compared with the SHIP population clearly reflects their selection because of periodontal disease; the decreased probing depth, however, reflects the success of treatment provided by the dental school. The relation of these two variables reflects the success of the treatment rendered in comparison with the general population, and illustrates the potential of benchmarking. For the variable attachment loss, there is a tendency towards the median with increasing age, which may mean that the dental school does not fulfill its function as a special care unit and does not treat the more diseased subjects in the older age strata. A lack of awareness of or disinterest in retaining more teeth of older patients, or the unwillingness of local dentists to make referrals may be responsible for this phenomenon.

The dental school population of Kiel shows a pattern of retaining more teeth

than the SHIP 0 population after 10 years of supportive periodontal treatment and it highlights the higher efficiency of preventive treatment measures rendered (Kressin et al. 2003), and clearly underlines the possibility of using population-based nomograms as a benchmark. The benchmark goal – to shift the subjects over the years into higher percentiles – has been achieved in this population.

To avoid the pitfalls of comparing practices where the majority of patients have a good prognosis (e.g., an office with primarily highly educated, young patients) versus practices where the majority of patients have a worse dental prognosis (office with primarily poorly educated subjects), it is necessary for meaningful benchmarking to include additional data to adjust the results. Besides age and smoking as risk factors for periodontal disease and tooth loss, other risk factors that should be included are social status, patients' level of education, marital status, diabetes, and attending preventive appointments. These data must be assessed. Furthermore, the outcome quality of a preventively oriented practice is not just determined by the practice itself, but also by the patients. In order to obtain a complete picture of outcome quality, data must be available on the number of patients making use of the prophylaxis offered, the number of drop-outs over time, and the number visiting the practice sporadically (Wilson et al. 1984, Mendoza et al. 1991, Checchi et al. 1994, König et al. 2001). Unfortunately, there is a lack of comparable data from practices in which integrated treatment is performed. The more highly selected a practice population is, the greater is the chance that only those patients will continue to attend who are highly interested in supportive dental care (König et al. 2001) and to whom the treating dentist ascribes a greater chance of success (Kocher et al. 2000). Therefore, a practice that places emphasis on prevention as its treatment goal should be characterized by patients with a large number of remaining teeth and low attachment loss and probing depth, and have a large number of patients enrolled in regular maintenance. Future studies must determine which of these variables are necessary. Benchmarking is not applicable to special practices such as oral surgeons, implantologists, or offices that are restricted to acute pain-relief dentistry.

In the further discussion of benchmarking, the necessity of including the number of decayed, missing and filled surfaces (DMFS) index must be investigated. The D component (decayed) of the DF-S indicates the number of untreated carious surfaces a patient has. If a patient regularly participates in a practice's prophylaxis program, the "decayed" part should be negligible (Axelsson et al. 1991). Lang et al. (1997) compared the OHSI and its components (decayed, missing, and replaced teeth, free ends, and moderate and severe periodontal disease measures) with epidemiologically based data and found a good correlation. In evaluating the composite index, they concluded that missing teeth as a single index component also worked well. The parameter probing depth indicates the immediate success of periodontal or preventive treatment, because the lower the proportion of surfaces with a probing depth of  $\ge 4 \text{ mm}$ , the more successful was the periodontal treatment or prevention of periodontal disease. The variable attachment loss shows the extent to which a periodontally diseased patient frequents the practice. From the relationship of the variables probing depth and attachment loss, the success with which periodontal treatment was performed for the entire practice population can be deduced. The more successful the periodontal treatment, the lower the frequency should be of surfaces with an attachment loss of  $\geq 4$  mm. If surfaces with an attachment loss of  $\geq 4$  mm are infrequent but a large number of teeth are missing, extraction was the preferred method of treatment. The relation of probing depth/attachment loss in the Greifswald population demonstrates the applicability of the benchmark idea: these subjects have more attachment loss, but fewer pockets  $\geq 4$  mm. Thus, the treatment rendered seems to be successful.

