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A community-based epidemiological study of periodontal disease in Keelung, Taiwan: a model from Keelung community-based integrated screening programme (KCIS No. 18)

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Abstract

Aims: To estimate the prevalence and severity of periodontal disease (PD) in the Taiwanese population aged 35–44 years and to investigate the association between demographic factors and PD.

Materials and Methods: Between 2003 and 2005, residents of Keelung of the appropriate age were invited to screening. The community periodontal index (CPI) and loss of attachment (LA) index were used to measure the periodontal status at subject (prevalence) and sextant levels (severity). Basic demographic information was also collected by a questionnaire.

Results: Of 8462 enrollees, 94.8% had some signs of PD, of whom 29.7% had periodontal pockets >3 mm and 35% LA >3 mm. Calculus was the most common problem in terms of both prevalence (49.6%) and severity (affecting an average of 3.0 sextants per person). Risk factors for poor periodontal status (as measured by CPI) were older age (odds ratio, OR: 1.44), male gender (OR: 2.70), low education level (OR: 1.40), and being a manual worker (OR: 1.51). Similar findings were observed for LA.

Conclusion: The prevalence of PD in 35–44-year-olds was found to be high in this large community-based study of screening for PD with CPI and LA. Poorer periodontal health was observed in males, the less educated, and manual workers.

Key words: community periodontal index; loss of attachment; periodontal disease; prevalence; screening; severity; treatment needs

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Conflict of interest and source of funding statement

The authors declare that they have no conflict of interests.

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As periodontal disease (PD) is one of the primary causes of tooth loss and is also associated with health problems such as cardiovascular disease (Howell et al. 2001, Hujoel et al. 2001), diabetes mellitus (Taylor et al. 1998, Lu & Yang 2004), and low birth weight (Jeffcoat et al. 2001, Lopez et al. 2002), the estimation of its prevalence in the population and the identification of high-risk groups are of paramount importance as regards primary healthcare.

From the aetiological viewpoint, because the occurrence of PD is affected by a range of factors, including genetics, socio-demographic features, oral hygiene,

and life-style (Page & Kornman 1997, Ronderos et al. 2001, Hyman & Reid 2003, Schätzle et al. 2003, Neely et al. 2005), its reported prevalence varies considerably across countries, regions, and populations (Albandar 2002a, Corbet et al. 2002). A large epidemiological study based on comprehensive data is therefore required to identify groups of individuals in the population who are at a high risk of developing the disease. Although many of the previous studies reporting the prevalence of PD relied solely on the community periodontal index (CPI), it is well known that the assessment of PD is better accomplished by measuring both probing depth and loss of attachment (LA) (Reddy 1997). The World Health Organization (WHO) therefore recommends that subjects aged 35–44 years comprise the standard group for monitoring periodontal conditions (WHO 1997) and that assessments are based on both CPI and the LA index. Accordingly, the aims of this study were to estimate the prevalence and severity of PD in the population using CPI and LA in subjects aged 35–44 years and to facilitate the identification of high-risk groups by investigating the association between socio-demographic factors and the development of PD.

Materials and Methods

Target and study population

This study was part of the Keelung Community-based Integrated Screening (KCIS) programme which provided routine screening services as mentioned below for the whole population aged 30 years or above of Keelung City, the northernmost city of Taiwan. Initially, the KCIS programme was a multiple-screening project to detect five cancers (cervical, breast, colorectal, oral, and hepatocellular) and three chronic diseases (hypertension, diabetes, and hyperlipidaemia) that has been running since 1999 in the light of evidence-based medicine. In order to cover at least one round of screening for each resident from 1999 to 2005, every year we invited a proportion of residents based on the residence registry to attend the KCIS programme at out-reaching screening centres covering seven city districts of Keelung City. The details of the study design and preliminary screening results of different diseases have been published elsewhere (Chen et al. 2004).

The assessment of PD using the CPI and LA indices for individuals aged 35–44 years has been incorporated into the programme since 2003. All the KCIS attendees were invited to receive a PD assessment when they attended the KCIS programme. In addition, the PD screening programme aimed not only at assessing the periodontal conditions but also at early intervention and treatment. All the subjects with abnormal findings on periodontal conditions were referred to further treatment or oral health education. This justifies the larger sample size of our study than that expected on the basis of formal sample size determination. Until the end of 2005, 12,294 subjects out of 70,000 residents or so aged 35–44 years in Keelung City attended the routine KCIS programme, and among them, 8698 (71%) received the assessment of PD. We considered only those subjects with complete CPI and LA information as eligible for our analysis. Three-hundred and four participants were excluded [incomplete information on CPI index ($n = 31$), LA index ($n = 205$), or both ($n = 68$)] leaving 8462 participants forming the present study population dataset. Socio-demographic details were collected by a face-to-face questionnaire. Individual written informed consent was obtained from all participants and the programme, as a whole, was approved by a local health committee endorsed by the Keelung health authority (as described previously in Chen et al. 2004).

