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Epidemiology of periodontal diseases in the study of health in Pomerania

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Abstract

Aim: The aim of this study was to assess the prevalence and extent of periodontal diseases among adults in a province in Eastern Germany.

Material and Methods: The Study of Health in Pomerania is a population-based study conducted during 1997–2001. The net random sample comprised 4310 20–81-year-old subjects. Periodontal status was assessed at four surfaces using a half-mouth recording protocol.

Results: The prevalence of attachment loss $\geqslant$3 mm was 89.7%, with 62.8% of teeth being affected. Probing depths $\geqslant$4 mm were prevalent in 69.7% of subjects, and 29.6% of teeth were affected. 25.3% of all subjects had severe pockets ($\geqslant$6 mm). Periodontitis was significantly more prevalent in males. For attachment loss, the prevalence and extent increased significantly with increasing age, whereas probing depth values levelled off after the age of 40. In older subjects, increased recession and attachment loss were found, while the probing depth remained constant. According to the recent CDC classification, 17.6% and 33.3% of persons had severe and moderate periodontitis, respectively. The prevalence of periodontitis increased significantly with age and remained constant after the age of 50–59.

Conclusions: Periodontitis is more prevalent in Pomerania than in the United States or Western Europe. In older subjects, attachment loss steadily increased, while the probing depth remained constant.

Key words: periodontal disease, prevalence, epidemiology, population-based, attachment loss, probing depth, gingival recession

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Conflict of interest and sources of funding statement

There are no conflicts of interest associated with this work.

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Periodontal diseases and caries constitute the major causes of tooth extraction in adults aged 40 years or older (Albandar et al. 1999, Albandar 2005). High prevalences of periodontal diseases among adults with considerable disparities between populations have been reported (Oliver et al. 1998, Albandar et al. 1999, Bourgeois et al. 1999, Micheelis & Reich 1999, Brennan et al. 2001, Morris et al. 2001, Sheiham & Netuveli 2002, Do et al. 2003, Gera 2004, Burt 2005, Bourgeois et al. 2007).

In several studies, a decrease in periodontal diseases was reported (Dye et al. 2007, Hugoson & Norderyd 2008, Hugoson et al. 2008). In contrast, the prevalence of periodontal diseases in Germany was estimated to increase (Micheelis et al. 2008), possibly due to an increased number of retained teeth being at risk. In parallel with the caries decline (Micheelis & Reich 1999, Micheelis & Schiffner 2006), tooth loss could be increasingly attributed to periodontitis within the next few years.

Through inflammatory processes, periodontal disease has a considerable impact on other systemic diseases (Papapanou 1999, Desvarieux et al. 2004, Holmlund et al. 2006, Lalla et al. 2006, Demmer et al. 2008a).

Because of the increasing epidemiological importance of especially subclinical levels of periodontitis (e.g. probing depth $\geqslant 3$ mm) for their effect on medical diseases (Demmer et al. 2008b), the understanding of periodontitis has changed substantially. In parallel, there is an increasing demand for comprehensive descriptions of the prevalence of periodontitis. Periodontitis starts with subtle signs of inflammation and may result in extensive loss of the supporting tissue. Subsequent bone loss may negatively impact the aesthetics and proper functioning of the tooth. Thresholds are necessary to obtain prevalence data from epidemiological surveys and plan dental care from a public health perspective.

At present, decisions for periodontal treatment are based on probing depth thresholds and not on attachment level thresholds. The finding that most attachment loss beyond the age of 40 is attributed to gingival recession and not to probing depth (Morris et al. 2001, Schurch & Lang 2004, Hujoel et al. 2005) was not sufficiently considered by the periodontal community so far. If the development of an increased probing depth is only a minor hallmark in the natural history of periodontitis and if recession contributes considerably to clinical signs of periodontitis, therapeutic regimens should be developed to prevent recession. To bring some uniformity to case definitions of periodontitis, the CDC Working Group has recently published new case definitions for moderate and severe periodontitis in population-based surveys (Page & Eke 2007). They defined periodontitis in terms of attachment loss and probing depth to enhance case definitions and to prevent underestimation of periodontitis, especially in older subjects.

To date, very few data have provided a comprehensive assessment of the periodontal status in German adults. Furthermore, a detailed description of the age-dependent association between periodontal parameters is missing. Existing studies are limited in generalizability due to pre-selected age cohorts (Micheelis & Reich 1999, Micheelis & Schiffner 2006) or due to use of the Community Periodontal Index for Treatment Needs (CPITN) (Mengel et al. 1993), which does not provide a proper description of the periodontal status (Gjermo et al. 2002). Mengel et al. (1993) reported a poor dental health status for the former Eastern Germany (GDR) in 1991/1992 with at least moderate pocket depths ($\geqslant 4$ mm) in more than 85% of subjects, indicating high treatment needs. Recent prevalence data provided by the German National Surveys on oral health (Micheelis & Reich 1999, Micheelis & Schiffner 2006) confirmed the poor periodontal status in adults and seniors. Comprehensive data on the age-dependent relationship between attachment loss and gingival recession are unavailable.

Therefore, the aim of this study was to evaluate the distribution of periodontal diseases using a population-based sample of adults from West Pomerania, the north-eastern part of Germany. The objectives of this study were (1) to provide a comprehensive description of the prevalence and extent of periodontal diseases with regard to varying diagnostic thresholds, stratified by age and gender, (2) to discriminate the role of recession and probing depth on attachment loss, and (3) to describe the prevalence of moderate and severe periodontitis according to the CDC definition (Page & Eke 2007).

