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The association of psychosocial factors and smoking with periodontal health in a community population

L.-J. Chiou[1,2], Y.-H. Yang[3], H.-C. Hung[4], C.-C. Tsai[2,3], T.-Y. Shieh[2], Y.-M. Wu[2], W.-C. Wang[2], T.-C. Hsu[5]

[1]Department of Health Business Administration, Meiho Institute of Technology, Taiwan, [2]Faculty of Dentistry (Graduate Institute of Dental Sciences), College of Dental Medicine and Chuan-Ho Memorial Hospital, Kaohsiung Medical University, Taiwan, [3]Faculty of Dental Hygiene (Graduate Institute of Oral Health Sciences), College of Dental Medicine and Chuan-Ho Memorial Hospital, Kaohsiung Medical University, Taiwan, [4]Department of Nursing, Meiho Institute of Technology, Taiwan and [5]Department of Nursing Management and University Hoapital, Fooyin University, Taiwan, China

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Background and Objective: The association between psychosocial factors and periodontal disease has been widely reported and might be modified by smoking status. This study investigated the association of periodontal status with psychosocial factors and smoking in a community population.

Material and Methods: A structured questionnaire was administered to a total of 1764 civilian noninstitutional (general population excluding from nursing homes, sanitariums and hospitals) Taiwanese individuals to assess the presence and severity of psychosocial factors [using the 12-item Chinese health questionnaire (CHQ-12)], smoking habits and other related factors. Periodontal status was established using the community periodontal index and by measuring clinical loss of attachment.

Results: Psychological factors and smoking were significantly associated with loss of attachment (odds ratio = 1.69, 95% confidence interval = 1.01–2.77, comparing the CHQ-12 score of ≥ 6 with the CHQ-12 score of 0–2 and $p = 0.032$ for linear trend; odds ratio = 2.21, 95% confidence interval = 1.45–3.37, comparing smokers with nonsmokers) but not with community periodontal index. The association was found to be stronger among smokers than among nonsmokers. Smokers with a CHQ-12 score of ≥ 6 had a higher odds ratio of loss of attachment (odds ratio = 2.49, 95% confidence interval = 0.91–6.49) than nonsmokers (odds ratio = 1.43, 95% confidence interval = 0.76–2.58). For periodontal health measured using the community periodontal index, married and divorced/widowed subjects tended to have poorer periodontal health (odds ratio = 3.38, 95% confidence interval = 1.26–10.81 and odds ratio = 3.83, 95% confidence interval = 1.21–13.83, respectively) than single subjects among nonsmokers but not among smokers.

Conclusion: Poor mental health had a stronger association with periodontal disease among smokers than among nonsmokers, especially in accumulative attachment loss. Our findings suggest that mental health and smoking might have a synergistic effect on the risk of developing periodontal disease.

Professor Chi-Cheng Tsai, DDS, PhD, College of Dental Medicine, Kaohsiung Medical University, No. 100 Shih-Chuan 1st Road, Kaohsiung, Taiwan, China
Tel: +886 7 313 3847
Fax: +886 7 3210637
e-mail: chchts@kmu.edu.tw

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Periodontitis is one of the most prevalent diseases in adults (1) and it is influenced by a variety of factors, including age, gender, race, education, psychosocial factors, cigarette smoking and infection (2–4). Many recent studies have investigated the influence of psychosocial factors on periodontal diseases and reported that different psychosocial factors, including depression, stress, anxiety, loneliness, negative life events, daily strain, occupational stress, life satisfaction, type-A personality and coping behaviors, were associated with periodontal diseases (5–13). However, one study reported that stress may only have a limited role in susceptibility to periodontal disease (3).

Therefore, susceptibility to periodontal disease may not be related as much to stress as it is to unhealthy periodontal behaviors that occur in individuals in response to their stressors (14,15). One of the risk factors for periodontitis is smoking (16–18), but that factor has also been associated with psychosocial stressors (19,20). However, two studies reported that poor psychosocial status seemed to be more strongly associated with periodontal health in smokers than in nonsmokers, but their findings were based on cytokine profiles among healthy subjects or limited sample size (21,22). Hence, in this study, we administered an oral health behavior survey, which covers demographic factors, smoking history, psychosocial variables and other related factors, to investigate the relationship of psychosocial factors and smoking with periodontal status in the general population in Taiwan.

