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Trends over 30 years, 1973–2003, in the prevalence and severity of periodontal disease

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Abstract

Aim: The present investigation presents findings of the prevalence and distribution of gingivitis and periodontitis in a Swedish population over the 30 years 1973–2003.

Material and Methods: Four cross-sectional epidemiological studies in 1973, 1983, 1993, and 2003 were performed in Jönköping, Sweden. Random samples of individuals aged 20, 30, 40, 50, 60, 70, and 80 years were examined clinically and radiographically. Diagnostic criteria were edentulousness, number of teeth, plaque, gingival status, probing pocket depth, gingival recession, alveolar bone level, and classification according to periodontal disease status.

Results: In all age groups, the number of edentulous individuals decreased dramatically and the number of teeth increased. Oral hygiene improved considerably. Over the 30 years, the proportion of periodontally healthy individuals increased from 8% in 1973 to 44% in 2003 and the proportion of individuals with gingivitis and moderate periodontitis decreased. There was a non-significant trend for the proportion of individuals with severe periodontal disease experience (Group 4) to decrease, while the proportion of individuals with advanced periodontitis (Group 5) remained unchanged.

Conclusion: Oral hygiene and periodontal health improved significantly in the 20–80-year age groups over the 30 years 1973–2003.

Key words: dental plaque; epidemiology; gingivitis; periodontal disease; probing pocket depth; trends

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In recent decades, a series of cross-sectional and longitudinal epidemiological studies on oral health and disease in adults were performed in Jönköping, Sweden. Apart from changes in tooth loss and dental caries prevalence in the past 30 years, changes in oral hygiene and periodontal diseases were described. These studies indicate that the prevalence and severity of periodontal disease increase with age. But the study by Hugoson & Jordan (1982) on the frequency distribution according to the periodontal disease severity of individuals aged 20–70 years revealed that severely advanced periodontal breakdown was unusual before age 40 and occurred at most in 8% of age groups 50 years and older. It was hypothesized that a much higher prevalence of advanced periodontal breakdown in the older age groups was masked by the high frequency of edentulous individuals and the large number of missing teeth, especially pre-molars and molars. The fact that advanced periodontal breakdown affected only a few individuals in the older population was confirmed by other investigators (Baelum et al. 1986, 1988, Loe et al. 1986, Papapanou et al. 1988, Schurch et al. 1988, Yoneyama et al. 1988).

Conflict of interest and source of funding statement

The authors declare that they have no conflicts of interests.
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The methods used in the Jönköping epidemiological studies included questionnaires on civil status, socio-economic data, general health and dental care habits and clinical and radiographic examinations. The first epidemiological study in 1973 covered the 3–70-year age groups. The 1973 and 1993 studies covered the 3–80-year age groups. Concurrent with the 1983 study, a preventive dental care system that began with the younger groups of the population was introduced (Hugoson & Koch 1981) and continuing education and training of dental care professionals in diagnostic and preventive dental care was begun (Hugoson 1981). A considerable decrease in dental disease was observed between 1973 and 1993 (Hugoson et al. 1998, Norderyd 1998). Changes in the

dental care system were needed to meet this new situation of a continuously healthier population. Another epidemiological study was undertaken in 2003–2004 to analyse the knowledge, attitudes, dental behaviour, and clinical status of the population (Hugoson et al. 2005a, b). An overview of changes in dental care knowledge and habits and clinical findings were presented in these studies.

Longitudinal studies on the progression of periodontitis in humans suggest that the rate of periodontal breakdown in most individuals and at most sites is very low (Lindhe et al. 1983, Lavstedt et al. 1986, Papapanou 1989, Albandar 1990, Wennstrom et al. 1993). This was confirmed in a prospective longitudinal follow-up that assessed periodontal bone height changes over 17 years in the 1973 Jönköping study participants (Norderyd et al. 1999, Hugoson & Laurell 2000). But few studies have reported time trends in periodontal disease prevalence among adults (Hugoson et al. 1992, Ankkuriniemi & Ainamo 1997, Hugoson et al. 1998, Kalsbeek et al. 2000, Borrell et al. 2005, Skudutyte-Rysstad et al. 2007). The aim of this study was therefore to assess the trends over a 30-year period from 1973 to 2003 in the prevalence, severity and distribution of gingivitis and periodontitis and alveolar bone levels among adults living in Jönköping, aged 20–80 years.

Material and Methods

Jönköping is a medium-sized Swedish city with 125,000 inhabitants. In Jönköping, as throughout Sweden, dental care is readily accessible.

In 1973, a random sample of individuals aged 3, 5, 10, 15, 20, 30, 40, 50, 60, and 70 years from four parishes were examined clinically and radiographically. In addition to the clinical examinations, subjects were asked about dental care habits and knowledge of oral health. The sample was chosen based on date of birth (between March and May), and all subjects in each age group were listed in chronological order so that each age group had 140–170 individuals. The first individual on each age group list was invited to the examination. In the event of non-attendance, the next individual on the list was invited until 100 participants in each age group had been chosen (Hugoson & Koch 1979).

In 1983, 1993, and 2003, new random samples of subjects were selected, consisted of 130 individuals in each of the age groups used in 1973 plus a group aged 80 years. Of the selected cases, 677, 655, and 589 individuals 20–80 years old showed up at the three different examinations respectively. Table 1 lists the numbers of subjects and the sex distribution in each age group.