Materials and Methods

Study design and sample

The Study of Health in Pomerania (SHIP) is a cross-sectional health survey in Pomerania approved by the local institutional review board. SHIP is based on a representative sample, with examinations held in 1997–2001. A two-stage cluster sampling was carried out (John et al. 2001). This two-stage cluster design was adopted from the World Health Organization Monitoring Trends and Determinants in Cardiovascular Disease (MONICA) project in Augsburg, Germany (Keil et al. 1988). In the first sampling stage, three cities (17,076–65,977 inhabitants) and 12 larger towns (>1500 inhabitants) within the three districts of the region were selected, and then 17 of 97 smaller villages (<1500 inhabitants) were drawn randomly. In the second sampling stage, from each of these selected communities, Caucasian subjects with German citizenship and main residency in the area were randomly drawn, proportional to each community population size, and stratified by age and gender. From the entire study population of 212,157 inhabitants, 7008 adults aged 20–79 years were sampled, with 292 subjects in each 5-year age stratum. Because of several reasons (126 had died, 615 had moved away, and five had severe medical problems), 746 subjects were excluded, resulting in the recruitment of 6262 inhabitants. The net random sample included 4310 individuals, corresponding to a response rate of 68.8% (John et al. 2001).

Examinations comprised a health-related interview, an oral health examination, a medical examination, and a health- and risk factor-related questionnaire. For the 4290 out of 4310 subjects receiving an oral examination, 515 subjects were edentulous in the examined side. Eleven subjects refused periodontal examination. Periodontal measurements were not recordable in 21 subjects (cardiovascular diseases, endocarditis, and other medical reasons). Attachment level could not be determined in 186 subjects mainly due to crowns, resulting in 3557 subjects with available attachment values. Probing depth was not measurable in six subjects, resulting in 3737 subjects for analysis. Because of the long sampling period, subjects were actually 20–81 years old at the day of examination. The distribution of sampled adults by age group and gender is shown in Table 1.

Table 1. Demographics of the study sample ($N = 3737$), the corresponding total population of Pomerania, and gender-specific response rates

Age (years)	Sample		Females		Males		Total population		Response rate (%)	
	No.	%	No.	%	No.	%	No.	%	females	males
20–29	590	15.8	316	16.5	274	15.1	24,966	16.3	76.0	65.5
30–39	753	20.1	400	20.9	353	19.4	32,530	21.3	75.6	69.3
40–49	733	19.6	389	20.3	344	18.9	32,925	21.6	72.9	66.2
50–59	737	19.7	390	20.3	347	19.1	22,426	14.7	76.6	70.0
60–69	601	16.1	278	14.5	323	17.8	26,457	17.3	65.2	74.3
70–81	323	8.6	145	7.6	178	9.8	13,448	8.8	49.5	63.2
Total	3737	100	1918	51.3	1819	48.7	152,752	100	69.4	68.2

Dental examination

Here, we describe the variables assessing the periodontal disease status including attachment loss and probing depth. Measurements were assessed at distobuccal, midbuccal, mesiobuccal, and midlingual sites according to the half-mouth method, alternating on the left or the right site. Attachment loss and probing depth values were determined using a periodontal probe (PCP-11, Hu-Friedy, Chicago, IL, USA). If recession was present at the examined site, attachment loss was directly measured as the distance between the cemento-enamel junction (CEJ) and the pocket base. In case of sub-gingival located CEJ, attachment loss was calculated as probing depth minus the distance between free gingival margin (FGM) and CEJ. Probing depth was measured as the distance between FGM and pocket base. Where the determination of the CEJ was indistinct (wedge-shaped defects, fillings, and crown margins), attachment level was not recorded. Measurements were mathematically rounded to the whole millimetre.

Dental examinations were conducted by calibrated and licensed dentists. Every 6–12-months calibration exercises were performed on persons not connected to the study, yielding an intra-class correlation of 0.82–0.91 per examiner and an inter-class correlation of 0.84 relative to attachment loss (Hensel et al. 2003).

Classification of periodontitis by extent and degree

To allow comparison with the NHANES III survey, tables were set up according to Albandar et al. (1999). The prevalence of a given condition, e.g. attachment loss $\geqslant 3$ mm, was defined as the percentage of subjects having at least one site with that condition. Extent was defined as the percentage of teeth displaying that condition. For attachment loss and probing depth, extent estimates were based on a maximum of 14 teeth (half-mouth) examined. According to Albandar et al. (1999), for data on the prevalence and extent of periodontal disease, no restriction according to the number of teeth was imposed. Edentulous subjects were excluded from analyses due to missing periodontal measurements.

Percentile plots were used to present the percentage of sites with varying amounts of attachment loss or probing depth (e.g. $\geqslant 3$ and $\geqslant 5$ mm) observed in age categories. The percentage of affected sites for each age group is reported along the *x*-axis in such a way that the subjects most severely affected are located to the right.

To provide future international comparability, individuals were further classified according to the current definition for periodontitis published by the CDC Working Group (Page & Eke 2007). The CDC case definition refers to interproximal sites, so that for this study distobuccal and mesiobuccal sites are used. To provide comparability to other studies with less sites, we also determined the prevalence of moderate and severe periodontitis based on mesiobuccal sites only. Severe periodontitis was defined as at least two sites with attachment loss $\geqslant 6$ mm (not on same tooth) and at least one site with probing depth $\geqslant 5$ mm. Moderate periodontitis was defined as at least two sites with attachment loss $\geqslant 4$ mm (not on same tooth) or at least two sites with probing depth $\geqslant 5$ mm. If neither moderate nor severe periodontitis applied, the subject had only mild or no periodontitis.

Statistical analysis

Data analysis was performed using R 2.5.0 (free statistical shareware) and STATA 10.0 (Stata Corp LP, College Station, TX, USA). Crude prevalence odds ratios (PORs) were calculated as the quotients of prevalence odds among exposed and unexposed, e.g. males and females. Confidence limits were calculated using unconditional maximum likelihood methods with Wald's limits. In case of sparse cells, a small sample adjustment was performed. To detect differences in the extent of periodontal disease markers between groups, analyses of variance were applied. *p* values were adjusted for multiple testing by controlling the false discovery rate (Benjamini et al. 2001).

Because of the complex sample design, standard errors were calculated using survey methods provided by the software package STATA 10.0 (Stata Corp LP). The final sampling weights and variables for the sample design were used to produce unbiased total estimates (Winship & Radbill 1994, Pfeffermann 1996, Little et al. 1997). The final sample weights adjusted for different probabilities of subject selection with reference to the base population in Pomerania, and rates of non-response. Afterwards, post-stratification weights were calculated to retain a representative distribution of age and gender with respect to geographical origin (Korn & Graubard 1999, Yansaneh 2003). Finally, to reduce variance, sample weights were trimmed (Potter 1990). Furthermore, design variables were considered (Korn & Graubard 1991). Design variables identify strata and clusters, and account for finite population corrections at both sampling stages. The design effect equals the quotient of variances without and with accounting for sampling weights and design. For prevalence and extent values, the design effect was estimated to range between 0.76 and 1.43 (0.96 and 1.28) for attachment loss (probing depth).

