

# Trends in the prevalence of periodontitis in Taiwan from 1997 to 2013

## A nationwide population-based retrospective study

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### Abstract

Periodontitis is one of the most prevalent oral diseases. In this study, we probed the nationwide registered database to assess the time trends of prevalence of periodontitis in Taiwan.

A retrospective study was conducted to analyze the registered database compiled by the National Health Insurance provided by the Department of Health, Taiwan, from 1997 to December 2013.

We found that the prevalence of periodontitis significantly increased from 11.5% in 1997 to 19.59% in 2013 ( $P$  for trend < .0001). The mean age  $\pm$  standard deviation with periodontitis from 1997 to 2013 was  $54.46 \pm 14.47$  and  $45.51 \pm 16.58$  years old, respectively. The proportion of individuals with periodontitis in age group >65 years old decreased markedly. The proportion of individuals with periodontitis in age groups <25 and 26 to 35 years old demonstrated an increased pattern. Compared to the reference cohort of 1953 to 1957, the recent birth cohort of 1993 to 1997 revealed the highest relative risk (RR) of periodontitis (male: RR, 67.42, 95% confidence interval [CI], 17.04–266.76; female: RR, 65.85, 95% CI, 16.70–259.70). Both male and female groups showed the similar age-effect pattern in the cross-sectional age curve from age–period–cohort model. There was an upturn with advancing age up to 40 to 50 years old and then a downward trend in both genders. Population dwelling in suburban area (RR, 0.95; 95% CI, 0.94–0.97) and rural area (RR, 0.97; 95% CI, 0.95–0.99) had the lower risk of periodontitis than those who lived in urban area. The higher income group revealed the higher risk of periodontitis compared with lower income group (RR, 1.20; 95% CI, 1.18–1.23).

The prevalence of periodontitis significantly increased in Taiwan over past 17 years. The mean age with periodontitis was shown in a decreased pattern. The use of a nationwide population-based database could provide sufficient sample size, generalizability, and statistical power to assess the periodontal status in Taiwan.

**Abbreviations:** APC = age–period–cohort analysis, CI = confidence interval, ICD-9-CM = International Classification of Diseases Ninth Clinical Modification, NHI = National Health Insurance, NHIRD = National Health Insurance Research Database, NTD = New Taiwan Dollar, PPY = percent per year, RR = relative risk, SD = standard deviation.

**Keywords:** nationwide population-based study, periodontitis, prevalence, Taiwan

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## 1. Introduction

In addition to caries, periodontal disease is the most prevalent oral diseases among adults worldwide that average 11.2% of the populations suffer from severe chronic periodontitis worldwide.<sup>[1]</sup> In general, periodontitis accounts for most cases of tooth loss, and their impact increases with age. The prevalence of periodontally healthy individuals is increasing and severe periodontitis is more common in older age groups.<sup>[2–6]</sup> Smoking, inadequate oral hygiene, stress, and lifestyle-related comorbidities are well-known risk factors for periodontitis.<sup>[7]</sup> Studies have also shown that irregular or no use of dental health services and low education level are important factors associated with periodontitis.<sup>[8–10]</sup>

Currently, in Taiwan, periodontitis is reported to have affected more than half of the adult population with the definition of community periodontal index  $\geq 3$ .<sup>[11]</sup> However, up to now, a retrospective large national cohort study involving patient samples stratified on the basis of demographic information has not been conducted. Taiwan's National Health Insurance (NHI) began in March 1, 1995 and covered 99.9% of Taiwan's residents by 2014.<sup>[12]</sup> Such a high coverage rate made the NHI database the best national indicator of health issues and easier to

update annually de-identified by scrambling the identification codes of both patients and medical facilities formatted as a National Health Insurance Research Database (NHIRD).

The aim of this study was then to investigate the prevalence of periodontitis in Taiwan from NHIRD. In addition, the age, sex, income, geographical region, and urbanization factors using the same methodology to investigate the prevalence of periodontitis in data available from cross-sectional analysis conducted from 1997 to 2013. In addition, age–period–cohort (APC) analysis was performed to investigate the effects of age, diagnosis period, and birth cohort with periodontitis from 1999 to 2013.