Screening procedure for PD

Periodontal status was assessed using a purpose-built instrument, known as a CPI (or WHO) probe. This tool has a 0.5 mm diameter ball at its tip, a black band between 3.5 and 5.5 mm, and coloured rings at 8.5 and 11.5 mm from the tip. The CPI scores periodontal status as follows: 0 for a healthy periodontium, 1 for gingival bleeding, 2 for calculus, 3 for a 4–5 mm periodontal pocket, and 4 for a 6 mm or deeper periodontal pocket. The LA scoring system uses the cementoenamel junction (CEJ) as the reference point for measuring the extent of attachment loss and assigns scores as follows: 0 for 0–3 mm, 1 for 4–5 mm, 2 for 6–8 mm, 3 for 9–11 mm, and 4 for 12 mm (WHO 1997).

The mouth was divided into six sextants: the right upper posterior (teeth 18–14), the upper anterior (teeth 13–23), the left upper posterior (teeth 24–28), the left lower posterior (teeth 38–34), the lower anterior (teeth 33–43), and the right lower posterior (teeth 44–48), labelled 1–6, respectively. Two molars in the posterior sextants and teeth 11 or 31 in the anterior sextants were selected for examination at six conventional sites: the mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual, and distolingual surfaces. The highest of the component scores for each sextant was taken to be the overall sextant score, and the highest of the sextant scores for each individual to be their overall assessment of PD.

There were four disease outcomes in this study: CPI prevalence, CPI severity, LA prevalence, and LA severity. Prevalence is defined as the percentage of subjects with a particular CPI or LA score and severity as the average number of sextants at each CPI or LA score level (Croxson 1993).

Calibration

A series of training courses, each lasting 6 h, were held by a senior periodontist (Dr. Lai-Hongmin, the first author of this study) and attended by 35 dentists. These courses focused on periodontal examination, diagnosis, screening using CPI and LA, and basic treatment. The calibration was checked, as recommended when using CPI and LA, by having a number of dentists repeat the assessment on the same 25 subjects (aged 35–44 years). In principle, all 36 of our examiners (including the gold standard, H. L.) should have participated in this, making their assessments in two sessions held 2–3 days apart. However, owing to the fact that this is a community-based study and that repeated periodontal probing is both time-consuming and unpleasant for patients (because it causes soft tissue damage and discomfort), we felt it infeasible to carry out re-testing on such a wide scale. Instead, we used the homogeneity of training and qualifications among dentists in Taiwan to justify basing our calibration on the assessments of only three. We consider this to be a fair representation of the group as a whole.

The weighted κ statistic, an indicator of the extent of deviation in repeated ordinal measurements (Kingman 1986, Altman 1991), was used to assess the intra- and inter-examiner reliability of scoring with CPI and LA. The degree of agreement is categorized as poor, fair,

moderate, good, or very good using the cut-points $\kappa \leqslant 0.20$, 0.21–0.40, 0.41–0.60, 0.61–0.80, and 0.81–1.00, respectively (Altman 1991).

Our weighted κ values for intra-examiner variability were 0.55–0.61 for CPI and 0.67–0.80 for LA, indicating a moderate to good agreement between dentists. The equivalent figures for inter-examiner variability were 0.42–0.44 for CPI and 0.41–0.57 for LA, which again indicates moderate agreement.

Statistical analysis

The association between PD and baseline demographic variables (such as age, gender, education, and occupation) was assessed using logistic regression models with either 6 mm or deeper periodontal pockets or attachment loss >3 mm as the dependent variable. Because there is a within-subjects correlation (because the sextants are not independent), we used Generalized Estimation Equations (GEE) (Liang & Zeger 1986) to obtain the parameter estimates. Both univariate and multivariate models were obtained, and the adjusted odds ratios (ORs) and their 95% confidence intervals (95% CIs) were calculated. We also calculated the crude OR relating to each demographic factor. All analyses were carried out using SAS statistical software (version 9.10).

Results

Prevalence and severity of PD

The overall prevalence and severity of PD in the study population (separately for CPI and LA) are given in Table 1. With CPI, calculus and 4–6 mm periodontal pockets were the most common findings (49.6% and 24.8% prevalence, respectively) but with LA the majority of subjects (65.4%) fell into the least severe (0–3 mm) category.