Everyone selected for the study was sent a written invitation to take part in a dental health examination. They were informed of the purpose of the investigation and that clinical and radiographic examinations of the mouth and jaws would be performed. They were also informed that the examination was free of charge and that radiographs would made available to their regular dentist. If an individual was physically unable to come to the examination, suitable means of transportation were arranged. Five dentists performed the 2003 examinations. Dental examinations of some handicapped or elderly people were performed in their homes or institutions.

Non-respondents

Not all selected individuals participated in the study. Non-respondents were contacted by telephone and asked about their reasons for not attending the clinical examination. The reasons for not taking part in the study were recorded.

The numbers of non-respondents in 1983 and 1993 were similar while the number of non-respondents in 2003 was somewhat higher than previously. In 2003, 26–36% of those in each of the 20–70-year age groups declined to participate for various reasons. In the 80-year age group, 53% declined to participate. Detailed information about the number of non-respondents and the reasons for not taking part in 1983, 1993, and 2003 are published elsewhere (Hugoson et al. 2005a).

Clinical Examination

Participants were examined clinically in dental offices with modern equipment and optimal lighting. Each clinical and radiographic examination took 60–90 min. A standardized computerized protocol designed for subsequent data processing was used in 2003.

Diagnostic criteria

Prevalence of edentulous individuals and number of existing teeth

The number of edentulous individuals and the number of existing erupted incisors, canines, pre-molars, and molars were recorded. Third molars were excluded from the analysis.

Plaque

The presence of visible plaque was recorded for four tooth surfaces after drying with air according to the criteria for Plaque Indices 2 and 3 (Silness & Loe 1964).

Gingival status

The presence of gingival inflammation corresponding to Gingival Indices 2 and 3 was recorded for four tooth surfaces. Gingival inflammation was recorded if the gingivae bled on gentle probing (Loe 1967).

Probing pocket depth

In 1973, the presence of probing pocket depths in the permanent dentition equal to or exceeding 4 mm was recorded for four sites at each tooth. In 1983, 1993,

Table 1. Numbers of subjects examined and sex distributions in each age group in 1973, 1983, 1993, and 2003

Age group	Number examined											
	1973			1983			1993			2003		
	total	female	male	total	female	male	total	female	male	total	female	male
20	100	60	40	100	55	45	100	50	50	84	38	46
30	100	49	51	98	48	50	102	39	63	92	50	42
40	100	52	48	99	52	47	93	39	54	83	36	47
50	100	60	40	103	60	43	97	52	45	91	50	41
60	100	60	40	98	47	51	92	42	50	90	45	45
70	100	52	48	99	51	48	100	64	36	88	48	41
80				80	50	30	71	37	34	61	39	21
Total	600	333	267	677	363	314	655	323	332	589	306	283

and 2003, pocket depth was recorded in millimetre. The periodontal probe designed by Hilming was used in all studies.

Gingival recession

In 2003, the prevalence of exposed root surfaces apical to the cemento-enamel junction or the crown margin was registered for four tooth surfaces.

Supragingival calculus

The presence of supragingival calculus was recorded for each tooth after drying with air.

Radiographic Examination

The 1973–2003 radiographic examinations included extra- and intra-oral radiographs. The examinations varied over the years to reflect the population's improved oral health and ethical considerations (Hugoson et al. 1995).

All participants wore a lead apron during radiographic examinations. If a participant had recently had a radiographic examination, the radiographs were obtained from the participant's dentist. When necessary, the intra-oral examinations were supplemented by separate radiographs.

In 1973 and 1983, participants of all age groups underwent a full-mouth intra-oral examination, 16 periapical, and four posterior bite-wing radiographs (6 mA, 60–65 kV, exposure time 0.4–0.6 s). The 1983 examination included an orthopantomogram (7 mA, 60 kV, exposure time 18 s).

The 1993 radiographic examination of the 20–30-year age groups comprised six bite-wing radiographs (two in the frontal region and four in the posterior region) and an orthopantomogram. The 40–80-year age groups had a full-mouth intra-oral examination and an orthopantomogram.

The 2003 radiographic examination of the 20–40-year age groups comprised six bite-wing radiographs (two in the frontal region and four in the posterior region) and an orthopantomogram. The 50–80-year age groups had a full-mouth, intra-oral radiographic examination and an orthopantomogram. When deep caries and root-filled teeth were visible in the orthopantomograms of the 20–40-year-olds, a periapical radiographic examination was made.

Intra-oral radiographs were mounted in frames or masked and subsequently studied using a pair of observation binoculars according to Matsson (1953).

Classification according to the severity of the periodontal disease experience

All dentate individuals were classified according to clinical and radiographic findings using Hugoson & Jordan's criteria (1982) where ''around most teeth'' (Groups 3, 4, 5) stands for 80–100% of the teeth:

Group 1. Healthy or almost healthy gingival units and normal alveolar bone height; $\leqslant 12$ bleeding gingival units in the molar–pre-molar regions.
Group 2. Gingivitis; >12 bleeding gingival units in the molar–pre-molar regions; normal alveolar bone height.
Group 3. Alveolar bone loss around most teeth not exceeding 1/3 of the length of the roots.
Group 4. Alveolar bone loss around most teeth ranging between 1/3 and 2/3 of the length of the roots.
Group 5. Alveolar bone loss around most teeth exceeding 2/3 of the length of the roots; presence of angular bony defects and/or furcation defects.