## 2. Materials and methods

### 2.1. Data source and ethical consideration

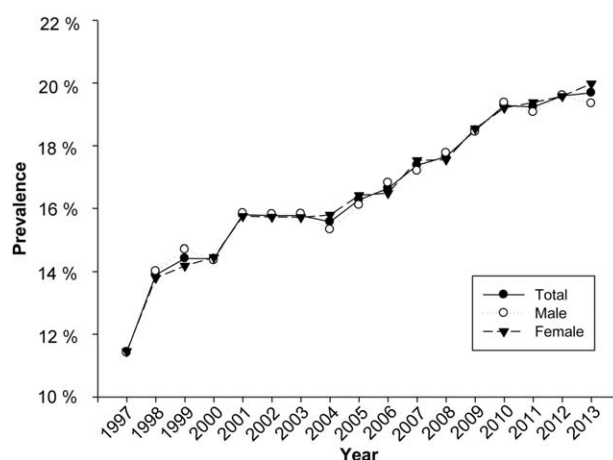
This study was approved by the Ethics Review Board at the Chung Shan Medical University Hospital. With strict confidentiality guidelines being closely followed in accordance with personal electronic data protection regulations; the National Health Research Institutes anonymized and maintained the NHI reimbursement data as files suitable for researches. No written informed consent was obtained from the participants, because the identification numbers used in the NHIRD assure patient anonymity. The data subset systematic sampling of the ambulatory care expenditures by visit together with the related records in details of ambulatory care orders was used for this study from 1997 to 2013. This report complies with Strengthening the Reporting of Observational Studies in Epidemiology guidelines for the observational studies.

### 2.2. Patient identification and measurements

The diagnostic coding of NHI in Taiwan is according to the International Classification of Diseases, Ninth Clinical Modification (ICD-9-CM). The cases of periodontitis were identified with ICD-9 codes of 523.3, 523.4, and 523.5. To ensure the criteria of indication and the accuracy of diagnosis for periodontitis, ICD-9 procedure code 9654, 2431, and 2439 were also defined. The codes 9654, 2431, and 2439 corresponding to Taiwan NHI's Fee Schedule for Medical Services claim codes from 91004 to 91010 were included. Information about the collection of pocket depth data in the patient's record has been described for each periodontal treatment. The estimated annual prevalence rate of periodontitis from 1997 to 2013 was extracted from population of systematic sampling of the ambulatory care expenditures by visit together with the related records in details of ambulatory care orders. The population aged equal to or under 12-year, older than 90-year and with missing data were excluded. Monthly income was categorized as follows: <New Taiwan Dollar (NTD) \$20,000, NTD \$20,000 to 40,000, and >NTD\$40,000. The urbanization of the locations of NHI registration was used as a proxy parameter for socioeconomic status. Urbanization was categorized 3 levels: urban, suburban, and rural areas based on the classification scheme proposed by Liu et al.<sup>[13]</sup>

### 2.3. Statistical analysis

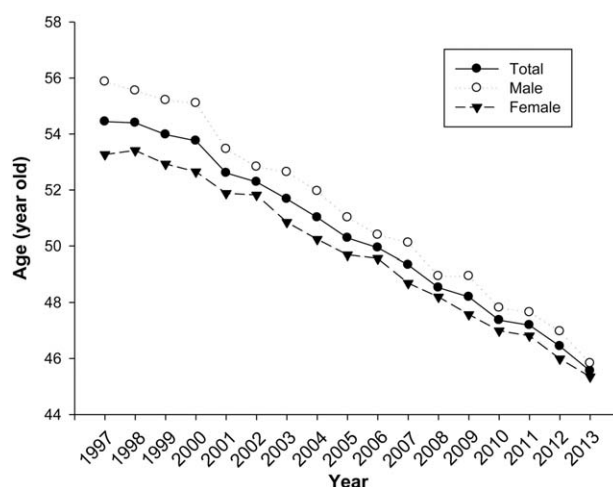
Annual prevalence rate of periodontitis was examined by Cochran–Armitage trend test for probing the trend from 1997 to 2013. A *P* value for trend <.05 was set to declare statistical significance. Mean age with standard deviation (SD) of



**Figure 1.** Time trends for the prevalence of periodontitis in Taiwan. The prevalence of periodontitis increased significantly from 11.5% in 1997 to 19.59% in 2013.

population of periodontitis was presented annually. The age-specific estimates and prevalence rates by age distribution which divided into 6 subgroups ( $\leq 25$ , 26–35, 36–45, 46–55, 56–65, and  $\geq 65$ ) were calculated. We conducted Student *t* test to investigate the differences within continuous variables and one sample chi-squared test within categorical variables.