Material and methods

Study population

Our study population consisted of 11,723 subjects residing in Taiwan in 21 counties, in Taipei City, in Kaoshiung City and in three aboriginal areas. This population consisted of respondents to the 2001 Oral Health Behavior Survey. The sampling design for this survey made use of a stratified multistage cluster sampling with selection probability proportional to size for adults > 18 years of age. In 2003, we sent a letter to these respondents to invite them to participate in the Taiwan Adult Oral Health Survey. Once the subjects had consented to the interview, trained dentists and interviewers visited places (homes or selected dental clinics) of participants to collect clinical data and to conduct the survey interview. Between 2003 and 2005, 2067 persons received an oral examination and completed the interview.

Questionnaire

The questionnaire items covered demographic data, smoking history, psychosocial variables and other related factors. The psychosocial variables were measured using the 12-item Chinese health questionnaire (CHQ-12), a self-reported and standardized questionnaire used to measure mental health in Taiwan (23,24). The CHQ-12 was adapted from a general health questionnaire (25) and has been validated for use in the Chinese population in some studies (24,26). It has been used in both community and clinical studies to screen for mental disorders (27). The CHQ-12 can be used to evaluate nonpsychotic psychiatric disorders, including anxiety, depression, sleeping disturbance, somatic symptoms, somatic concern and feelings of inadequacy. It consists of 12 items and assesses the severity of a mental problem using the simple scoring method of 0-0-1-1. Its total score ranges from 0 to 12: the higher the score, the poorer the mental health (28). Other variables relevant to this study were age, gender, marital status, education and smoking habits.

Clinical data

Periodontal status was assessed by trained dentists at the places (homes or selected dental clinics) of participants according to a previous publication 29. The periodontal examination included obtaining a community periodontal index score and a loss of attachment score for index teeth. The index teeth were probed and the highest score was recorded in the appropriate box. The community periodontal index range was 0–4, as follows: 0, healthy; 1, gingival bleeding upon probing; 2, calculus; 3, periodontal pocket depth 4–5 mm; and 4, periodontal pocket depth ≥ 6 mm. If no index teeth were present in a sextant qualifying for examination, all the remaining teeth in that sextant were examined and the highest score was recorded as the score for the sextant. The loss of attachment scores were divided into the following groups: 0, loss of attachment 0–3 mm; 1, loss of attachment 4–5 mm; 2, loss of attachment 6–8 mm; 3, loss of attachment 9–11 mm; and 4, loss of attachment ≥ 12 mm. The method of examining for loss of attachment in each sextant was to record it immediately after recording the community periodontal index score for that particular sextant. The kappa statistics of interexaminer agreement were higher than 0.7 at subject level for community periodontal index and loss of attachment for all examiners.

Of the 2067 subjects, we excluded 119 (5.76%) with diabetes, 80 (3.87%) with cardiovascular disease, 39 (1.89%) with cancer and 65 past smokers (3.14%), leaving us with a total sample of 1764 persons in this study. Both community periodontal index and loss of attachment were considered as measurements of periodontal health in our study. Participants were grouped by community periodontal index score (3–4 for the disease group and 0–2 for the nondisease group). They were also grouped by loss of attachment score (2–4 for the disease group and 0–1 for the nondisease group).

Statistical analysis

We compared the distribution of variables of the disease group with that of a nondisease group. Using simple logistic regression analysis, we calculated the odd ratio relative risk of a high score in the CHQ-12, smoking, age, gender, marital status, education and remaining teeth for the risk of poor periodontal health. We further conducted multivariate logistic regression analyses to evaluate factors potentially associated with periodontal diseases after adjusting for other covariates. We used community periodontal index and loss