Periodontal health

Individuals in periodontal disease Groups 3, 4, or 5 were subdivided into subgroups to differentiate between those with periodontal health and disease. The criteria for periodontal health were $\leqslant 20\%$ bleeding sites and $\leqslant 10\%$ sites with probing pocket depths $\geqslant 4$ mm. These criteria were extrapolated from clinical experience and the literature on clinical results of successful periodontal therapy (Lindhe et al. 1982, Badersten et al. 1984, 1985, Laurell & Pettersson 1988, Hugoson et al. 1992).

Alveolar bone level

To determine the alveolar bone level, periapical radiographs were primarily used but otherwise an orthopantomogram was used. Proximal bone level was calculated as a percentage of the total length of the tooth (Bjorn et al. 1969). Periodontal bone level in the premolar and molar regions of the lower jaw was chosen as being representative of the entire dentition (Björn 1974). Bone level was recorded mesially and distally for each molar and pre-molar tooth in the lower jaw. The mean of these measurements [Bone Level Index (BLI)] was calculated for each individual.

Subgingival calculus

The dentition was divided into sextants, delimited by the canines in each jaw. Subgingival calculus visible interproximally was recorded. A sextant was recorded as having calculus when interproximal calculus was visible on at least one tooth surface.

Additional Variables

Caries, restorations, defective marginal adaptation of restorations (overhangs), occlusion, status of the oral mucosa, salivary factors such as secretion rate and buffer capacity, root surface caries, stomatognathic variables, function of complete or removable partial dentures, periapical status and endodontic treatment, dental implants, and the prevalence and position of third molars were also recorded.

Ethical Considerations

Each of the 1973–2003 studies were conducted according to the ethical principles of the World Medical Association Declaration of Helsinki (Rickham 1964) that were current at the time of the study. The Ethics Committee at Linköping University, Linköping, Sweden, approved the 2003 study.

Data Processing and Methodological Analysis

A computerized dental record system was used. Data were analysed using the Statistical Package for the Social Sciences (SPSS, version 13.0, SPSS Inc., Chicago, IL, USA). The mean values, standard deviations (SDs), 95% confidence intervals (CIs) ($p<0.05$), and frequencies and distributions were calculated. Statistical differences over time for plaque, gingivitis, probing pocket depth, and alveolar bone level were determined using repeated measures ANOVA and the Scheffe test for post hoc analysis and for periodontal disease group using non-parametric ANOVA (Kruskal–Wallis test). Before the examinations were begun (1973,

1983, 1993, 2003), two senior examiners calibrated all other examiners regarding diagnostic criteria. In 2003, a sample of radiographs from the 1983, 1993, and 2003 examinations were selected from the database by the statistician. The sample individuals represented all stages of periodontal tissue health and various degrees of periodontal disease experience. Two of the authors (A. H. and O. N.) re-examined the radiographs of the sample individuals, which had been evaluated by 10 examiners. Each case was classified according to the severity of the periodontal disease experience. Bone-level measurements were made twice. Agreement between the two examiners was significant concerning classification of periodontal disease experience with Cohen's $\kappa = 0.70$ (Landis & Koch 1977) and bone level (ICC = 0.7; 95% CI, 0.57–0.80).

These were the mean BLIs and SDs for each of the five periodontal disease severity groups in 2003: Group 1 (healthy), 67% (3.8); Group 2 (gingivitis), 64% (3.3); Group 3 (periodontitis levis), 58% (5.6); Group 4 (periodontitis gravis), 52% (6.3); and Group 5 (periodontitis complicata), 44% (10.7).

Results

About 90% of all age group participants in all studies were Caucasian and born in Sweden.

Prevalence of edentulous individuals

The frequency of edentulous individuals aged 40–70 years decreased from 16% in 1973 to 1% in 2003 (Table 2). The youngest edentulous person in 1973 was 40 years old. No individuals under 60 years were edentulous in 1993 and 2003.

Number of teeth

Table 3 shows the mean number of teeth in dentate individuals. The mean number of teeth per subject in the four samples decreased with increasing age. The mean number of teeth per subject in the 40–80-year age groups was significantly higher in 2003 than in 1983 or 1993. The 70-year age group had a mean of seven more teeth per subject in 2003 than in 1973, which was the largest overall difference for any age group. The largest increase in the number of retained teeth between 1973 and 2003 in the 30–70-year age groups was in the pre-molars and molars. For example, the mean numbers of molars increased from 2.3 in 1973 to 5.9 in 2003 among 60-year-olds (Fig. 1).

Figure 2 shows the mean number of teeth per individual in the different periodontal disease groups in 1983, 1993, and 2003. The number of teeth increased between 1973 and 2003, especially in individuals in periodontal disease Group 4.

Table 2. Numbers (%) of edentulous individuals in the 20–80-year age groups in 1973, 1983, 1993, and 2003

Age group	No. of edentulous individuals			
	1973	1983	1993	2003
20				
30				
40	1 (1)			
50	5 (5)	4 (3)		
60	20 (20)	14 (14)	9 (10)	4 (4)
70	37 (37)	29 (29)	23 (23)	1 (1)
80		45 (56)	30 (42)	2 (3)
Total	63 (11)	92 (14)	62 (9)	7 (3)

Plaque and gingivitis

Table 4 and Fig. 3 present the frequency of tooth surfaces with plaque as percentages of existing tooth surfaces. A general decrease in the percentage of tooth surfaces with plaque was observed in all age groups in 2003 compared with 1993. The mean number of tooth surfaces with plaque in 1993 varied between 30% and 43%, except in the 80-year age group, where 56% of the tooth surfaces had plaque. Plaque scores in 2003 decreased between 20% and 30% depending on the age group. Thus 30-year-olds had a plaque score of 30% (95% CI, 24.8–35.5) in 1993 compared with 20% (95% CI, 15.4–24.0) in 2003. The corresponding figures for 70-year-olds were 43% (95% CI, 36.8–48.7) in 1993 and 25% (95% CI, 20.0–30.6) in 2003. The proximal surface was the tooth surface most frequently having plaque (Hugoson et al. 2005b).