APC analysis was performed to investigate the effects of age, diagnosis period, and birth cohort with periodontitis. Cases of periodontitis were categorized into 15 age groups (16–20 to 86–90), 3 period groups (1999–2003, 2004–2008, and 2009–2013), and 17 birth cohort groups (1913–1917 to 1993–1997) with a corresponding 5-year interval. Several models such as age alone, period alone, cohort alone, and APC were generated. The goodness of fit for the specified model was evaluated by the deviance/degree of freedom. Relative risk (RR), percent per year (PPY), and 95% confidence interval (CI) of periodontitis for males and females by APC analysis were calculated. The socioeconomic-specific estimates and prevalence rates by subgroups including distribution of urbanization and payroll bracket



**Figure 2.** Mean age of patients with periodontitis in Taiwan. The mean age for periodontitis was shown a decrease pattern from 1997 to 2013.

**Table 1****Mean age of patients with periodontitis in Taiwan from 1997 to 2013.**

Year	Extracted residents	Periodontitis	Mean age, y	Standard deviation	Male	Mean age, y	Standard deviation	Female	Mean age, y	Standard deviation	P
1997	40,119	4851	54.46	14.47	2201	55.87	14.58	2650	53.27	14.27	<.00001
1998	42,565	6227	54.33	14.60	2894	55.55	14.81	3333	53.41	14.45	<.00001
1999	44,036	6614	53.97	14.81	3066	55.21	14.90	3548	52.93	14.68	<.00001
2000	44,680	6668	53.68	14.90	3038	55.10	15.21	3630	52.65	14.59	<.00001
2001	46,564	7577	52.59	15.11	3523	53.46	15.38	4054	51.88	14.87	<.00001
2002	47,228	7635	52.23	15.12	3567	52.83	15.17	4068	51.82	15.09	.0036
2003	47,713	7675	51.67	15.47	3604	52.64	15.63	4071	50.85	15.28	<.00001
2004	52,973	8381	51.03	15.60	3833	51.96	15.70	4548	50.24	15.47	<.00001
2005	53,568	8820	50.29	15.71	4037	51.02	15.74	4783	49.69	15.67	<.00001
2006	53,716	8990	49.96	16.13	4187	50.40	16.32	4803	49.56	15.95	.0138
2007	54,420	9484	49.34	16.06	4361	50.12	16.27	5123	48.69	15.84	<.00001
2008	54,967	9679	48.53	16.06	4447	48.94	16.18	5232	48.20	15.94	.0238
2009	55,065	10,131	48.18	16.16	4673	48.94	16.23	5458	47.57	16.05	<.00001
2010	54,777	10,452	47.34	16.25	4822	47.81	16.41	5630	46.99	16.08	.01
2011	53,711	10,192	47.18	16.73	4678	47.65	16.79	5514	46.81	16.66	.0116
2012	54,409	10,483	46.38	16.63	4852	46.97	16.70	5631	45.99	16.49	.0026
2013	55,065	10,614	45.51	16.58	4802	45.83	16.72	5812	45.35	16.41	.137

(monthly income) were calculated separately. The RR and 95% CI of periodontitis for urbanization and payroll bracket from 1997 to 2013 after adjusting for year, gender, and age groups were evaluated by multivariate Poisson regression. The results were considered significant with a 2-tailed  $P < .05$ . All statistical analyses were performed with the SPSS version 22 (SPSS, Chicago, IL). For APC analysis, we performed with a web tool (Division of Cancer Epidemiology and Genetics, National Cancer Institute, National Institutes of Health, Maryland).<sup>[14]</sup>

### 3. Results

A total of 904,380 subjects were enrolled into this study. Of these, 144,473 subjects (66,585 males and 77,708 females, respectively) were diagnosed as periodontitis according to the ICD-9-CM criteria in this study. As shown in Fig. 1, the annual prevalence steadily increased for overall and both gender during the study period. The annual prevalence rates of periodontitis examined by Cochran–Armitage trend test indicated significant increasing trends for prevalence of periodontitis ( $P$  for trend  $< .0001$ ). The prevalence of periodontitis by year gradually increased from 11.5% in 1997 to 19.59% in 2013 over the 17-year study period. The prevalence of periodontitis was also increased significantly in both genders (male:  $P$  for trend  $< .0001$ ; female:  $P$  for trend  $< .0001$ ).