Estimates for females or males were standardized by age, while comparisons by age group used estimates standardized by gender.

Results

Attachment loss

The overall prevalence of at least one site with $\geqslant 3$ mm attachment loss was 89.7% (Table 2), corresponding to 136,560 adults of the Pomeranian population. The extent of teeth affected by attachment loss $\geqslant 3$ mm was 62.8%. Severe attachment loss (i.e. $\geqslant 5$ mm) was still present in 54.0% of the subjects. The prevalence and extent of attachment loss increased statistically significantly with increasing age (except for the last age group) independent of the threshold ($p < 0.05$). In the age group of 20–29 years, the prevalence of $\geqslant 3$ mm attachment loss was 64.0%, with 22.2% of teeth being affected. In contrast, for 70–81-year-old subjects, both the prevalence and the extent were extremely high (100% and 95.7%, respectively).

In males, attachment loss $\geqslant 4$ mm was more prevalent than that in females, regardless of age ($p < 0.05$, except for the youngest and the oldest age groups). The corresponding POR for a threshold of attachment loss $\geqslant 4$ mm was 1.26 (95% CI, 1.09–1.45). However, for the prevalence of attachment loss $\geqslant 3$ mm, gender differences were not detectable ($p > 0.05$).

The total mean attachment loss was 2.44 mm (compare with Fig. 2), with men being significantly more affected than women (2.58 vs. 2.29 mm, $p < 0.001$). The mean attachment loss

Table 2. Prevalence (%) and mean extent on tooth level by degree of attachment loss according to age and gender

Attachment loss	Age (years)	All subjects ($N = 3557$)		Females ($N = 1825$)		Males ($N = 1732$)		POR (95% CI)
		% (SE)	mean (SE)	% (SE)	mean (SE)	% (SE)	mean (SE)	
⩾3 mm	20–29	64.0 (2.00)	22.2 (1.10)	61.9 (2.74)	20.0 (1.37)	65.8 (2.88)	24.2 (1.68)	1.18 (0.84–1.66)
	30–39	89.7 (1.11)	49.6 (1.24)	87.8 (1.65)	45.5 (1.67)	91.5 (1.49)	53.4 (1.79)	1.45 (0.90–2.35)
	40–49	96.6 (0.68)	72.2 (1.13)	96.9 (0.90)	68.4 (1.62)	96.4 (1.02)	75.9 (1.54)	0.88 (0.39–1.98)
	50–59	98.5 (0.46)	82.2 (0.96)	97.8 (0.76)	78.8 (1.38)	99.1 (0.53)	85.7 (1.30)	1.79 (0.62–7.66)*
	60–69	100.0 (0)	91.1 (0.77)	100 (0)	88.0 (1.28)	100 (0)	94.6 (0.75)	–
	70–81	100.0 (0)	95.7 (0.89)	100 (0)	95.1 (1.31)	100 (0)	96.9 (0.85)	–
	Total	89.7 (0.55)	62.8 (0.53)	89.3 (0.74)	60.4 (0.87)	90.1 (0.80)	64.7 (0.93)	1.09 (0.88–1.34)
⩾4 mm	20–29	26.8 (1.85)	5.3 (0.51)	25.1 (2.45)	4.6 (0.66)	28.3 (2.74)	5.8 (0.77)	1.18 (0.82–1.70)
	30–39	61.5 (1.79)	21.6 (1.01)	56.3 (2.50)	19.0 (1.35)	66.4 (2.53)	24.1 (1.49)	1.52 (1.13–2.05)
	40–49	83.9 (1.37)	46.8 (1.35)	79.8 (2.06)	41.4 (1.80)	87.8 (1.79)	52.1 (1.97)	1.82 (1.21–2.75)
	50–59	90.7 (1.09)	59.4 (1.31)	86.7 (1.77)	53.3 (1.84)	94.8 (1.23)	65.6 (1.82)	2.80 (1.58–4.97)
	60–69	96.1 (0.86)	74.5 (1.35)	94.4 (1.45)	69.2 (2.07)	98.0 (0.82)	80.2 (1.62)	2.43 (1.06–6.98)*
	70–81	95.8 (1.34)	83.4 (1.80)	95.7 (1.89)	82.6 (2.55)	96.1 (1.58)	84.9 (2.16)	0.95 (0.36–3.64)*
	Total	71.4 (0.68)	40.5 (0.55)	68.7 (1.10)	37.8 (0.89)	73.3 (1.15)	42.7 (0.96)	1.26 (1.09–1.45)
⩾5 mm	20–29	11.2 (1.33)	1.6 (0.22)	8.6 (1.58)	1.3 (0.29)	13.6 (2.08)	1.9 (0.33)	1.68 (0.99–2.84)
	30–39	34.6 (1.76)	9.9 (0.74)	34.6 (2.30)	8.3 (0.94)	39.3 (2.61)	11.4 (1.13)	1.55 (1.14–2.10)
	40–49	64.2 (1.79)	30.0 (1.30)	57.5 (2.54)	25.5 (1.66)	70.7 (2.49)	34.2 (1.96)	1.78 (1.30–2.43)
	50–59	78.2 (1.56)	42.0 (1.36)	71.5 (2.36)	35.7 (1.84)	85.0 (1.98)	48.4 (1.95)	2.27 (1.55–3.31)
	60–69	86.6 (1.51)	55.9 (1.61)	80.9 (2.49)	48.9 (2.39)	92.9 (1.50)	63.5 (2.02)	3.10 (1.80–5.34)
	70–81	88.4 (2.17)	67.6 (2.47)	87.1 (3.13)	65.4 (3.51)	90.8 (2.35)	71.4 (2.85)	1.50 (0.69–3.26)
	Total	54.0 (0.77)	27.0 (0.60)	49.5 (1.18)	24.4 (0.80)	57.3 (1.26)	29.3 (0.86)	1.37 (1.21–1.56)
⩾6 mm	20–29	4.6 (0.89)	0.5 (0.11)	3.2 (0.99)	0.4 (0.13)	5.9 (1.43)	0.6 (0.16)	1.91 (0.85–4.27)
	30–39	18.2 (1.43)	4.9 (0.52)	18.2 (1.76)	4.0 (0.67)	21.9 (2.21)	5.8 (0.79)	1.69 (1.16–2.47)
	40–49	46.2 (1.87)	19.1 (1.11)	38.1 (2.49)	15.2 (1.35)	54.0 (2.73)	22.8 (1.72)	1.93 (1.43–2.60)
	50–59	62.1 (1.84)	28.3 (1.25)	53.0 (2.61)	22.0 (1.55)	71.3 (2.51)	34.6 (1.90)	2.20 (1.61–3.02)
	60–69	70.8 (1.99)	39.7 (1.60)	61.8 (3.07)	32.6 (2.25)	80.7 (2.30)	47.5 (2.19)	2.66 (1.81–3.92)
	70–81	73.3 (2.99)	50.4 (2.73)	69.8 (4.28)	47.8 (3.87)	79.6 (3.28)	55.1 (3.18)	1.74 (0.99–3.06)
	Total	39.1 (0.81)	18.0 (0.54)	33.8 (1.11)	15.4 (0.66)	43.4 (1.23)	20.2 (0.74)	1.52 (1.33–1.73)