Table 5 and Fig. 4 show the frequency of sites exhibiting gingivitis. The frequency of sites with gingivitis was the lowest in all age groups in 2003 compared with the 1973–1993 examinations.

Table 3. Mean number of teeth and 95% confidence interval (CI) in 1983, 1993, and 2003 (dentate individuals) in the age groups 20–80 years in 1973, 1983, 1993, and 2003

Age group	Number of teeth						
	1973	1983		1993		2003	
	mean	mean	95% CI	mean	95% CI	mean	95% CI
20	27.2	27.4	27.2–27.6	27.3	27.0–27.6	27.4	27.1–27.6
30	25.8	26.9	26.6–27.2	27.3	27.0–27.6	27.2	26.9–27.5
40	23.2	24.8	24.0–25.7	26.6*a	26.2–27.1	26.5*b	25.9–27.0
50	21.5	22.7	21.8–23.7	24.7*a	23.7–25.6	26.1*b	25.5–26.3
60	18.2	18.6	17.2–20.0	21.7*a	20.4–23.0	23.3*b	21.9–24.7
70	13.3	15.5	13.8–17.1	18.1*a	16.6–19.5	20.7*b	19.3–22.0
80	–	13.7	11.6–15.9	15.7*a	13.4–17.6	18.4*b	16.9–20.0

*$p < 0.05$, comparison between 1983 and 1993 (a), 1983 and 2003 (b).

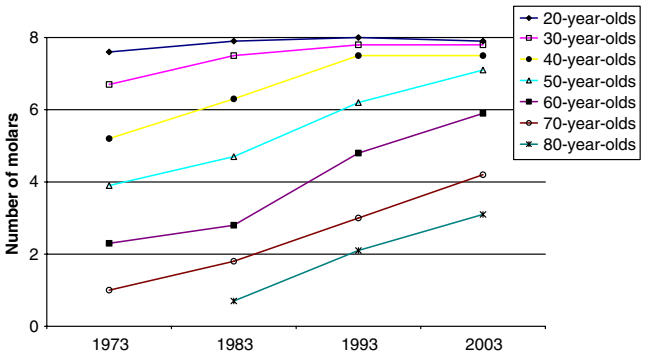

Fig. 1. Number of molars (excluding edentulous individuals). Means in the different age groups in 1973, 1983, 1993, and 2003.

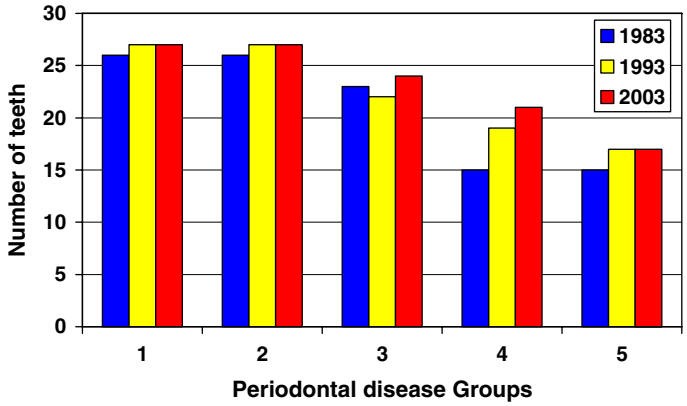

Fig. 2. Mean number of teeth per individual in the different periodontal disease groups in 1983, 1993, and 2003.

Table 4. Frequency (%) of the total numbers of tooth surfaces with plaque as a percentage of the total numbers of existing surfaces

Age group	1973	1983		1993		2003	
	mean	mean	95% CI	mean	95% CI	mean	95% CI
20	29.1	19.9	15.6–24.2	33.2*a	27.8–38.7	15.6*b	11.2–16.8
30	30.3	25.3	20.8–29.6	30.1	24.8–35.5	19.7*b	15.4–24.0
40	40.4	31.8	26.4–37.1	34.7	29.7–39.7	22.3*b	16.3–28.3
50	44.3	37.5	32.2–42.5	32.5	27.4–37.0	18.9*b	14.3–23.6
60	49.7	41.1	33.4–48.4	36.7	30.5–42.2	23.3*b	18.4–28.2
70	66.2	43.1	35.5–50.8	42.8	36.8–48.7	25.1*b	20.0–30.6
80	–	62.1	52.8–71.4	55.8	46.6–65.1	30.7*b	23.8–37.1

*$p < 0.05$, comparison between 1983 and 1993 (a), 1993 and 2003 (b).
Means and 95% CI in the different age groups in 1973, 1983, 1993, and 2003.
CI, confidence interval.