If the *F* component (filled) and *number of crowns* are also recorded, the comparison of these variables shows whether the practice is oriented toward restoration/conservation or prosthetics. In the future, it will almost certainly be necessary to record the *number of implants*, since this includes elements of missing teeth, probing depth, and attachment loss.

To judge the efficacy or quality of care given, patient-centered data are necessary. Probing depth reduction might occur, but the outcome (e.g., recession) could be esthetically unacceptable to the patient (Kalkwarf et al. 1992). Thus, it may be that although the treatment is a failure from the patients's point of view (Wiles et al. 2001), it is a success from the dentist's point of view. Quality-oflife data in relation to preventive measures or periodontal treatment are sparse in the literature (Matthews, 1994, Marcus & Spolsky 1998).

Measures of quality assessment should:

- 1. be linked to a goal (e.g., above the median of SHIP or shift from a lower to higher percentile over the years),
- 2. be easy to use,
- 3. be low-cost.
- 4. not impose undue burden on the practioners,
- 5. help providers improve care delivery.

The advantage of using variables such as number of teeth, attachment loss, etc. as individual parameters and not as a composite index is that they can quickly be compared with epidemiologically available data and can be implemented in benchmarking with multivariate analyses that include risk factors.

#### Conclusion

With these characteristics, benchmarking comparisons of dental practices can be drawn to standard profiles of population-based data. This instrument makes the quality of a dental practice more transparent. Where dental services are paid for by insurance or health-care organizations, these parameters can be used in creating a fee system. Further research is required to determine the validity of these thoughts.

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#### Reference

- Axelsson, P., Lindhe, J. & Nyström, B. (1991) On the prevention of caries and periodontal disease. Results of a 15-year longitudinal study in adults. *Journal of Clinical Periodontology* 18, 182–189.
- Brothwell, D. J. (1998) Quality assurance in the dental profession, 64, 726–731.
- Checchi, L., Pelliccioni, G. A., Gatto, M. R. & Kelescian, L. (1994) Patient compliance with maintenance therapy in an Italian periodontal practice. *Journal of Clinical Periodontology* 21, 309–312.
- Hensel, E., Gesch, D., Biffar, R., Bernhardt, O., Kocher, T., Splieth, C., Born, G. & John, U.Study of Health in Pomerania (SHIP) (2003) A health survey in an East German region. Objectives and design of the oral health section. *Quintessence International* 34, 370–378.
- Hirschfeld, L. & Wasserman, B. (1978) A longterm survey of tooth loss in 600 treated periodontal patients. *Journal of Periodontology* 5, 225–237.
- John, U., Greiner, B., Hensel, E., Lüdemann, J., Piek, M., Sauer, S., Adam, C., Born, G., Alte, D., Greiser, E., Haertel, U., Hense, H. W., Haerting, J., Willich, S. & Kessler, C. (2001) Study of Health In Pomerania (SHIP): a health examination survey in an east German region: objectives and design. *Sozial Praventivmedizin* 46, 186–194.
- Kalkwarf, K. L., Kahldahl, W. B. & Patil, K. D. (1992) Patient preference regarding 4 types of periodontal therapy following 3 years of

maintenance follow-up. *Journal of Clinical Periodontology* **19**, 788–793.