As shown in Fig. 2, the mean age for periodontitis was shown a decreased pattern from 1997 to 2013. The mean age  $\pm$  SD of

patients with periodontitis in Taiwan from 1997 to 2013 was demonstrated in Table 1. The mean age  $\pm$  SD with periodontitis from 1997 to 2013 was  $54.46 \pm 14.47$  and  $45.51 \pm 16.58$  years old, respectively. In addition, the mean age  $\pm$  SD in male group from 1997 to 2013 was  $55.87 \pm 14.58$  and  $45.83 \pm 16.72$  years old, respectively. The mean age  $\pm$  SD in female group from 1997 to 2013 was  $53.27 \pm 14.27$  and  $45.35 \pm 16.41$  years old, respectively.

Prevalence categorized by age group and gender is shown in Table 2. The prevalence of periodontitis at age group  $\leq 25$ , 26–35, 36–45, 46–55, 56–65, and  $> 65$  years old was 4.66%, 15.51%, 19.85%, 21.22%, 20.83%, and 16.04%, respectively. It was also noted that male with significantly higher prevalence rates than female in age group of 46 to 55 and 56 to 65 years old ( $P < .0001$ ), while female who aged  $< 25$  years old had a significantly higher prevalence rate than male ( $P < .0001$ ).

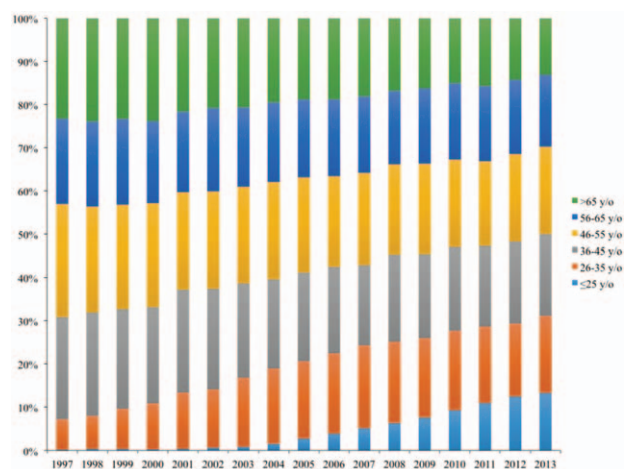
Frequency distribution (%) of patients with periodontitis in various age groups in Taiwan from 1997 to 2013 is shown in Fig. 3. The proportion of age group  $> 65$  years old with periodontitis individuals decreased markedly. Interestingly, the proportion of age groups  $< 25$  and 26 to 35 years old with periodontitis individuals significantly increased.

Table 3 showed the results of APC model for male and female groups. The effects of age, diagnosis period, and birth cohort of periodontitis by gender were revealed in Table 4. The full APC model provided a significantly better fit to the data in male ( $P = .12$ ) than that in female ( $P = .03$ ). The age effect showed significant differences in both gender, indicating the age groups

**Table 2****Population and prevalence of periodontitis by age distribution in Taiwan from 1997 to 2013.**

Age, y	Extracted resident	Periodontitis	Total prevalence rate, %	Male	Male prevalence rate, %	Female	Female prevalence rate, %	P
$\leq 25$	164,433	7657	4.66	3517	4.39	4140	4.91	<.0001
26–35	148,287	22,996	15.51	9872	15.37	13,124	15.63	.1809
36–45	150,321	29,834	19.85	12,990	20.14	16,844	19.78	.0817
46–55	147,589	31,315	21.22	14,784	22.14	16,531	20.55	<.0001
56–65	128,107	26,102	20.38	12,518	21.12	13,584	19.75	<.0001
$> 65$	165,643	26,569	16.04	12,904	15.82	13,665	16.26	.9203

Chi-squared test was conducted for statistical analysis.



**Figure 3.** Frequency distribution of age-specific group in the prevalence of periodontitis in Taiwan from 1997 to 2013.

16 to 20 years old had highest PPY than any other age groups. Compared to the reference cohort of 1953 to 1957, the recent birth cohort of 1993 to 1997 had highest RR of periodontitis (male: RR, 67.42; 95% CI, 17.04–266.76; female: RR, 65.85; 95% CI, 16.70–259.70). No obvious period effect of periodontitis was observed in both genders. As shown in Fig. 4, it was evident that both male and female demonstrated the similar age-effect pattern in the cross-sectional age curve from APC model. There was an upturn with advancing age up to 40 to 50 years old and then a downward trend in both genders.