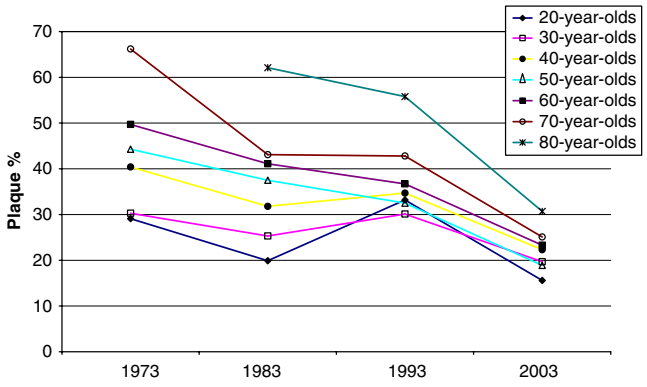

Fig. 3. Mean plaque scores (%) in the various age groups in 1973, 1983, 1993, and 2003.

Depending on the age group, the frequencies of sites with gingivitis had decreased by around 40% in 2003. Thus, among 30-year-olds, the mean percentage of sites with gingivitis was 32% (95% CI, 26.8–36.9) in 1993 compared with 17% (95% CI, 13.4–21.4) in 2003. The corresponding figures for 70-year-olds were 26% (95% CI, 21.6–31.4) in 1993 and 16% (95% CI, 12.3–21.1) in 2003. For more data on plaque and gingivitis, see Hugoson et al. (2005b).

Table 6 lists the mean numbers (95% CI) of probing pocket depths 4–5 mm and ⩾6 mm. The mean numbers of 4–5 mm pocket increased with age in each of the 1973–2003 examinations among 30–40-year-olds but show less variation in the 50–80-year age groups.

The mean numbers of 4–5 mm probed pockets decreased statistically significantly between 1983 and 1993 for 30–40-year-olds and increased between 1993 and 2003 for 30-year-olds. The mean numbers of 4–5 mm pockets in the 40–80-year age groups varied between 11% and 14% in 2003.

The mean numbers of ⩾6 mm pockets were low in the 20–40-year age groups and slightly higher in the 50–80-year age groups. In 2003, the mean number of pockets probed ⩾6 mm varied between 0% and 2% in the 20–40-year age groups and between 2% and 3% in the 50–80-year age groups.

Gingival recession

Table 7 show the frequency of tooth surfaces in 2003 that exhibited gingival recession as percentage of existing tooth surfaces. A general increase in the percentage of tooth surfaces with gingival recession occurred with age. The mean percentage gingival recession was 0% (0.7) among 20-year-olds, which increased to 12% (13.4) among 50-year-olds and to 22% (21.8) among 80-year-olds.

Alveolar bone level (BLI)

Table 8 shows the mean BLI for each age group in 1973, 1983, 1993, and 2003 as the percentage of total tooth length in mandibular pre-molars and molars. BLI decreased in all age groups and at all examinations with increasing age from normal bone height to around 65% of the total length of the tooth. The mean bone level in 2003 was 66% in the 20-year age group. Although proximal bone level successively decreased with age in 2003, the mean BLIs in all age groups were higher than in previous examinations. The mean bone level in the 60-year age group in 2003 was similar to inter-proximal bone levels in the 40-year age groups in 1973 and in 1983.

Classification according to severity of the periodontal disease experience

During the 30 years, 1973–2003, the proportion of periodontally healthy individuals increased markedly [i.e., the number of individuals with no alveolar bone loss and no or low levels of gingivitis (periodontal disease Group 1) increased from 8% in 1973 to 44% in 2003 (Fig. 5)]. In addition, the number of individuals with gingivitis or

moderate alveolar bone loss (Groups 2 and 3) decreased. Between 1983 and 1993, the proportion of individuals with more pronounced alveolar bone loss (Groups 4 and 5) was 13% of the population studied and, in general, did not change. These two groups were considerably smaller in 1973. Although the proportion of individuals in Groups 4 and 5 together decreased to 11% in 2003, the number of individuals in the most severe alveolar bone loss (Group 5) remained unchanged between 1993 and 2003.

The proportion of individuals in each age group with a healthy periodontium and no alveolar bone loss (Group 1) increased significantly in the 20–50-year age groups between 1993 and 2003 (Table 9). Similarly, the proportion of individuals with gingivitis and no alveolar bone loss (Group 2) decreased significantly in the 20–40-year age groups between 1993 and 2003.

The proportion of individuals with moderate alveolar bone loss (Group 3) decreased in the 30–50-year age groups between 1983 and 1993 and in the 40–70-year age groups between 1973 and 2003 (Table 10).

The proportion of individuals with periodontal disease experience in Group 4 decreased in the 50–70-year age groups between 1993 and 2003 (Table 11). But the only change that was statistically significant was in the 70-year age group. Finally, the proportion of individuals in each age group who had the most severe periodontal disease experience (Group 5) was 6–8% in 1993 and 2003 (Table 11). None in the 20–30-year age groups fell within this classification.

No gender differences in periodontal disease severity were seen in the 2003 study.

Table 5. Frequency (%) of the total number of sites with gingivitis as a percentage of the total number of existing sites

Age group	1973	1983		1993		2003	
	mean	mean	95% CI	mean	95% CI	mean	95% CI
20	34.5	17.4	13.6–21.2	32.2*a	27.2–37.2	11.8*b	9.2–14.3
30	23.9	24.6	20.6–28.7	31.8	26.8–36.9	17.4*b	13.4–21.4
40	32.7	26.1	21.1–31.2	28.7	24.3–33.1	16.0*b	11.4–20.5
50	38.5	29.3	24.0–34.4	31.5	26.2–36.2	15.1*b	11.1–19.2
60	43.5	26.7	20.1–33.2	30.6	25.0–35.8	15.2*b	11.2–19.1
70	60.2	32.0	27.0–39.7	26.4	21.6–31.4	16.4*b	12.3–21.1
80	–	34.6	25.8–42.9	36.2	27.7–44.7	18.2*b	12.4–23.0

*$p < 0.05$, comparison between 1983 and 1993 (a), 1993 and 2003 (b).
Means and 95% CI in the different age groups in 1973, 1983, 1993, and 2003.
CI, confidence interval.