As regards severity (the average number of sextants affected), calculus was the most likely level of disease, affecting an average of three sextants per person, whereas bleeding (on average) affected only 1.5 sextants and periodontal pockets deeper than 3 mm <1. Attachment loss was far more localized, the severest occurrences (9–11 mm) being extremely rare (affecting <0.01 sextant per person) and mildest (0–3 mm) being the most common (affecting an average of 4.97 sextants per person).

Because of an excess of women in the study population (64% as compared with 49% in Keelung City), we used the gender distribution of Keelung City to also calculate gender-standardized prevalence rates. These (for both CPI and LA) differed little from the crude estimates.

Prevalence by sextant

Figure 1 shows the distribution of CPI prevalence, by sextant. There were significant variations in prevalence across the sextants ($p < 0.01$). Sextant 2 was the healthiest with respect to CPI (healthy periodontium 22%, gingival bleeding 30%, calculus 43%, and periodontal pockets deeper than 3 mm 5%), followed by sextant 5 (healthy periodontium 14%, gingival bleeding 19%, calculus 64%, and periodontal pockets deeper than 3 mm 3%). Sextants 1 and 3 were the least healthy, with 16–17% having periodontal pockets deeper than 3 mm. Furthermore, calculus predominated in sextant 5.

The distribution of LA prevalence by sextant is shown in Fig. 2. The most favourable distribution of LA was in Sextant 2 where attachment loss >3 mm was seen in only 11% of subjects. Sextants 1 and 3 were the least favourable, with about 21% having attachment loss exceeding 3 mm. The corresponding prevalence of LA in the mandibular sextants was 14–17%.

Association between PD and demographic features

Table 2 illustrates the subject-level association between PD and demographic factors (age, gender, education, and occupation). In the univariate analysis, those aged 40–44 years were 45% (95% CI: 18–76) more likely to have 6 mm or deeper periodontal pockets than those aged 35–39 years. Males were also more likely to have 6 mm or deeper periodontal pockets than females (OR = 2.55, 95% CI: 2.09–3.12) and those with the lowest levels of education more likely than the college educated individuals (taking the college educated as baseline, OR = 1.37, 95% CI: 1.04–1.80 for those educated to only junior high level, and OR = 1.13, 95% CI: 0.89–1.43 for those leaving education after senior high). Those who were unemployed or manual workers were (approximately) twice as likely to have 6 mm or deeper periodontal pockets as teachers, office holders, and military personnel. After adjusting for these variables in a multivariate analysis, the effects remained roughly the same, except that the odds ratios relating to unemployment and manual work were attenuated. We found very similar results when repeating the analysis using the LA assessment of PD. However, after controlling for age, gender, and education level, those who were teachers, office holders, and military personnel had a lower risk of moderate to severe attachment loss (>3 mm) than other occupation groups. A sextant-level analysis was also carried out and the results, again very similar, are shown in Table 3.

Discussion

Our community-based screening study demonstrated a high prevalence of PD (up to 94.8%) among subjects aged 35–44 years in Keelung City. Calculus and 4–5 mm periodontal pockets were the most common problems (49.6% and 24.8% prevalence, respectively) with a joint prevalence of 74.4%, which is in keeping with estimates of 68.8–80% derived from previous Taiwanese studies (Tseng et al. 1993, 1998a, b). Furthermore, the prevalence of 6 mm or deeper periodontal pockets in our study (5%) is close to that found in two previous Taiwanese surveys: a nation-wide survey (6%) (Peng 1985) and a survey of Taipei City (8%) (Peng et al. 1990). However, previous studies

Table 1. Prevalence and severity of PD, at the subject and sextant levels

Codes	Prevalence (%)						Severity (mean no. of affected sextants)						
	N	0	1	2	3	4	*N*	0	1	2	3	4	*X*
CPI*	8462	5.2	15.5	49.6	24.8	4.9	8462	0.83	1.45	2.98	0.58	0.07	0.08
LA†	8462	65.4	25.4	6.8	2.0	0.4	8462	4.97	0.77	0.15	0.00	0.00	0.07

*0, healthy periodontium; 1, gingival bleeding; 2, calculus; 3, 4–5 mm periodontal pockets; 4, 6 mm or deeper periodontal pockets; *X*, <2 functioning teeth in each sextant.

†0, 0–3 mm; 1, 4–5 mm; 2, 6–8 mm; 3, 9–11 mm; 4, $\geqslant 12$ mm.