Crude prevalence odds ratios with 95% confidence interval [POR (95% CI)] for male *versus* female subjects are reported.
*Small sample adjustment.

increased significantly with age in the total population and for either gender considered separately ($p < 0.05$). In the youngest age cohort, the mean attachment loss was 0.85 mm and increased to 4.60 mm in the oldest age cohort.

At a site-specific level, the age-dependent increase of the prevalence of periodontal disease severity is depicted by the percentile curves for two attachment levels (i.e. ⩾3 and ⩾5 mm, Fig. 1a and b). The likelihood of multi-site involvement decreased as the attachment threshold increased. The vertical distance between successive percentile curves was most pronounced among the 20–29-, 30–39-, and 40–49-year-old age groups (Fig. 1a and b), indicating a relatively sharp increase in the prevalence of attachment loss. The percentage of subjects presenting ⩾3 mm attachment loss in ⩾30% of the examined sites was, in the ascending order of age groups, 9.9%, 35.8%, 65.9%, 80.1%, 92.7%, and 96.9% (Fig. 1a). In comparison, between 0% and 39.7% of the subjects presented that attachment level at all examined sites.

The association between attachment loss and tooth loss is shown in Fig. 3a. Within each 10-year age cohort, the mean attachment loss increased with increasing tooth loss, especially in subjects older than 40 years. Less teeth did not translate into less attachment loss.

Probing depth

The prevalence of at least one site with probing depth ⩾4 mm was 69.7% (Table 3), representing 105,857 adults in Pomerania. The mean extent of probing depth ⩾4 mm was 29.6%. Severe probing depths (i.e. ⩾6 mm) were prevalent in 25.3% of subjects. Both the prevalence and the extent of probing depth ⩾4 mm increased from the youngest age group until the 40–49-year-old age group ($p < 0.001$) and then remained nearly consistent ($p > 0.05$), also with regard to gender. For the youngest age group, the mean extent of ⩾4 mm probing depth was 10.2% and, in contrast, about 40% in 40–81-year-old subjects. There was a tendency towards lower prevalence values for subjects aged 70 and older compared with subjects aged 40–69 years.

A comparison by gender showed no differences in the prevalence of probing depth ⩾3 mm (Table 4). However, higher probing depth values, i.e. ⩾4 mm, were more prevalent in males than in females, regardless of the age cohort ($p < 0.05$, except for the youngest age group). PORs indicated an up to 2.4-fold higher risk for males.

The mean probing depth was 2.50 mm in the total population (see Fig. 2). Males (2.59 mm) were more affected than females (2.41 mm, $p < 0.001$) in total as well as in separate age cohorts ($p < 0.001$), except in the youngest and the oldest categories.

At a site-specific level, the percentage of affected sites was evaluated for varying probing depth thresholds and different age groups (Fig. 1c and d). Percentile curves show the age-dependent increase of the prevalence of periodontal pocket depth for two levels (i.e. ⩾4, ⩾6 mm). The age-dependent increase of the percentage of subjects