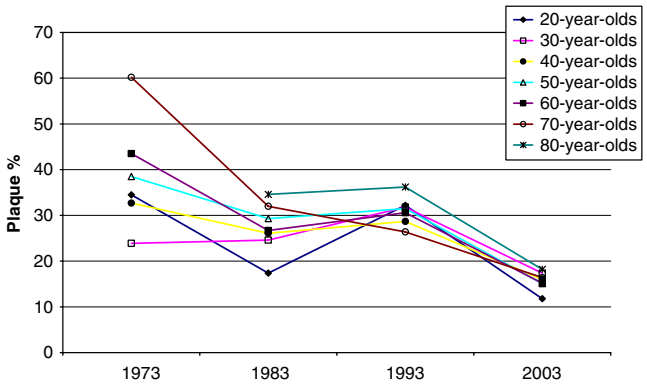

Fig. 4. Mean gingivitis scores (%) in the various age groups in 1973, 1983, 1993, and 2003.

Periodontal health

The periodontal disease severity Groups 3, 4, and 5 express an individual's experience of periodontal disease verified by different degrees of alveolar bone loss and the presence of gingivitis and probing pocket depth. Individuals falling into any of these groups were divided into subgroups that differentiated between periodontal health and disease in 1983, 1993, and 2003 according to the criteria set-up. In 1983, 18% of the individuals in Group 3 were regarded as periodontally healthy, 15% in Group 4, and 0% in Group 5. The corresponding figures in 1993 were 17%, 15%, and 4% and 31%, 12%, and 5% in 2003.

Table 6. Mean numbers of existing sites that have probing pocket depths 4–5 mm and ⩾6 mm

Age group	1983				1993				2003			
	4–5 mm		⩾6 mm		4–5 mm		⩾6 mm		4–5 mm		⩾6 mm	
	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI
20	1.9	1.3–2.5	0.0	0.0–0.03	1.5	0.6–2.3	0.0	0.0–0.04	0.9	0.3–1.4	0.0	0.0–0.1
30	9.7	7.0–12.5	0.9	0.4–1.5	2.1*a	1.3–2.8	0.0*a	0.0–0.07	4.9*b	2.9–6.9	0.2	0.1–0.3
40	11.4	8.4–14.6	1.4	0.1–2.8	5.7*a	4.0–7.5	0.6	0.3–0.9	11.0	7.4–14.6	1.6	0.3–2.9
50	16.6	13.0–20.2	2.0	1.2–2.8	10.8	8.3–13.2	1.8	1.0–2.7	11.1	7.6–14.6	2.6	0.9–4.3
60	16.8	12.4–21.1	3.4	1.9–4.8	12.0	8.5–15.4	2.3	1.1–3.5	14.2	10.7–17.6	2.0	1.0–3.8
70	14.9	11.3–18.4	2.5	1.5–3.6	10.4	7.8–13.1	0.9*a	0.4–1.3	12.3	9.2–15.4	2.2	1.1–3.3
80	20.9	14.1–27.7	5.8	1.3–10.4	11.7	7.7–15.7	1.1	0.6–1.8	11.9	8.8–15.0	1.9	0.6–3.2

*$p < 0.05$, comparison between 1983 and 1993 (a), 1993 and 2003 (b).
Means and 95% CIs in the different age groups in 1973, 1983, 1993, and 2003.
CI, confidence interval.

Table 7. Frequency (%) of the numbers of tooth surfaces with gingival recessions as a percentage of the total number of existing tooth surfaces in 2003

Age group	Mean	SD
20	0.1	0.7
30	2.5	3.3
40	6.8	7.4
50	11.8	13.4
60	14.6	14.8
70	19.6	19.2
80	22.2	21.8
Total	10.5	15.1

Table 8. Periodontal proximal bone level (BLI) as a percentage of the total tooth length, means, and 95% CI, for the various age groups in 1973, 1983, 1993, and 2003

Age group	1973	1983		1993		2003	
	mean	mean	95% CI	mean	95% CI	mean	95% CI
20	61.1	63.3	62.2–64.3	64.2	63.5–64.7	65.6*b	65.3–66.7
30	60.7	62.6	60.1–63.9	63.1	60.2–64.0	63.5	62.1–64.0
40	57.0	58.9	57.6–60.4	61.0	60.3–61.8	61.6	60.4–62.7
50	53.5	57.9	55.3–59.9	58.1	57.1–59.2	59.3	58.7–61.0
60	45.7	50.9	47.2–55.8	57.3	56.0–58.7	58.0	56.6–59.5
70	40.0	46.7	44.2–49.1	53.7*a	52.4–55.0	55.7	54.0–57.4
80	–	37.6	35.1–40.2	53.1*a	51.1–55.2	52.0	49.4–53.6

*$p < 0.05$, comparison between 1983 and 1993 (a), 1993 and 2003 (b).
CI, confidence interval.