Table 1. Descriptive summary

Variables	Total		CPI 0–2 (n = 1606)		CPI 3–4 (n = 158)		p-value[a]	OR (95% CI)	LOA 0–1 (n = 1592)		LOA 2–4 (n = 172)		p-value[a]	OR (95% CI)
	n	%	n	%	n	%			n	%	n	%		
Age (years)														
18–34	339	19.2	323	20.1	16	10.1	< 0.001	1.00	335	21.0	4	2.3	< 0.001	1.00
35–49	575	32.6	534	33.3	41	26.0		1.55 (0.87–2.89)	537	33.7	38	22.1		5.93 (2.36–19.89)
50–64	449	25.5	395	24.6	54	34.2		2.76 (1.59–5.07)	380	23.9	69	40.1		15.21 (6.22–50.31)
65+	401	22.7	354	22.0	47	29.8		2.68 (1.52–4.96)	340	21.4	61	35.5		15.02 (6.11–49.85)
Gender														
Female	982	55.7	917	57.1	65	41.1	< 0.001	1.00	907	57.0	75	43.6	< 0.001	1.00
Male	782	44.3	689	42.9	93	58.9		1.90 (1.37–2.66)	685	43.0	97	56.4		1.71 (1.25–2.36)
Marital status														
Single	278	15.8	268	16.7	10	6.3	0.001	1.00	271	17.0	7	4.1	< 0.001	1.00
Married	1334	75.6	1206	75.1	128	81.0		2.84 (1.55–5.85)	1198	75.3	136	79.1		4.39 (2.19–10.47)
Divorced/widowed	152	8.6	132	8.2	20	12.7		4.06 (1.89–9.28)	123	7.7	29	16.9		9.12 (4.11–23.16)
Education														
College or higher	550	31.2	519	32.3	31	19.6	< 0.001	1.00	528	33.2	22	12.8	< 0.001	1.00
Senior high	407	23.1	384	23.9	23	14.6		1.00 (0.57–1.74)	374	23.5	33	19.2		2.12 (1.22–3.74)
Junior high	184	10.4	163	10.2	21	13.3		2.16 (1.19–3.84)	166	10.4	18	10.5		2.60 (1.35–4.96)
Elementary	393	22.3	335	20.9	58	36.7		2.90 (1.85–4.63)	331	20.8	62	36.1		4.50 (2.75–7.60)
< Elementary	230	13.0	205	12.8	25	15.8		2.04 (1.17–3.54)	193	12.1	37	21.5		4.60 (2.67–8.11)
CHQ-12 score														
0–2	1113	63.1	1012	63.0	101	63.9	0.972	1.00	1014	63.7	99	57.6	0.023	1.00
3–5	477	27.0	435	27.1	42	26.6		0.97 (0.66–1.40)	431	27.1	46	26.7		1.09 (0.75–1.57)
6+	174	9.9	159	9.9	15	9.5		0.95 (0.52–1.62)	147	9.2	27	15.7		1.88 (1.17–2.94)
Smoking habit														
Nonsmoker	1411	80.0	1295	80.6	116	73.4	0.031	1.00	1299	81.6	112	65.1	< 0.001	1.00
Smoker	353	20.0	311	19.4	42	26.6		1.51 (1.03–2.17)	293	18.4	60	34.9		2.37 (1.69–3.32)
Remaining teeth														
< 10	172	9.8	166	10.3	6	3.8	< 0.001	1.00	165	10.4	7	4.1	< 0.001	1.00
10–19	278	15.8	239	14.9	39	24.7		4.51 (2.01–12.08)	226	14.2	52	30.2		5.42 (2.56–13.36)
≥ 20	1314	74.5	1201	74.8	113	71.5		2.60 (1.23–6.73)	1201	75.4	113	65.7		2.22 (1.09–5.32)
CPI														
0, healthy	686	38.9							682	42.8	4	2.3	< 0.001	1.00
1, gingival bleeding upon probing	375	21.3							362	22.7	13	7.6		6.12 (2.15–21.83)
2, calculus	545	30.9							459	28.8	86	50.0		31.95 (13.22–104.99)
3, pocket depth, 4–5 mm	126	7.1							78	4.9	48	27.9		104.92 (41.38–354.17)
4, pocket depth, ≥ 6 mm	32	1.8							11	0.7	21	12.2		325.50 (105.20–1270.03)
LOA														
0, 0–3 mm	1091	61.9	1072	66.8	19	12.0	< 0.001	1.00						
1, 4–5 mm	501	28.4	431	26.8	70	44.3		9.16 (5.57–15.81)						
2, 6–8 mm	131	7.4	89	5.5	42	26.6		26.63 (15.07–48.67)						
3, 9–11 mm	27	1.5	10	0.6	17	10.8		95.92 (39.70–245.17)						
4, ≥ 12 mm	14	0.8	4	0.3	10	6.3		141.05 (43.20–552.48)						

[a]Chi-square test.