PD, periodontal disease; CPI, community periodontal index; LA, loss of attachment.

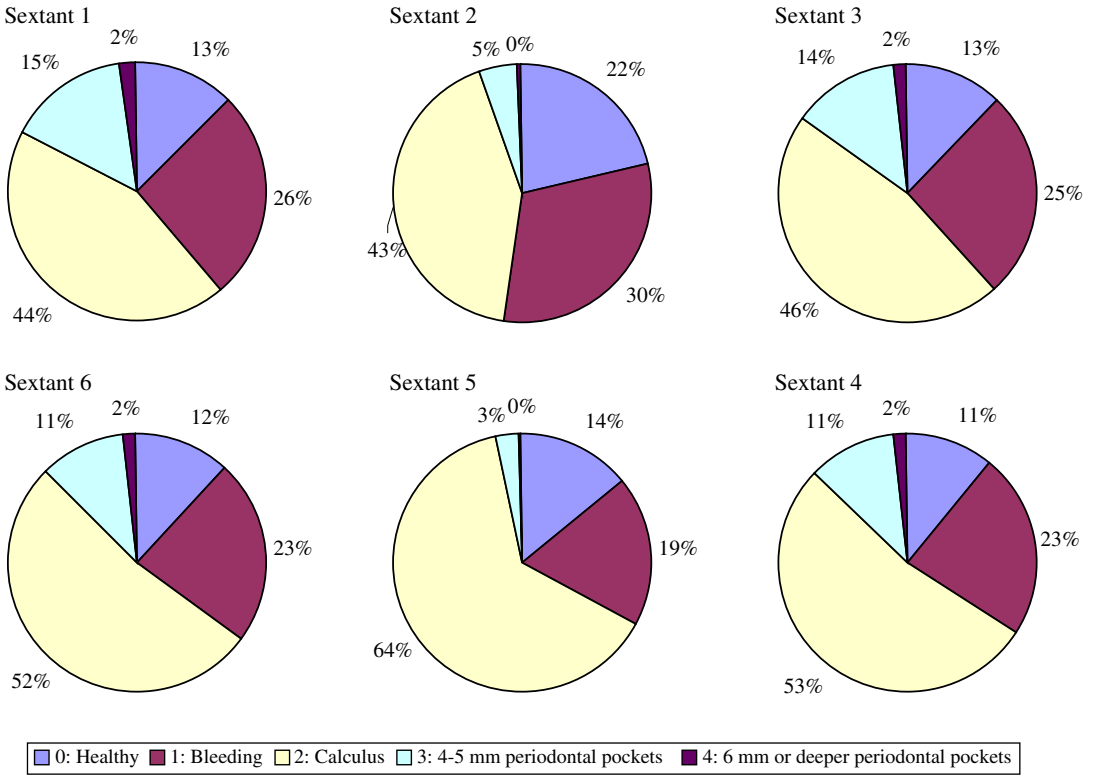

Fig. 1. Distribution of Community Periodontal Index prevalence by different sextants in dentition.

from southern Taiwan estimated the prevalence of this to be between 11% and 31% (Tseng et al. 1993, 1998a, b). These studies were based only on CPI though and had smaller sample sizes, ranging between 64 and 615 subjects.

We compared our findings with those of WHO (Periodontal Profile Main Page, 2007), and tabulated the large sample estimates of prevalence (based on more than 1000 subjects) in the Appendix A, by country. The CPI prevalence of periodontal pockets deeper than 3 mm was moderate (20–37%) in most countries, including Madagascar, Zimbabwe, Malaysia, China, Sri Lanka, and French Polynesia, which agrees with our findings on Taiwan, whereas the prevalence is high (46–73%) in Thailand, Italy, the USA, and Canada. Similarly, as regards the severity of PD, we found few studies based on the LA index. One, Corbet et al. (2001), reported the prevalence of attachment loss $\geqslant$4 mm in a Chinese population to be approximately 56%, which is much higher than the 35% estimate from our study. However, there was better accordance between the two studies as regards the mean number of sextants affected; approximately 1.5 in the Corbet study and slightly over 1.0 in ours.