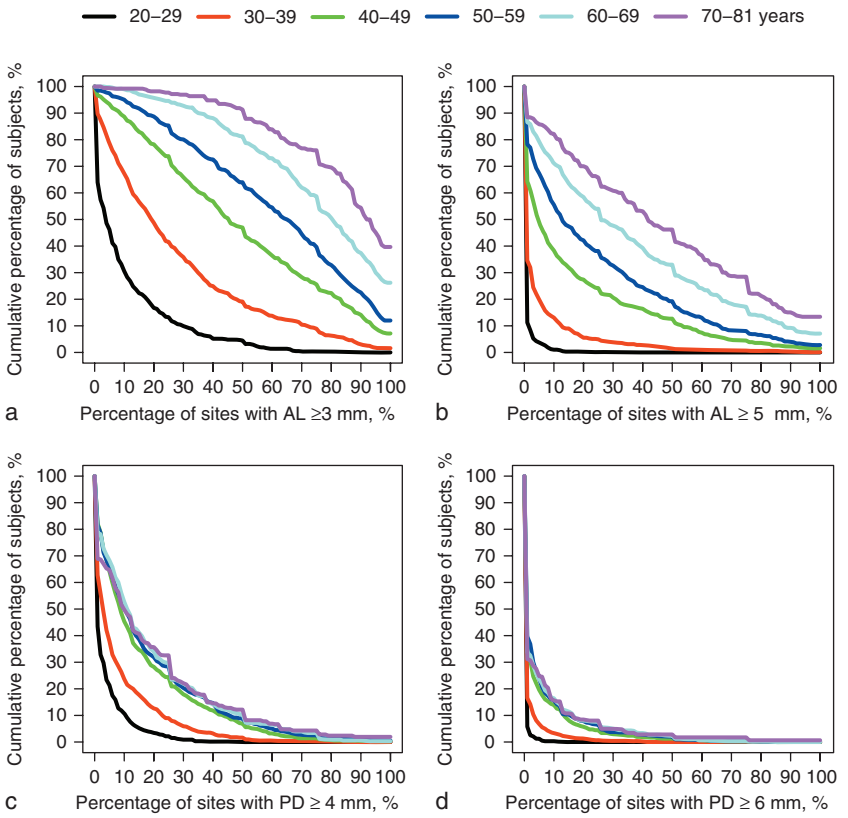

Fig. 1. Extent of attachment loss (AL) and probing depth (PD) according to age cohort. Lines represent the cumulative percentage of subjects (*y*-axis) with, e.g. AL ⩾ 3 mm in at least 30% of the examined sites (*x*-axis).

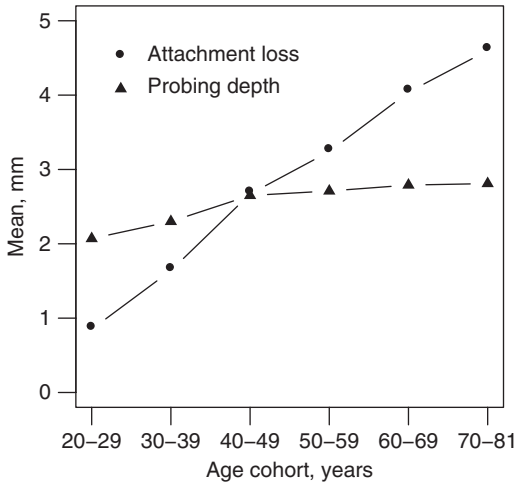

Fig. 2. Differentiation of the role of gingival recession and probing depth in attachment loss according to age cohorts.

with affected sites (Fig. 1c and d) was not as pronounced as that for the attachment loss (Fig. 1a and b). It was the highest between the three youngest age groups, and negligible between age groups including 40–81-year-old subjects (Fig. 1c and d). The percentage of subjects presenting ⩾4 mm probing depth in ⩾30% of the examined sites was, in the ascending order of age groups, 0.9%, 5.9%, 17.9%, 20.3%, 22.5%, and 22.1% (Fig. 1c).

Figure 3b shows the association between probing depth and tooth loss. Although the increase of the mean probing depth with increasing tooth loss was not as pronounced as with attachment loss, it was still present in subjects older than 40 years. Less teeth did not result in lower pocket depths.

Recession

Mean gingival recession was virtually absent in subjects aged 20–39 years, but increased consistently in the upper age cohorts from 0.07 mm (40–49 years) to 1.9 mm (70–81 years). This was reflected in the age-dependent association between attachment loss and probing depth (see Fig. 2). Mean attachment loss increased significantly throughout the whole age range, whereas the mean probing depth increased until the 40–49-year age cohort and then remained constant.

Classification of subjects by the extent and severity of periodontitis (CDC classification)

In this study, 17.6% of persons had severe periodontitis and 33.3% had moderate periodontitis (see Table 4). In the total population, but also in females and males, the prevalence of periodontitis increased significantly among age strata up to the 50–59-year-old age group ($p < 0.05$). Seventy-four per cent of persons aged 50–59 years, but only 12.4% of the youngest persons had moderate or severe periodontitis. The percentage of persons with periodontitis decreased slightly with increasing age between 60 and 81 years from 79.6 to 73.6%. Males between 30 and 69 years had a significantly higher prevalence of periodontitis than females ($p < 0.05$).

Discussion

In SHIP, the prevalence and extent of periodontitis was high in all age strata, with around 90% of subjects being at least moderately affected. The prevalences differed considerably according to age and gender.

In Germany, there is only one study on the prevalence of periodontitis that allows comparison with our study. The German National Survey on oral health (DMS III) presented comparable prevalence values for Eastern Germany, confirming the poor periodontal status found in our study (Micheelis & Reich 1999). In the adult (35–44 years), moderate or severe probing depths according