CHQ-12, 12-item Chinese health questionnaire; CPI, community periodontal index; LOA, loss of attachment.

of attachment as independent outcome variables in two independent models. For example, a community periodontal index score of ≥ 3 and a loss of attachment score of < 2 would be defined as disease for community periodontal index but as nondisease for loss of attachment. A community periodontal index score of < 3 and a loss of attachment score of ≥ 2 would be defined as disease for loss of attachment but as nondisease for community periodontal index. When comparing the risk factors for periodontal diseases between smokers and nonsmokers, we conducted analyses to evaluate whether the association between mental health and periodontal health (community periodontal index and loss of attachment, respectively) could be modified by smoking status. We also used linear trend analyses to reveal the dose–response effect of the variables with periodontal status. All statistical operations were performed using SAS version 9.1 (SAS Institute, Cary, NC, USA).

Results

We characterized the participants by demographic variables and periodontal status (Table 1). Male, divorced/widowed or married people, older subjects, those with a lower level of education, smokers and those with a larger number of remaining teeth tended to have higher community periodontal index scores (community periodontal index 3–4 disease group). The same groups and those with poorer CHQ-12 scores tended to have higher loss of attachment scores (loss of attachment 2–4 disease group) (Table 1).

Table 2 shows the results of multivariate logistic regression analysis. Gender, marital status, level of education and number of remaining teeth were significantly associated with higher community periodontal index scores. Age, CHQ-12 score and smoking were not. Men were more likely to have higher community periodontal index scores than women (odds ratio = 2.10, 95% confidence interval = 1.42–3.10). Married and divorced/widowed individuals were more likely to have higher community periodontal index scores than those who were single (odds ratio = 2.21, 95% confidence interval = 1.06–4.99, and odds ratio = 2.53, 95% confidence interval = 1.03–6.53, respectively). Age, level of education, CHQ-12 score, smoking and number of remaining teeth were significantly associated with higher loss of attachment scores. Gender and marital status were not. Subjects 65+, 50–64 and 35–49 years of age tended to have higher loss of attachment scores than those who were 18–34 years of age (odds ratios = 7.99, 9.05, and 4.04, respectively). Subjects with CHQ-12 scores of ≥ 6 were more likely to have higher loss of attachment scores than those with CHQ-12 scores of 2 or below (odds ratio = 1.69, 95% confidence interval = 1.01–2.77). Moreover, there was a dose–response trend between the CHQ-12 score and the loss of attachment score (p trend = 0.032). Smokers were more likely to have higher loss of attachment scores (odds ratio = 2.21, 95% confidence interval = 1.45–3.37).

We examined in more detail the association of these variables and periodontal health stratified by smoking status (community periodontal index in Table 3, loss of attachment in Table 4). Age and CHQ-12 score seemed to be more strongly associated with loss of attachment among smokers than nonsmokers, while marital status was only significantly associated with community periodontal index scores among nonsmokers. Compared with nonsmokers in the 18–34 years age-range, smokers had a greater risk

Table 2. Multivariate logistic regression results for the community periodontal index (CPI) scores (3–4 vs. 0–2) and loss of attachment (LOA) scores (2–4 vs. 0–1)