Identification of high-risk groups by socio-demographic features

The association between PD and demographic factors (age, gender, and education) demonstrated in our study is consistent with previous findings (Hansen et al. 1993, Genco 1996, Corbet et al. 2001, Ronderos et al. 2001, Albandar 2002a, Hyman & Reid 2003, Schätzle et al. 2003, Kocher et al. 2005, Neely et al. 2005). The effect of age may be explained by the fact that tissue damage accumulates over time (Genco 1996, Ronderos et al. 2001, Albandar 2002a, Hyman & Reid 2003, Schätzle et al. 2003). The poorer periodontal condition of men (as compared with women) may be explained by poor oral hygiene, hormonal (Albandar 2002a, b), or other physiological differences between the sexes. Both low education level and low income have been found to be independent risk factors for PD, significant even after controlling for behavioural factors such as oral hygiene, dental visits, and smoking (Hansen et al. 1993, Genco 1996, Corbet et al. 2001, Craig et al. 2001, Albandar 2002a, Klinge & Norlund 2005, Kocher et al. 2005, Peres et al. 2007). Few studies have investigated the association between PD and occupation. Given the correlation between income, education level, and occupation, it is interesting that in our study occupation was found to be an independent indicator of PD risk.

Clinical implications for the early detection of PD

The high burden of PD reported in our study, in combination with other factors suggests a need to detect PD earlier via screening. Firstly, because most patients with PD are asymptomatic, especially in the early stages, the disease often goes undetected and untreated for a long time. Previous studies have reported that only 2% of Finnish (Murtomma et al. 1997), 9% of New Zealanders (Croxson 1993), and 8% of Irish (Buckley 1993) were aware that they had gingival inflammation. Secondly, because periodontal conditions tend to deteriorate with age, as indicated by the fact that older age is frequently reported as being the key risk factor (American Academy of Periodontology 2005), early intervention is again recommended. The current ''burst theory'' of periodontal progression (Goodson et al. 1982, Socransky et al. 1984, Pilot 1997) places more

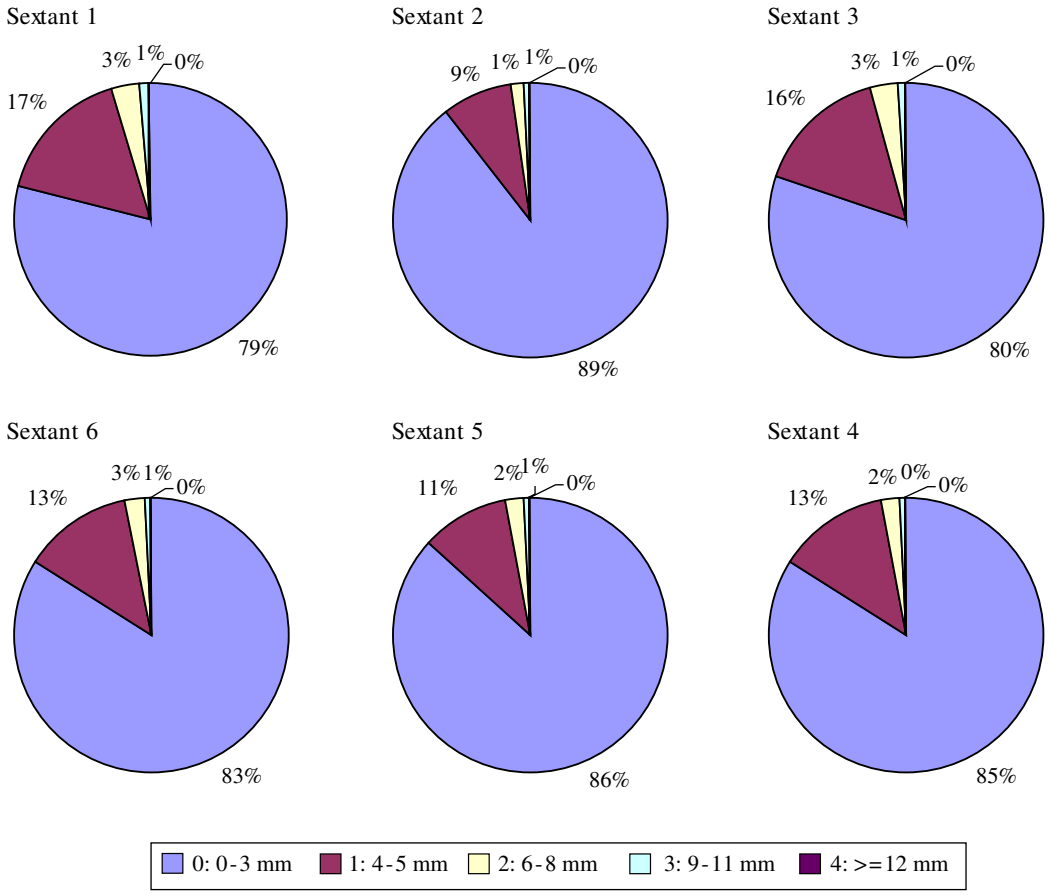

Fig. 2. Distribution of loss of attachment prevalence by different sextants in dentition.