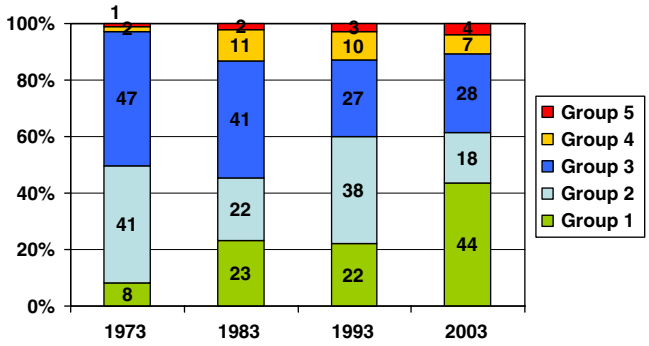

Fig. 5. Frequency (%) distribution of individuals according to the severity of periodontal disease experience in 1973, 1983, 1993, and 2003. Total number of individuals in age groups 20–70.

Discussion

Epidemiology has been a central issue within health care and is an important instrument for analysis of a population's treatment needs, planning of suitable interventions, and evaluation of preventive behaviours and care received. Furthermore, it is a tool for the development of quality in medical and dental care. Properly used information from epidemiological investigations is the most important source of data for a prospective analysis of the development of health and care that will be needed in a population.

The population examined constituted a random sample of individuals aged 20–80 years from Jönköping, a medium-sized town of around 125,000 inhabitants. Most of the individuals were born in Sweden, but about 10% were born abroad. In general, the ethnic compositions of all samples were similar to that of Sweden as a whole (Hugoson et al. 2005a).

The non-respondent rate in the 1973, 1983, and 1993 epidemiological studies was 15–25%, depending on the age group. But it was more difficult to convince the selected individuals to take part in the 2003 study, and the non-respondent rate was 29–36% for the 20–70-year age groups. The reasons for declining to participate were usually *not interested* or *had no time*. Another reason could be that recent, more rigorous ethical rules do not allow study participants to be persuaded to participate. Although there were many reasons for not taking part, none were likely to have significantly affected the results (Hugoson et al. 2005a).

The results of this study for edentulous individuals, number of teeth, oral hygiene and caries status, and attitudes to and knowledge of dental care were similar to those found in other epidemiological investigations from different parts of Sweden (Axelsson et al. 1993, Unell et al. 1999, Uhrbom & Bjerner 2003, Wänman et al. 2004). These findings justify the assumption that data from the present study can be used to draw more general conclusions.

Periodontal diagnosis and classification of periodontal disease have been discussed for many years, and classification systems have been changed by replacing old diagnoses with new ones (Armitage 1999). In a recent consensus conference regarding epidemiological data on periodontal disease, it was concluded that representative population samples, measurable variables that are universally recognizable, well-defined socio-economic data, cumulative frequency analysis, and patient sample outcomes were the goals of a successful epidemiological study; these goals were observed in the Jönköping studies (Davies et al. 2005).

During the planning of the first epidemiological survey in 1972, it was decided that the research protocol's description of periodontal status should be similar to the clinicians' descriptions of the symptoms of periodontal disease they used in their diagnosis and treatment of patients. Hence, clinical *and* radiographic variables were used to assess full-mouth periodontal status and form the basis of the diagnosis. Each tooth and tooth surface or site in the dentition was given an individual diagnosis concerning plaque, gingivitis, probing pocket depth, gingival recession, supra- and subgingival calculus, and bone level (pre-molars, molars). A classification system in use at the end of the 1960s and the beginning of the 1970s at the periodontal departments of the faculties in Umeå and later in Göteborg was used to group the participants according to their historical experience of gingivitis or chronic periodontitis in five groups. Group 3 was synonymous with moderate periodontitis and Groups 4 and 5 were synonymous with severe or advanced periodontitis (Lindhe & Lang 2003). In this classification system, most of the teeth

Table 9. Periodontal disease experience, Groups 1 and 2; frequency (%) distributions of individuals in the different age groups in 1973, 1983, 1993, and 2003

Age group	Group 1				Group 2			
	1973 (%)	1983 (%)	1993 (%)	2003 (%)	1973 (%)	1983 (%)	1993 (%)	2003 (%)
20	28	58***c	37**a	71***b	68	40***c	63**a	28***b
30	16	35**c	39	55*b	69	42***c	58*a	33***b
40	5	17**c	23	51***b	51	22***c	44**a	16***b
50		8	10	41**b	38	11***c	28**a	16
60		12	15	23	11	4	17**a	8
70		1	4	12	11	7	8	8

*$p<0.05$, **$p<0.01$, ***$p<0.001$, comparisons between 1973 and 1983 (c), 1983 and 1993 (a), 1993 and 2003 (b).

Table 10. Periodontal disease experience, Group 3; frequency (%) distributions of individuals in the different age groups in 1973, 1983, 1993, and 2003

Age group	Group 3			
	1973 (%)	1983 (%)	1993 (%)	2003 (%)
20	4	1		1
30	15	21	3***a	10
40	42	57*c	28***a	25***d
50	59	68	40***a	31***d
60	81	53***c	44	47***d
70	83	49***c	55	63***d

*$p<0.05$; ***$p<0.001$, comparisons between 1973 and 1983 (c), 1983 and 1993 (a), 1973 and 2003 (d).

Table 11. Periodontal disease experience, Groups 4 and 5; percentage of individuals in the different age groups in 1973, 1983, 1993, and 2003

Age group	Group 4				Group 5			
	1973 (%)	1983 (%)	1993 (%)	2003 (%)	1973 (%)	1983 (%)	1993 (%)	2003 (%)
20		1						
30		2		2				
40		3	3	6	2	1	2	3
50	2	9	14	7	1	3	7	6
60	3	25**c	18	14	5	6	6	8
70	6	38**c	26	12*b		4	7	6

*$p<0.05$, **$p<0.01$, comparisons between 1973 and 1983 (c), 1993 and 2003 (b).