	CPI (3–4 vs. 0–2)		LOA (2–4 vs. 0–1)	
Variables	Odds ratio (95% CI)	p-Value	Odds ratio (95% CI)	p-Value
Age (years)				
18–34	1.00		1.00	
35–49	0.92 (0.47–1.87)	0.815	4.04 (1.49–14.25)	0.013
50–64	1.20 (0.59–2.54)	0.622	9.05 (3.30–32.24)	< 0.001
65+	0.99 (0.45–2.26)	0.984	7.99 (2.74–29.60)	< 0.001
Test for linear trend		0.010		< 0.001
Gender				
Female	1.00		1.00	
Male	2.10 (1.42–3.10)	< 0.001	1.49 (1.00–2.22)	0.052
Marital status				
Single	1.00		1.00	
Married	2.21 (1.06–4.99)	0.043	1.76 (0.78–4.52)	0.203
Divorced/widowed	2.53 (1.03–6.53)	0.047	2.48 (0.99–6.89)	0.064
Education				
College or higher	1.00		1.00	
Senior high	0.91 (0.51–1.60)	0.745	1.64 (0.93–2.94)	0.093
Junior high	1.84 (0.98–3.39)	0.052	1.47 (0.74–2.89)	0.264
Elementary	2.50 (1.44–4.41)	0.001	1.96 (1.12–3.51)	0.021
< Elementary	2.25 (1.12–4.53)	0.023	2.34 (1.20–4.64)	0.013
Test for linear trend		< 0.001		< 0.001
CHQ-12 score				
0–2	1.00		1.00	
3–5	0.97 (0.65–1.43)	0.885	1.04 (0.70–1.52)	0.844
6+	0.92 (0.49–1.62)	0.774	1.69 (1.01–2.77)	0.042
Test for linear trend		0.158		0.032
Smoking habit				
Nonsmokers	1.00		1.00	
Smokers	1.03 (0.67–1.58)	0.885	2.21 (1.45–3.37)	< 0.001
Remaining teeth				
< 10	1.00		1.00	
10–19	5.95 (2.58–16.21)	< 0.001	7.80 (3.57–19.70)	< 0.001
≥ 20	4.23 (1.90–11.26)	0.001	4.49 (2.11–11.11)	< 0.001
Test for linear trend		< 0.001		0.463

CHQ-12, 12-item Chinese health questionnaire; CI, confidence interval.

Table 3. Multivariate logistic regression result for the community periodontal index score (3–4 vs. 0–2) in nonsmokers and smokers

	Nonsmokers (n = 1411)		Smokers (n = 353)	
Variables	Odds ratio (95% CI)	p-Value	Odds ratio (95% CI)	p-Value
Age (years)				
18–34	1.00		1.00	
35–49	0.93 (0.43–2.17)	0.857	0.64 (0.17–2.58)	0.517
50–64	1.07 (0.47–2.62)	0.875	1.19 (0.30–5.03)	0.811
65+	1.25 (0.50–3.30)	0.646	0.40 (0.08–2.02)	0.259
Test for linear trend		0.013		0.351
Gender				
Female	1.00		1.00	
Male	1.96 (1.30–2.96)	0.001	3.29 (0.84–22.46)	0.1378
Marital status				
Single	1.00		1.00	
Married	3.38 (1.26–10.81)	0.024	1.16 (0.38–4.04)	0.806
Divorced/widowed	3.83 (1.21–13.83)	0.029	1.27 (0.24–6.61)	0.774
Education				
College or higher	1.00		1.00	
Senior high	0.92 (0.48–1.73)	0.796	0.89 (0.23–3.36)	0.858
Junior high	1.60 (0.77–3.24)	0.196	2.75 (0.76–10.77)	0.127
Elementary	1.91 (1.01–3.68)	0.048	5.98 (1.90–22.23)	0.004
< Elementary	1.66 (0.73–3.73)	0.222	4.25 (0.97–19.87)	0.057
Test for linear trend		< 0.001		0.144
CHQ-12 score				
0–2	1.00		1.00	
3–5	1.07 (0.67–1.67)	0.758	0.74 (0.32–1.61)	0.458
6+	0.92 (0.44–1.79)	0.815	0.96 (0.25–2.98)	0.948
Test for linear trend		0.161		0.920
Remaining teeth				
< 10	1.00		1.00	
10–19	10.47 (3.57–44.73)	< 0.001	1.72 (0.37–9.48)	0.501
≥ 20	6.82 (2.39–28.75)	0.002	1.63 (0.46–7.74)	0.488
Test for linear trend		< 0.001		0.030

CHQ-12, 12-item Chinese health questionnaire; CI, confidence interval.