The results of multivariate Poisson regression on the risk of periodontitis for urbanization and payroll bracket (monthly income) in Taiwan from 1997 to 2013 were shown in Table 5. Population dwelling in suburban area (RR, 0.95; 95% CI, 0.94–0.97) and rural area (RR, 0.97; 95% CI, 0.95–0.99) had the lower risk of periodontitis than those who lived in urban area. In addition, the higher income group revealed the higher risk of periodontitis compared with lower income group (RR, 1.20; 95% CI, 1.18–1.23).

**4. Discussion**

The nationwide survey of the prevalence of periodontitis had been reported in France,<sup>[2]</sup> German,<sup>[3]</sup> China,<sup>[15]</sup> the United States,<sup>[10]</sup> and Taiwan.<sup>[11]</sup> Several studies of the trends in periodontal conditions had been reported in the cities of

**Table 4**  
Percent per year (PPY), relative risk (RR), and 95% confidence interval (CI) of periodontitis for males and females by age–period–cohort analysis in Taiwan from 1999 to 2013.

	Male		Female	
	PPY	95% CI	PPY	95% CI
Age, y				
16–20	42.737	26.32, 61.29	42.329	25.75, 61.10
21–25	14.163	6.86, 21.97	12.48	5.48, 19.95
26–30	7.026	2.02, 12.27	5.922	1.37, 10.67
31–35	2.671	–1.00, 6.48	2.84	–0.52, 6.31
36–40	0.518	–2.76, 3.91	0.923	–2.05, 3.99
41–45	–0.013	–3.23, 3.31	0.163	–2.86, 3.28
46–50	–0.778	–3.85, 2.39	–0.095	–3.12, 3.03
51–55	–1.206	–4.23, 1.91	0.077	–2.91, 3.15
56–60	–0.846	–3.92, 2.32	0.427	–2.69, 3.65
61–65	–1.001	–4.42, 2.54	0.087	–3.37, 3.66
66–70	–1.066	–5.28, 3.34	–0.755	–4.88, 3.55
71–75	–0.463	–5.39, 4.72	–0.811	–5.50, 4.11
76–80	–0.716	–6.38, 5.29	–0.747	–6.26, 5.09
81–85	–1.48	–7.71, 5.17	–0.975	–7.95, 6.53
86–90	–1.256	–9.43, 7.65	–1.057	–11.04, 10.04
	RR	95% CI	RR	95% CI
Period				
1999–2003	0.873	0.758, 1.00	0.862	0.75, 0.99
2004–2008	1 (Ref)	—	1 (Ref)	—
2009–2013	0.974	0.86, 1.11	1	0.88, 1.13
Cohort				
1913–1917	1.478	0.49, 4.46	1.239	0.35, 4.35
1918–1922	1.419	0.60, 3.37	1.179	0.47, 2.94
1923–1927	1.302	0.62, 2.74	1.114	0.54, 2.31
1928–1932	1.222	0.66, 2.28	1.069	0.59, 1.95
1933–1937	1.212	0.73, 2.03	1.034	0.63, 1.71
1938–1942	1.167	0.78, 1.75	0.985	0.66, 1.47
1943–1947	1.089	0.80, 1.49	0.958	0.70, 1.31
1948–1952	1.055	0.82, 1.36	0.994	0.77, 1.28
1953–1957	1 (Ref)	—	1 (Ref)	—
1958–1962	0.934	0.72, 1.21	1.002	0.78, 1.28
1963–1967	0.925	0.68, 1.27	0.991	0.73, 1.35
1968–1972	0.933	0.64, 1.37	1.018	0.71, 1.46
1973–1977	0.974	0.63, 1.51	1.086	0.72, 1.63
1978–1982	1.215	0.73, 2.01	1.347	0.84, 2.16
1983–1987	1.921	1.03, 3.59	1.93	1.08, 3.45
1988–1992	4.567	2.01, 10.36	4.367	1.99, 9.57
1993–1997	67.419	17.04, 266.76	65.85	16.70, 259.70