- Kay, E. & Nuttall, N. (1997) Clincial Decision Making. An Art or a Science? London: British Dental Association.
- Kocher, T., König, J., Dzierzon, U., Sawaf, H. & Plagmann, H. C. (2000) Disease progression in periodontally treated and untreated patients-a retrospective study. *Journal of Clinical Periodontology* 27, 866–872.
- Kocher, T., Sawaf, H., Fanghänel, J., Timm, R. & Meisel, P. (2002) Association between bone loss in periodontal disease and polymorphism of N-acetyltransferase (NAT2). *Journal of Clinical Periodontology* 29, 21–27.
- Klock, K. S. (1995) Patients' perceptions of the decision-making process leading to extraction of permanent teeth in Norway. *Community of Dental and Oral Epidemiology* 23, 165–169.
- König, J., Plagmann, H. C., Langenfeld, N. & Kocher, T. (2001) Retrospective comparison of clinical variables between compliant and non-compliant patients. *Journal of Clinical Periodontology* 28, 227–232.
- König, J., Plagmann, H. C., Rühling, A. & Kocher, T. (2002) Tooth loss and pocket probing depths in compliant periodontally treated patients: a retrospective analysis. *Journal of Clinical Periodontology* 29, 1092–1100.
- Marcus, M., Koch, A. L. & Gershen J, A. (1983) A proposed index of oral health status: a practical application. *Journal of the American Dental Association* **107**, 729–733.
- Marcus, M. & Spolsky, V. (1998) Concepts of quality and the provision of periodontal care: a survey. *Journal of Periodontology* 69, 228–240.
- Matthews, D. C. (1994) Decision making in periodontics: a review of outcome measures. *Journal of Dental Education* 58, 641–647.
- Mendoza, A. R., Newcomb, G. M. & Nixon, K. C. (1991) Compliance with supportive periodontal therapy. *Journal of Clinical Periodontology* 62, 731–736.
- Kressin, N. R., Boehmer, U., Nunn, M. E. & Spiro, A. III (2003) Increased preventive practices lead to greater tooth retention. 82, 223–227.
- Lang, W. P., Borgnakke, W. S., Taylor, G. W., Woolfolk, M. W., Ronis, D. L. & Nyquist, L. V. (1997) Evaluation and use of an index of oral health status. *Journal of Public Health Dentistry* 57, 233–242.
- Middleton, S. & Donnelly, N. (2002) New South Wales Carotid Endarterctomy Audit Project Working Group Outcomes of carotid endarterectomy: how does the Australian state of New South Wales compare with international benchmarks? *Journal of Vascular Surgery* 36, 62–69.
- Rosling, B., Hellström, M. K., Ramberg, P., Socransky, S. S. & Lindhe, J. (2001) The use of PVP-iodine as an adjunct to non-surgical treatment of chronic periodontitis. *Journal of Clinical Periodontology* 28, 910–1031.

- Spolsky, V. W., Marcus, M., Coulter, I. D., Der-Martirosian, C. & Atchison, K. A. (2000) An empirical test of the validity of the Oral Health Status Index (OHSI) on a minority population. *Journal of Dental Research* 79, 1983–1988.
- Unell, L., Söderfeldt, B., Halling, A. & Birkhed, D. (1998) Explanatory models for oral health expressed as number of remaining teeth in an adult population. *Community Dental Health* 15, 155–161.
- Unell, L., Soderfeldt, B., Halling, A. & Birkhed, D. (1999) Explanatory models for clinically determined and symptom-reported caries indicators in an adult population. *Acta Odontologica Scandinavica* 57, 132–138.
- Wiles, N. J., Scott, D. G., Barrett, E. M., Merry, P., Arie, E., Gaffney, K., Silman, A. J. & Symmons, D. P. (2001) Benchmarking: the five year outcome of rheumatoid arthritis assessed using a pain score, the Health Assessment Questionnaire, and the Short Form-36 (SF-36) in a community and a clinic based sample. Annals of the Rheumatic Diseases 60, 956–961.
- Wilson, T. G. Jr., Glover, M. E., Malik, A. K., Schoen, J. A. & Dorsett, D. (1987) Tooth loss in maintenance patients in a private periodontal practice. *Journal of Clinical Periodontology* 58, 231–235.
- Wilson, T. G., Glover, M. E., Schoen, J., Baus, C. & Jacobs, T. (1984) Compliance with

maintenance therapy in a private periodontal practice. *Journal of Periodontology* **55**, 468–473.

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