Table 2. Prevalence of PD (at the subject level) and its association with demographic factors

Index	No.	CPI		LA	
		OR* (95% CI)	OR† (95% CI)	OR‡ (95% CI)	OR§ (95% CI)
Age					
35–39 years	4465	1.00	1.00	1.00	1.00
40–44 years	3997	1.45 (1.18–1.76)	1.44 (1.17–1.76)	1.27 (1.16–1.39)	1.24 (1.13–1.36)
Gender					
Female	5443	1.00	1.00	1.00	1.00
Male	3019	2.55 (2.09–3.12)	2.70 (2.09–3.47)	1.70 (1.55–1.86)	1.83 (1.63–2.05)
Education					
Junior high school or below	1696	1.37 (1.04–1.80)	1.40 (1.03–1.90)	1.41 (1.24–1.60)	1.40 (1.22–1.60)
Senior high school	4115	1.13 (0.89–1.43)	1.16 (0.90–1.49)	1.23 (1.11–1.37)	1.24 (1.10–1.38)
College or above	2651	1.00	1.00	1.00	1.00
Occupation					
None	657	2.17 (1.52–3.12)	1.23 (0.84–1.81)	1.95 (1.62–2.34)	1.26 (1.04–1.54)
Housewife	1779	0.89 (0.63–1.25)	1.29 (0.87–1.92)	1.12 (0.97–1.29)	1.27 (1.08–1.49)
Manual	609	2.18 (1.51–3.15)	1.51 (1.02–2.23)	1.68 (1.39–2.03)	1.26 (1.03–1.54)
Teacher, office holder, military	1752	1.00	1.00	1.00	1.00
Business, professional	336	1.09 (0.62–1.93)	1.23 (0.69–2.17)	1.25 (0.98–1.60)	1.35 (1.05–1.73)
Service trades, others	3329	1.11 (0.83–1.48)	1.14 (0.84–1.55)	1.25 (1.11–1.42)	1.22 (1.07–1.40)

*OR: Crude odds ratio of having 6 mm or deeper periodontal pockets.
†OR: Odds ratio of having 6 mm or deeper periodontal pockets adjusting for age, gender, education level, and occupation.
‡OR: Crude odds ratio of having attachment loss >3 mm.
§OR: Odds ratio of having attachment loss >3 mm, adjusting for age, gender, education level, and occupation.
PD, periodontal disease; CPI, community periodontal index; LA, loss of attachment; CI, confidence interval.

Table 3. Severity of PD (mean number of affected sextants) and its association with demographic factors

Index	No.	CPI		LA	
		OR* (95% CI)	OR† (95% CI)	OR‡ (95% CI)	OR§ (95% CI)
Age					
35–39 years	4465	1.00	1.00	1.00	1.00
40–44 years	3997	1.54 (1.30, 1.81)	1.39(1.18–1.64)	1.13 (1.03, 1.24)	1.10 (1.00, 1.20)
Gender					
Female	5443	1.00	1.00	1.00	1.00
Male	3019	1.67 (1.42, 1.97)	1.63(1.34–1.99)	1.57 (1.43, 1.72)	1.61 (1.43, 1.80)
Education					
Junior high school or below	1696	2.20 (1.75, 2.76)	2.23(1.78–2.81)	1.40 (1.24, 1.60)	1.37 (1.19, 1.57)
Senior high school	4115	1.44 (1.17, 1.77)	1.49(1.22–1.81)	1.27 (1.14, 1.42)	1.25 (1.12, 1.40)
College or above	2651	1.00	1.00	1.00	1.00
Occupation					
None	657	2.36 (1.73, 3.20)	1.42(1.03–1.95)	2.15 (1.80, 2.57)	1.52 (1.26, 1.84)
Housewife	1779	1.20 (0.91, 1.57)	1.13(0.85–1.49)	1.21 (1.04, 1.40)	1.33 (1.13, 1.57)
Manual	609	1.86 (1.36, 2.52)	1.17(0.85–1.60)	1.78 (1.47, 2.15)	1.40 (1.15, 1.70)
Teacher, office holder, military	1752	1.00	1.00	1.00	1.00
Business, professional	336	0.82 (0.48, 1.40)	0.90(0.55–1.47)	1.37 (1.06, 1.77)	1.43 (1.11, 1.86)
Service trades, others	3329	1.03 (0.80, 1.32)	0.90(0.71–1.14)	1.34 (1.18, 1.52)	1.30 (1.13, 1.49)