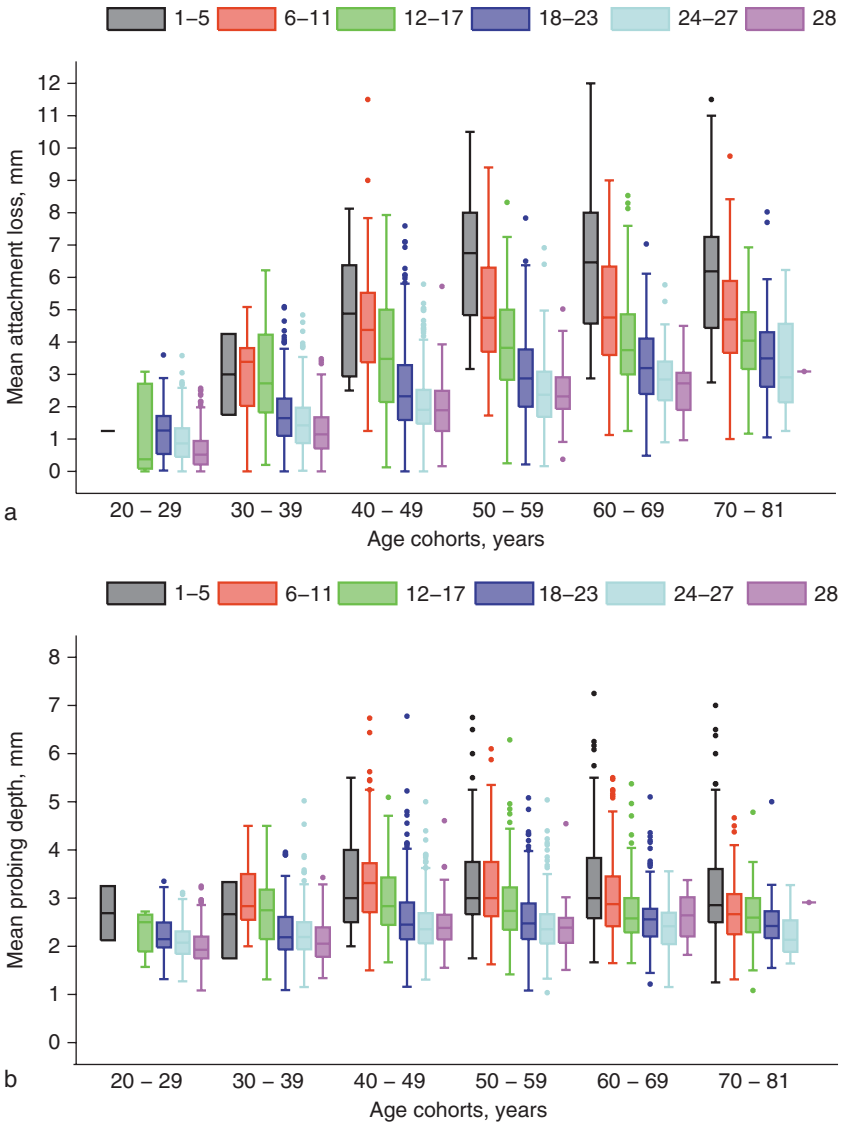

Fig. 3. Association between tooth loss (colouring) and mean attachment loss (a) or mean probing depth (b) according to age cohorts (*x*-axis).

to CPITN occurred in 76.5% (SHIP; 30–39 years: 62.7%, 40–49 years: 82.2%). In seniors (65–74 years), 77.8% had probing depths ⩾4 mm (SHIP; 60–69 years: 78.7%, 70–81 years: 68.9%). Attachment levels ⩾5 mm were documented in 48.8% of adults (SHIP; 30–39 years: 34.6%, 40–49 years: 64.2%) and 74.2% of seniors (SHIP; 60–69 years: 86.6%, 70–81 years: 88.4%).

In Europe, few studies provide comprehensive and comparable information on the epidemiology of periodontitis. Furthermore, comparison with published studies is difficult due to differences in the definitions for periodontitis, and methodological and recording disparities (Papapanou 1999, Albandar & Rams 2002). A recent French study is not comparable because of restriction of analysis to persons with at least six teeth, leading to an underestimation of periodontitis (Bourgeois et al. 2007). In Britain, 43% of persons aged 20 to 65+ years exhibited attachment loss ⩾4 mm, and 8% had attachment loss ⩾6 mm (Morris et al. 2001). Probing depths ⩾4 mm were present in 54%, and severe probing depths (⩾6 mm) in 5% of subjects, which was considerably lower than the prevalences we observed. In general, in Europe, the prevalences of at least moderate attachment loss and probing depth in adults varied between 20% and 58% with a moderate extent at the site level (Kalsbeek et al. 2000, Morris et al. 2001, Sheiham & Netuveli 2002, Schurch & Lang 2004, Hugoson & Norderyd 2008, Hugoson et al. 2008). Severe periodontitis was prevalent in 3–8% of adults, with few teeth being affected. For East Europe, Sheiham & Netuveli (2002) estimated higher prevalences in 35–44-year-olds for probing depths of 4–5 mm (45%) compared with West Europe (36%). Further, for East European countries, the extent of severe periodontitis was found to vary between 30% and 47% (Sheiham & Netuveli 2002). However, these values were derived from poorly documented studies based on CPITN, and may thus underestimate the true prevalence. In conclusion, in this study, we found higher prevalences of periodontal disease compared with West and North European countries, and similar rates as for East European countries.

For North Americans and Australians, considerably lower prevalences were found (Albandar et al. 1999, Brennan et al. 2001, Albandar 2005, Dye et al. 2007). Recent NHANES studies reported a decrease in periodontitis, with 10.4% of subjects (age 20–64 years) exhibiting pockets ⩾4 mm with an age-dependent increase from 6.7% (20–34 years) to 13.2% (50–64 years) (Dye et al. 2007). Severe probing depths ⩾6 mm were found in only 1.0% of the total subjects. Attachment loss ⩾3 mm was prevalent in 32.7% of subjects, with 9.2% having attachment loss ⩾5 mm.

Recently, the CDC Working Group has published a new case definition for periodontitis in population-based surveys (Page & Eke 2007). Periodontitis was defined in terms of attachment loss and probing depth to enhance case definitions and to prevent underestimation of periodontitis, especially in older subjects. In SHIP, the overall prevalence of periodontitis was high, with 33.3% and 17.6% of subjects being moderately and severely affected. The prevalence of moderate or severe periodontitis varied with age, ranging between 12.4% and 79.6%.

For NHANES III and IV, Dye et al. (2007) provided estimates according to the CDC definition. Overall, the prevalence of moderate or severe periodontitis decreased from 9.6% to 5.0%. In the NHANES IV, the prevalence was 0% in subjects aged 20–34 years, 5% in subjects aged 35–49 years, and 10.7% in the oldest age group (50–64 years). Do et al. (2008) reported slightly higher prevalence rates for Australian adults aged 15 to 65+ years. In comparison with SHIP, even if analysis was

Table 3. Prevalence (%) and mean extent on tooth level by degree of probing depth according to age and gender