of loss of attachment than nonsmokers at all ages (odds ratios: 65+ years, 16.96 vs. 5.29; 50–64 years, 22.54 vs. 5.56; and 35–49 years 7.62 vs. 2.77). Smokers with a CHQ-12 score of ≥ 6 were more likely to have higher loss of attachment scores than smokers with a CHQ-12 score of 0–2 (odds ratio = 2.49, 95% confidence interval = 0.91–6.49). Nonsmokers with a CHQ-12 score of ≥ 6 were more likely to have higher loss of attachment those with a CHQ-12 score of 0–2 (odds ratio = 1.43, 95% confidence interval = 0.76–2.58). In the community periodontal index model, compared with single subjects, nonsmoking married and divorced/widowed subjects tended to have a higher community periodontal index score (odds ratio = 3.38, 95% confidence interval = 1.26–10.81, and odds ratio = 3.83, 95% confidence interval = 1.21–13.83, respectively).

Discussion

This study found a significant association between psychosocial factors and loss of attachment (odds ratio = 1.69, 95% confidence interval = 1.01–2.77), which was stronger among smokers than among nonsmokers (odds ratio = 2.49, 95% confidence interval = 0.91–6.49 for smokers; odds ratio = 1.43, 95% confidence interval = 0.76–2.58 for nonsmokers). The relationship between psychosocial factors and attachment loss also showed a dose–response effect. We found marital status to be a significant risk factor for periodontal disease among nonsmokers but not among smokers.

While psychosocial stress (determined using the CHQ-12) was predictive of loss of attachment, it was not found to be significantly correlated to the community periodontal index. The reason for this difference may be that loss of attachment demonstrates long-term accumulative disease status and represents true periodontal destruction, whereas the community periodontal index reflects more the pocket depth rather than loss of attachment, although the higher scores of community periodontal index could mean gingival enlargement without loss of attachment, loss of attachment alone, or a combination of these two processes. Therefore, the association we identified between psychosocial factors and periodontal health was found in loss of attachment. The biological mechanism behind this association may be related to the possibility that stress or depression modifies the immune response, regulates other responses to periodontopathic bacteria, changes the gingival circulation and produces endocrinological disturbance (30,31), all of which may cause an imbalance in the immune system, leading to a breakdown of the microenvironment equilibrium and resulting in the development of periodontal disease (1).

We examined the association between psychosocial factors and periodontal health stratified in smokers and nonsmokers, and found that smoking was not only significantly associated with periodontal health (odds ratio = 2.21, 95% confidence interval = 1.45–3.37) in the loss of attachment regression model but also that it could modify the association between psychosocial factors and periodontal health. Those with a CHQ-12 score of ≥ 6 had a higher odds ratio (odds ratio) of loss of attachment if they were smokers (odds ratio = 2.49, 95% confidence interval = 0.91–6.49) than if they were nonsmokers (odds ratio = 1.43, 95% confidence interval = 0.76–2.58). The mechanism of smoking's effect on loss of attachment might be that nicotine inhibits the attachment and growth of periodontal ligament fibroblasts, resulting in periodontal destruction (32). The synergistic effect of smoking and psychosocial factors

Table 4. Multivariate logistic regression result for loss of attachment score (2–4 vs. 0–1) in nonsmokers and smokers