*OR: Crude odds ratio of having 6 mm or deeper periodontal pockets.
†OR: Odds ratio of having 6 mm or deeper periodontal pockets adjusting for age, gender, education level, and occupation.
‡OR: Crude odds ratio of having attachment loss >3 mm.
§OR: Odds ratio of having attachment loss >3 mm, adjusting for age, gender, education level, and occupation.
PD, periodontal disease; CPI, community periodontal index; LA, loss of attachment; CI, confidence interval.

importance on site but it is well established that mild PD (bleeding or calculus) is most common in subjects aged 15–19 years (Miyazaki et al. 1991a), moderate PD (4–5 mm periodontal pockets) in subjects aged 35–44 years (Miyazaki et al. 1991b), and severe PD (6 mm or deeper periodontal pockets) or edentulous sextants in those aged over 45 years (Pilot et al. 1992). Thirdly, there are good screening tools available, such as CPI and LA, which have gained universal acceptance (Pilot & Miyazaki 1994, WHO 1997). Finally, early intervention (with oral health advice, scaling, and root planing) has been demonstrated to be an effective means of treating and controlling PD (Cobb 1996, 2002, van der Weijden & Hioe 2005, Hugoson et al. 2007).

Methodological considerations

Our study has several strengths. Firstly, we used components of both the CPI and LA indices to gain a better understanding of periodontal status. Although CPI has several advantages for epidemiological purposes (such as being simple, quick, cheap, and easy to use) and can be used to plan future treatment needs and influence policy making (Lennon 1994, Page & Morrison 1994), it has its limitations because it only detects signs of PD rather than measuring the accumulated periodontal damage. The LA index, on the other hand, does provide this information and so is probably a more meaningful measure of PD in the population (Holmgren 1994a, Koch & Paquette 1997, WHO 1997, Gilbert et al 2002). The LA index and CPI have now been combined to form a new index: CPI and LA (WHO 1997).

Because they are designed to measure different things, the results from the two indices are not necessarily consistent but they do complement each other. In the 35–44-year age group for example, attachment loss is usually at an early stage and so using LA may not yield sufficient information. However, as attachment loss increases significantly with age (Corbet et al. 2001, Schätzle et al. 2003), the LA component is more efficient at measuring PD in the older age groups. By combining the two, we were therefore able to satisfy our goal of detecting PD earlier, and in all age groups.

Secondly, with 8462 subjects our study of PD is the second largest we have found (those listed in the Appendix A were based on sample sizes of between 1028 and 21,352 subjects). To achieve this scale, several obstacles had to be overcome, the most critical being to encourage participation and compliance in a country where public awareness of PD is very low and oral health is considered to be a low priority. For this reason, we chose the citizens of Keelung City to be our target population. The pre-existing multiple-screening programme there (KCIS) has been running for several years and has good coverage (Chen et al. 2004) and so by integrating our PD screening into the KCIS programme, we were able to easily access a suitable population and avoid many of the usual start-up problems and costs.

Thirdly, the KCIS programme provides comprehensive longitudinal information about a variety of diseases (five cancers and three chronic diseases), lifestyle, and other risk factors. Although PD is thought to be a chronic infection caused by bacteria (mostly *Porphyromonas gingivalis* and *Actinobacillus actinomycetemcomitans*; Consensus Report 1996), bacteria alone is not sufficient to trigger the disease and so recent studies have attempted to elucidate the relationship between PD and other risk factors, such as diabetes mellitus (Taylor et al. 1998, Lu & Yang 2004) and cardiovascular disease (Howell et al. 2001, Hujoel et al. 2001). The fact that this is a prospective cohort study of population-based multiple screening therefore enables us to further explore the suspected interactions between smoking, diabetes, and obesity, and development of PD. Work in this area is currently ongoing.

Our study has two limitations, the first one being that the study subjects

were not randomly selected but invited through an existing screening programme. This means that selection bias cannot be ruled out, although we do think it is unlikely for the following reasons: firstly, the basis for making the invitations was completely unrelated to PD status. Secondly, this is a very large and long-running population-based screening programme with almost 300 screening centres scattered around the city. Thirdly, those who attended appeared to be fairly representative of the general population in terms of demographic factors, age, and education level. The mean age of attendees was 39.4 (SD = 2.9) years compared with 39.5 (SD = 2.9) years in those who did not attend. The education levels of attendees and non-attendees were very similar as well (respectively, 22% *versus* 20% studied no further than junior high, 50% *versus* 49% left education after senior high, and 28% *versus* 31% went on to college). The only apparent difference between the groups is the significantly greater proportion of woman attendees (64% *versus* 47% in the underlying population, $p < 0.0001$). It may be that women had more incentive to attend because PAP screening was on offer and cervical cancer is one of the most prevalent female cancers in Taiwan. Had we ignored this imbalance, our estimates of the overall prevalence and severity of PD would be slightly conservative because women tended to have better PD status than men. However, by standardizing our results to the Keelung City population, we have shown that the excess of females in the study group has little impact.