Probing depth	Age (years)	All subjects ($N = 3742$)		Females ($N = 1921$)		Males ($N = 1821$)		POR (95% CI)
		% (SE)	Mean (SE)	% (SE)	Mean (SE)	% (SE)	Mean (SE)	
⩾3 mm	20–29	98.8 (0.45)	66.3 (1.19)	98.7 (0.63)	64.9 (1.61)	98.9 (0.63)	67.4 (1.73)	0.87 (0.27–4.56)*
	30–39	99.1 (0.33)	74.6 (0.99)	98.5 (0.61)	70.2 (1.37)	99.7 (0.28)	78.4 (1.41)	2.67 (0.65–22.92)*
	40–49	99.5 (0.25)	84.8 (0.79)	99.0 (0.51)	81.6 (1.19)	100 (0)	87.8 (1.02)	–
	50–59	99.2 (0.33)	85.2 (0.79)	99.0 (0.51)	82.6 (1.13)	99.4 (0.41)	87.8 (1.08)	1.19 (0.34–7.60)*
	60–69	98.9 (0.45)	87.9 (0.88)	98.2 (0.80)	85.0 (1.42)	99.7 (0.31)	91.2 (0.95)	2.93 (0.70–26.39)*
	70–81	96.6 (1.04)	86.8 (1.45)	97.2 (1.36)	87.4 (1.98)	95.5 (1.55)	85.6 (1.86)	0.54 (0.20–2.06)*
	Total	99.0 (0.17)	79.8 (0.47)	98.6 (0.27)	77.3 (0.61)	99.4 (0.17)	82.0 (0.61)	2.49 (1.24–5.04)*
⩾4 mm	20–29	43.4 (2.06)	10.2 (0.72)	43.0 (2.79)	9.9 (1.00)	43.8 (3.00)	10.5 (1.03)	1.03 (0.74–1.43)
	30–39	62.7 (1.77)	20.5 (0.95)	58.4 (2.46)	17.6 (1.23)	66.9 (2.51)	23.2 (1.43)	1.44 (1.07–1.94)
	40–49	82.2 (1.41)	36.8 (1.19)	79.0 (2.07)	32.3 (1.52)	85.2 (1.91)	41.1 (1.78)	1.53 (1.05–2.25)
	50–59	81.6 (1.42)	39.5 (1.25)	76.4 (2.15)	32.8 (1.65)	86.7 (1.82)	46.2 (1.81)	2.02 (1.37–3.00)
	60–69	78.7 (1.71)	41.7 (1.45)	72.0 (2.69)	34.6 (2.05)	86.1 (1.93)	49.6 (1.95)	2.40 (1.59–3.61)
	70–81	68.9 (2.83)	41.4 (2.32)	64.8 (3.98)	40.2 (3.26)	76.5 (3.18)	43.8 (2.65)	1.77 (1.09–2.88)
	Total	69.7 (0.80)	29.6 (0.55)	65.8 (1.09)	26.1 (0.70)	72.9 (1.11)	33.0 (0.79)	1.40 (1.22–1.60)
⩾5 mm	20–29	16.3 (1.54)	2.5 (0.30)	14.6 (1.99)	2.5 (0.46)	17.9 (2.32)	2.4 (0.39)	1.28 (0.82–1.98)
	30–39	33.4 (1.73)	8.2 (0.62)	27.4 (2.23)	6.9 (0.80)	39.1 (2.60)	9.5 (0.94)	1.70 (1.25–2.31)
	40–49	55.8 (1.84)	19.4 (1.01)	48.7 (2.53)	15.5 (1.23)	62.6 (2.61)	23.2 (1.57)	1.76 (1.31–2.37)
	50–59	56.6 (1.83)	21.8 (1.08)	48.2 (2.53)	17.3 (1.36)	65.1 (2.56)	26.3 (1.64)	2.01 (1.49–2.70)
	60–69	53.7 (2.06)	22.8 (1.25)	43.0 (2.97)	17.9 (1.68)	65.6 (2.65)	29.7 (1.78)	2.53 (1.82–3.52)
	70–81	48.2 (3.01)	24.8 (2.10)	46.2 (4.15)	24.5 (2.93)	52.0 (3.74)	25.5 (2.47)	1.26 (0.81–1.95)
	Total	43.1 (0.86)	15.0 (0.46)	37.0 (1.11)	12.6 (0.54)	48.8 (1.22)	17.4 (0.62)	1.62 (1.43–1.85)
⩾6 mm	20–29	5.8 (0.94)	0.7 (0.13)	5.7 (1.31)	0.8 (0.22)	5.8 (1.42)	0.5 (0.13)	1.03 (0.51–2.05)
	30–39	16.5 (1.37)	3.6 (0.41)	14.2 (1.75)	3.0 (0.51)	18.7 (2.08)	4.3 (0.63)	1.39 (0.94–2.04)
	40–49	33.9 (1.76)	10.3 (0.76)	26.9 (2.25)	7.8 (0.91)	40.6 (2.65)	12.7 (1.20)	1.85 (1.36–2.53)
	50–59	39.6 (1.81)	13.1 (0.88)	30.0 (2.32)	9.8 (1.09)	49.3 (2.69)	16.5 (1.36)	2.27 (1.68–3.07)
	60–69	33.8 (1.92)	13.3 (1.03)	24.4 (2.57)	9.0 (1.31)	44.3 (2.77)	18.1 (1.57)	2.47 (1.74–3.50)
	70–81	31.2 (2.77)	13.8 (1.59)	29.7 (3.81)	13.1 (2.18)	34.1 (3.55)	15.1 (2.03)	1.23 (0.77–1.97)
	Total	25.3 (0.74)	8.1 (0.34)	20.7 (0.93)	6.4 (0.39)	30.2 (1.10)	9.7 (0.48)	1.66 (1.43–1.92)

Crude prevalence odds ratios with 95% confidence interval [POR (95% CI)] for male *versus* female subjects are reported.
*Small sample adjustment.

Table 4. Prevalence of periodontitis (%) according to CDC classification based on attachment loss and probing depth (Page & Eke 2007), stratified by age and gender

	Age (years)						
	20–29 ($N = 587$)	30–39 ($N = 745$)	40–49 ($N = 714$)	50–59 ($N = 695$)	60–69 ($N = 544$)	70–81 ($N = 267$)	Total
Total population ($N = 3552$)							
No or mild	87.7	66.2	36.9	26.0	20.4	26.4	49.1
Moderate	11.5	26.5	41.9	42.7	46.8	44.4	33.3
Severe	0.9	7.3	21.2	31.3	32.8	29.2	17.6
Females ($N = 1823$)							
No or mild	88.3	70.3	44.3	31.5	25.9	29.3	52.7
Moderate	11.1	24.6	38.5	46.5	48.6	44.8	33.4
Severe	0.6	5.1	17.2	22.0	25.5	25.9	13.8
Males ($N = 1729$)							
No or mild	87.1	62.4	29.9	20.5	14.3	21.2	45.6
Moderate	11.8	28.2	45.1	38.8	44.7	43.7	33.3
Severe	1.1	9.4	25.1	40.7	41.0	35.1	21.1
Total population (mesiobuccal sites only) ($N = 3546$)							
No or mild	94.2	77.5	51.9	38.1	30.1	34.9	60.1
Moderate	5.5	19.1	32.9	40.5	47.2	44.9	28.1
Severe	0.3	3.4	15.3	21.4	22.7	20.1	11.8

Estimates are based on mesiobuccal and distobuccal sites in half-mouth, and additionally on mesiobuccal sites only (see lower part of the table).

restricted to mesiobuccal sites like in NHANES, the prevalences of moderate or severe periodontitis were still considerably higher in our study.