(80–100%) should have the diagnosis that characterized the group.

Successful prevention and treatment of plaque-induced periodontitis restores periodontal health, but with reduced periodontium. In such cases, damage from previous periodontal disease (gingival and alveolar bone recessions) may persist.

Over 10 dentists conducted the clinical and radiographic examinations during the 30-year period. To minimize variations in diagnoses, two senior examiners calibrated the other examiners on several occasions. In the 2003 study, two of the authors re-examined radiographs from a group of selected individuals that represented examinations by 10 examiners. Double measurements of bone level were made. The classification of periodontal disease experience for Groups 1 and 2 is based on clinical *and* radiographic findings and solely on radiographic findings for Groups 3, 4, and 5. The reliability of the method was tested in previous studies (Hugoson & Jordan 1982, Hugoson et al. 1989) and in this study, and the inter-examiner variation was small (Cohen's $\kappa = 0.70$).

For ethical reasons, the extent of the radiographic examination of the younger age groups (initially a full-mouth intra-oral examination) was limited over the years to bite-wings and orthopantomograms. But several studies found good agreement between marginal bone-level assessments on intra-oral and panoramic radiographs (Akesson et al. 1989, Persson et al. 2003).

Over the 30-year period, the average numbers of teeth in all age groups increased and the numbers of edentulous individuals in the older age groups drastically decreased in the studied population. In all age groups, oral hygiene improved significantly and the proportions of gingivally healthy individuals increased. During the same period, the number of individuals with gingivitis and moderate periodontitis decreased. It is interesting to note that the numbers of healthy Group 3 individuals according to our criteria for periodontal health increased from 18% in 1983 to 31% in 2003.

A major feature of destructive periodontal disease is attachment loss with recession of the gingival margin, with the effect that advanced attachment loss is not associated with correspondingly deep pockets (Okamoto et al. 1988). In this study, the average numbers of periodontal pockets remained nearly unchanged over time. The increasing number of tooth surfaces with gingival recessions found (indicating a recession of the gingival margin with age) would explain this.

Low numbers of deeper periodontal pockets ($\geqslant 6$ mm) were seen in all age groups at all examinations with a slight non-significant increase with age. This agrees with few individuals being classified with severe periodontitis.

The number of periodontally healthy individuals increased and the number of individuals with gingivitis and with moderate periodontitis decreased between 1973 and 2003. The studies therefore show that it is possible on a population level to improve periodontal conditions, especially gingivitis and moderate periodontitis, in all age groups. The proportion of individuals with severe periodontitis (Groups 4 and 5) remained almost unchanged at the 1983–2003 examinations. But at the 1993–2003 examinations, the proportion of individuals in Group 4 decreased non-significantly from 10% in 1993 to 7% in 2003. At the same time, the mean number of teeth in Group 4 successively increased from 15 in 1983 to 21 in 2003, and 12% were periodontally treated or healthy in 2003. The proportion of individuals in Group 5 did not change

during the 30-year period. The average numbers of teeth in Group 5 did not increase between 1983 and 2003. But the numbers of healthy individuals tended to increase, from 0% in 1983 to 5% in 2003. With less strict criteria for periodontal health than were used in this study, more cases would have been considered to be periodontally healthy.

A recent Norwegian study presented epidemiological data on 35-year-olds in Oslo from surveys between 1973 and 2003 (Skudutyte-Rysstad et al. 2007). Oral hygiene was assessed according to the Simplified Oral Hygiene Index. A significant reduction in calculus *and* plaque scores, which indicates a substantial improvement in oral hygiene, agrees with the results of our studies. The Oslo study assessed proportions of individuals with marginal bone loss using orthopantomograms; it found that the proportions of individuals with no recorded bone loss increased significantly from 46% to 76% over 30 years. The mean values for the 30–40-year age groups in Jönköping were 78% in 2003. Proportions of Oslo participants with $\leqslant$10% bone loss also decreased substantially over 30 years. This group corresponds to periodontal disease severity Group 3 in the Jönköping survey. The numbers of individuals with moderate alveolar bone loss in 2003 were 17% in Oslo and 18% in Jönköping. Proportions of individuals with severe periodontal disease (Groups 4 and 5 in Jönköping and more than 20% bone loss in Oslo) were also similar between the studies: 6% in Jönköping (mean for 30–40-year age groups) and 7% in Oslo (35-year age group). This is an interesting comparison between countries, and supports a wider applicability of the Jönköping data.

In conclusion, periodontal conditions (especially gingivitis and moderate periodontitis) improved considerably over 30 years. The trend among periodontal disease experience Group 4 individuals was towards improved periodontal health while the health of Group 5 individuals appeared to be static during the 30 years; the future challenge is to improve or to continue to improve the trends in these groups.

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Clinical Relevance

Scientific rationale for the study: The prevalence and severity of oral health and disease were studied in a series of epidemiological studies to provide information for planning and evaluating public oral health preventive and treatment measures.

Principal findings: Although a dramatic improvement in oral health was observed over 30 years, the small proportion with the most advanced cases of periodontal disease experience remained unchanged.

Practical implications: The studies have shown that it is possible, on a population level, to improve periodontal conditions, especially gingivitis and moderate periodontitis.