Variables	Nonsmokers (n = 1411)		Smokers (n = 353)	
	Odds ratio (95% CI)	p-Value	Odds ratio (95% CI)	p-Value
Age (years)				
18–34	1.00		1.00	
35–49	2.77 (0.85–12.84)	0.130	7.62 (1.35–144.25)	0.060
50–64	5.56 (1.69–26.00)	0.012	22.54 (3.83–435.42)	0.005
65+	5.29 (1.48–26.00)	0.020	16.96 (2.57–341.74)	0.013
Test for linear trend		< 0.001		< 0.001
Gender				
Female	1.00		1.00	
Male	1.33 (0.85–2.05)	0.205	3.31 (0.98–15.76)	0.082
Marital status				
Single	1.00		1.00	
Married	2.18 (0.68–9.90)	0.242	1.52 (0.50–5.73)	0.494
Divorced/widowed	2.88 (0.81–13.98)	0.136	2.92 (0.67–14.28)	0.163
Education				
College or higher	1.00		1.00	
Senior high	1.48 (0.74–3.00)	0.265	2.35 (0.81–7.60)	0.131
Junior high	1.12 (0.43–2.70)	0.800	2.62 (0.84–8.88)	0.105
Elementary	1.84 (0.93–3.77)	0.085	2.48 (0.89–7.76)	0.096
< Elementary	2.57 (1.16–5.85)	0.022	1.91 (0.52–7.34)	0.334
Test for linear trend		< 0.001		< 0.001
CHQ-12 score				
0–2	1.00		1.00	
3–5	0.82 (0.49–1.33)	0.439	1.61 (0.81–3.17)	0.167
6+	1.43 (0.76–2.58)	0.244	2.49 (0.91–6.49)	0.066
Test for linear trend		0.172		0.122
Remaining teeth				
< 10	1.00		1.00	
10–19	7.98 (3.25–24.09)	< 0.001	6.86 (1.54–48.89)	0.022
≥ 20	3.92 (1.63–11.70)	0.006	5.94 (1.55–39.45)	0.024
Test for linear trend		0.861		0.410

CHQ-12, 12-item Chinese health questionnaire; CI, confidence interval.

may contribute to the complex and interactive mechanisms of the immunological reactions between these two factors (33–35). Kamma (21) reported that both exposure to smoking and stress affects the cytokine network, resulting in an increased pathogenicity of the microbial flora. In addition, anxiety and depression have been reported to be associated with the number of cigarettes consumed (36). The significant relationship identified between psychosocial factors and loss of attachment in smokers may partially contribute to the residual confounders from the number of cigarettes smoked on a regular basis. Further studies are required to clarify this possibility.

Divorced/widowed and married nonsmoker subjects were more likely to have a higher community periodontal index score than single -nonsmoker subjects after adjusting for age and other variables. That, as reported in another study, widowed individuals had poor periodontal health may be a result of traumatic life events increasing the risk for periodontal disease (37). However, our finding in married vs. single subjects was different from the results of this Swedish study, which reported that the incidence of periodontal disease was not significantly different between single subjects and married individuals (37). This might be explained by the different populations. Further studies are required to evaluate this relationship.

As tooth loss is partly a consequence of periodontal disease, inclusion of number of remaining teeth in our analyses might have led to over-adjustment in the analyses. However, both loss of attachment and community periodontal index scores were measured in selected teeth and these scores might be affected by the number of remaining teeth, which were also exposed to smoking and other factors. Hence, we still included number of remaining teeth in our analysis. Additional analyses without number of remaining teeth were also performed to evaluate the potential bias caused by over-adjustment and the results were similar to our final analyses.

This study had several limitations. First, the proportion of subjects with a community periodontal index score of 3–4 or a loss of attachment score of 2–4 were lower than reported in other studies. This may be the result of selection bias, as people who wish to participate in a dental health study and be examined are probably those who are more careful of their own dental health. Second, clinical analyses were made on index teeth according to the World Health Organization oral health surveys. The selection of test teeth may produce a biased estimate of disease status (38,39). We conducted clinical evaluations without knowing the smoking and psychosocial status. The potential error in measuring periodontal disease was unlikely to be associated with exposure status. Hence, this non-differential misclassification was more likely to attenuate our findings on the association between periodontal diseases and other factors. Therefore, the significant findings obtained in our study could be expected to be stronger. However, if such misclassification did not provide a tendency for a randomly even distribution of disease classification, the results of our study may have some unpredictable bias on the association between periodontal diseases and other factors. Further studies are needed to verify this result. Third, the subjects of our study were Taiwanese. As ethnicity is a risk factor in periodontal health, our findings might be valid, particularly with reference to the Asian population. Further studies are recommended in subjects of other races to verify our present findings.

In conclusion, this study found an association between psychosocial factors and periodontal disease. The association was made stronger by smoking. The effects of these factors are closely associated with loss of

attachment and not with community periodontal index. Among nonsmokers, marital status was a significant risk factor for periodontal disease in the community periodontal index.

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