For health planning institutions, the CDC definition may provide a better estimation on the resources necessary for treatment of periodontal disease. Because periodontal treatment focuses on pocket depth reduction, the combination of probing depth and attachment loss in the CDC definition also incorporates aspects of treatment needs. In contrast, prevalence estimates lead to an overestimation of periodontal treatment needs, because one involved site is enough to classify a subject as periodontal diseased. The most precise information on the prevalence and extent of periodontal disease is displayed by the percentile plots (see Fig. 1); unfortunately, they have no single numerical equivalent.

The main drawback of our study is the partial recording protocol, which underestimates prevalence and extent (Kingman & Albandar 2002). For the recording used in SHIP, extent and prevalence estimates of periodontal disease for the 4 mm values are expected to be unbiased, whereas prevalence estimates for the 7 mm value could be biased (Kingman et al. 1988). Examination of two or three buccal sites in the half-mouth generally underestimates prevalence and extent depending on the cut-off (Kingman & Albandar

2002, Beck et al. 2006). Thus, an underestimation of disease prevalence can be expected for most studies, including e.g. NHANES studies. Only for a few small studies with a full-mouth design and six sites (Baelum et al. 2003, Desvarieux et al. 2003, Susin et al. 2004) an unbiased estimate for prevalence and extent can be achieved.

Attachment loss may be reflected by recession, probing depth, or a combination of both (Beck & Koch 1994, Page & Eke 2007). It was observed that probing depth remained constant with age and gingival recession increased (Baelum et al. 1988, Yoneyama et al. 1988, Brown et al. 1989, Albandar & Kingman 1999, Albandar et al. 1999, Morris et al. 2001). In an American population of adults aged 65+ experiencing attachment loss >3 mm over 18 months, 65% (24%) of the adults had attachment loss at mesio-buccal (buccal) sites mainly due to probing depth, and 42% (97%) mainly due to gingival recession (Beck & Koch 1994). Here, in subjects older than 40 years, the mean attachment loss increased steadily with age, while the mean probing depth remained constant. This is in agreement with other studies (Morris et al. 2001, Schurch & Lang 2004), and supports the suggestion that recession is common in older populations (Yoneyama et al. 1988, Albandar & Kingman 1999, Albandar et al. 1999, Albandar 2005).

It is well established that tooth loss increases with age (Dye et al. 2007, Mundt et al. 2007). The relation between tooth loss and periodontal disease can be discussed in terms of two aspects: (1) if the decision of tooth extraction is based on increased pocket depths (Hujoel et al. 2005), then tooth loss due to deep pockets could have partly accounted for the fact that the mean probing depth remained constant after the age of 40 in this study. Under this assumption, the prevalence of periodontitis would have been underestimated. (2) In SHIP, the mean attachment loss and mean probing depth increased with increasing tooth loss within each age group (see Fig. 3). Obviously, tooth extraction did not inhibit the onset or the progression of periodontal disease on residual teeth. Thus, we believe that tooth loss only partly accounts for the fact that probing depth remained constant after the age of 40. Furthermore, East German dentists seemed to favour tooth extraction as a treatment option for even moderate periodontal disease. Splieth et al. (2002) had randomly selected 500 extracted teeth from a dental waste company operating in East Germany and there was a marked increase in the frequency of extracted teeth that had only one-third loss of periodontal attachment. Also, Hujoel et al. (1999) found that even moderate attachment loss had an impact on increased tooth loss. Thus, tooth extraction may not be restricted to teeth with deep pockets or high attachment loss.

Hujoel and colleagues proposed two distinctive disease entities with different aetiologies and treatment needs – pocket-free gingival recession, referred to as periodontal atrophy, and abnormal pocket depths, referred to as destructive periodontal disease (Glickman 1964, Page & Sturdivant 2002, Hujoel et al. 2005). Ageing (Danenberg et al. 1991), continuous eruption (Danenberg et al. 1991), aggressive oral hygiene procedures (Page & Sturdivant 2002, Rajapakse et al. 2007), iatrogenic causes, and anatomic periotypes have been suggested as potential causes of periodontal atrophy (Hujoel et al. 2005). Recession is also known to occur during the healing processes after a successful periodontal treatment (Hallmon & Rees 2003). Because about 10% of the SHIP population received periodontal treatment within the last 5 years (unpublished data), recent periodontal treatment probably did not contribute very much to reduced probing depths.

Both longitudinal studies and genomewide association studies may help to understand whether destructive periodontitis and pocket-free recession are different phenotypes with different underlying genotypes. In addition, studies that analyse biomarkers of ageing (hormones, age cytokines, etc.) in relation to pocketing and recession may help to understand the role of age in the history of periodontal disease.

This survey is a population-based study representative for Pomerania, a provincial state in Eastern Germany. Here, the prevalence and extent of periodontal diseases were extremely high in all age groups. Overall, one-third of the persons had moderate periodontitis, and one-sixth had severe periodontitis. The prevalence of moderate or severe periodontitis increased with age from 12.4% to 73.4%. In the older subjects, attachment loss increased steadily with age, while the probing depth remained constant.

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Clinical Relevance

Scientific rationale for the study: The prevalence and extent of periodontal diseases was assessed in subjects aged 20–81 years representative of West Pomerania.

Principal findings: The prevalence of periodontitis is high, with moderate and severe periodontitis being present in one-third and one-sixth of the subjects, respectively. With age, beyond 40 years, attachment loss increased while the probing depth remained constant.

Practical implications: For health planning issues, a case definition of periodontitis that encompasses attachment loss and probing depth may be helpful.