The other limitation of our study is that in order to carry it out on such a large scale, we were forced to employ a large number of personnel. There were 36 examiners for the 8462 subjects in our study, which made it infeasible and unethical to carry out the recommended calibration exercise. Hence we based our calibration on three examiners, whom we felt (owing to the consistency of dental training and qualifications in Taiwan) were representative. All 36 examiners attended the same continuing educational course to learn how to perform the CPI and LA examinations. It should be noted, however, that because both CPI and LA are five-category indices one should not expect the same level of agreement one would expect if they were binary indices. The interpretation of the weighted κ statistics in this study therefore differ from the more usual interpretation of simple κ statistics for binary outcomes. Analysis of the calibration data indicated a moderate to good intra- and inter-examiner agreement for both CPI and LA. This is within the range reported by a survey of Chinese 35–44-year-olds in Hong Kong using CPITN, which gave figures (weighted κ statistics) of between 0.45 and 0.67 for probing depth, 0.34 and 0.58 for attachment loss, and 0.11–0.54 for calculus (Holmgren et al. 1994b).

In conclusion, we estimated the overall prevalence of severe PD (6 mm or deeper periodontal pockets) in subjects 35–44 years of age to be 4.9% using CPI, and of attachment loss >3 mm to be 35% using LA, in a large population-based screening study. Periodontal health, as assessed by CPI and LA, was found to be poorer in males, the less educated, and the manual workers. A similar study to elucidate the association between PD and other risk factors is currently underway.

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Clinical Relevance

Scientific rationale for the study: PD has been found to be preventable and is a major barrier to maintaining natural dentition throughout life. Empirical population-based data on the prevalence and severity of PD, particularly attachment loss, are lacking.

Principal findings: 94.8% of the study subjects had some degree of PD (calculus and 4–5 mm periodontal pockets predominantly) and 35% had attachment loss exceeding 3 mm. Poorer periodontal health was found in males, the less educated, and manual workers.

Practical implications: Our study reveals the important role that community-based screening could play in the early detection of PD. The treatment is to advise patients on how to improve their oral hygiene and to carry out scaling and root planing.

Appendix A

Table A1. Comparison of CPI status in subjects aged 35–44 years around the world[*,†]

Country	*N*	Prevalence (%)						Severity (mean no. of sextants)					
		0	1	2	3	4	3–4	0	1–4	2–4	3–4	4	*X*
Madagascar	1386	8	5	67	17	3	20	1.2	4.1	3.2	0.5	0.1	0.0
Zimbabwe	1195	9	9	59	19	4	23	2.4	3.6	2.6	0.5	0.1	0.0
Malaysia	2453	5	3	61	23	9	32	1.0	3.9	3.6	0.7	0.2	1.1
China	1572	0	0	64	32	4	36	0.2	5.7	5.3	0.7	0.1	0.1
Sri Lanka	1867	5	1	55	27	10	37	–	4.4	4.2	0.9	0.2	–
French Polynesia	1101	17	1	45	31	6	37	2.6	1.8	1.7	0.6	0.1	1.7
Philippines	1028	–	–	–	–	–	–	1.8	3.2	2.8	0.4	0.0	1.0
Thailand	1420	1	0	53	35	11	46	0.4	5.4	5.3	1.3	0.2	0.2
Italy	21,352	3	4	45	36	12	48	0.8	4.8	3.9	1.3	0.2	0.4
USA	2839	4	10	27	38	20	58	1.0	4.1	2.9	1.1	0.4	0.9
Canada	2110	5	6	16	52	21	73	1.9	3.3	2.8	1.7	0.3	0.8

[*]0, healthy periodontium; 1, gingival bleeding; 2, calculus; 3, 4–5 mm periodontal pockets; 4, 6 mm or deeper periodontal pockets; *X*, <2 functioning teeth in each sextant.

[†]Source: Periodontal Profile Main Page, World Health Organization. URL http://www.dent.niigata-u.ac.jp/prevent/perio/perio.html.

CPI, community periodontal index.