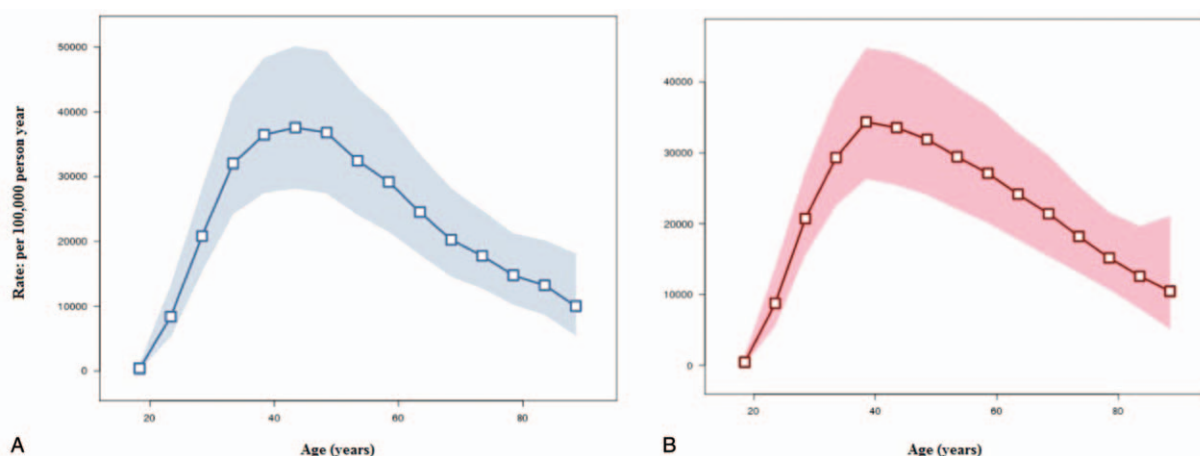
Ref=Reference group.

Europe.<sup>[4–6,16–19]</sup> These surveys were mostly based on the cross-section design, noninstitutionalized population data according to the level of clinical attachment loss and the depth of probing pocket depth. In the present study, to the best of our knowledge, this is the first large-scale, retrospective, and longitudinal population-based study to investigate the prevalence of periodontitis in Taiwan significantly increased from 1997 to 2013. In 2013, the prevalence of periodontitis in Taiwan is approximately up to 20%. However, the ratio is significantly lower than previous nationwide periodontitis survey reports.<sup>[2,3,10,11,15]</sup> The reasons may be explained as following. In this study, the collected data regarding the diagnoses of periodontitis based on the ICD-9 codes recorded in the NHIRD may not truly indicate the severity of periodontitis. In addition, the use of dental care was estimated up to 45% of Taiwan’s population in 2013.<sup>[12]</sup> Therefore, prevalence and severity of

**Table 3**  
Results of age–period–cohort model for periodontitis in Taiwan from 1999 to 2013.

Model	Gender	DF	Deviance	Deviance/DF	P
Age	Male	13	63.81	4.91	<.01
	Female	13	55.42	4.26	<.01
Period	Male	1	1.90	1.90	.17
	Female	1	1.73	1.73	.19
Cohort	Male	15	43.16	2.88	<.01
	Female	15	37.56	2.50	<.01
Age–Period–Cohort	Male	1	2.43	2.43	.12
	Female	1	4.67	4.67	.03

DF=degree of freedom.



**Figure 4.** Cross-sectional age curve from age-period-cohort model in the rate of periodontitis in Taiwan from 1999 to 2013. (A) Male group, (B) Female group.

disease might be underestimated by using nationwide registration system in Taiwan. However, our results discover the important findings that the prevalence of periodontitis increased gradually by year from 1997 to 2013.

To the best of our knowledge, we first found that the mean age of patients suffered from periodontitis was significantly decreased, especially, the proportion of age groups <25 and 26 to 35 years old. Consequently, the proportion of individuals in age group >65 years old with periodontitis was decreased markedly. The reason for this age decreasing trend is not quite clear. It may be due to the data bank used from NHIRD is based on the dental treatment records. A government-run insurer with a single-payer insurance system was established by the Taiwanese Government in 1995 with the goal of ensuring health coverage for the entire population. Moreover, the awareness of periodontitis in Taiwan Government, NHI offers dental prophylaxis twice a year to the public above 12 years old. The youngest cohort aged 16 to 20 years old in 2013 was fully covered by NHI after birth. Therefore, this efficient strategy has successfully increased the rates of early diagnosis and the treatment need for periodontitis.

Socioeconomic statuses such as lower income peoples have been shown to be associated with periodontitis.<sup>[15,20,21]</sup> By contrast, our results found higher income and the level of urbanization with RR of the periodontitis. It might be due to the convenient of dental service. In addition, patients' attitudes toward dental treatment could also influence people's utiliza-

tion of NHI in Taiwan. However, in a systematic review, socioeconomic variables were less important when smoking was included in the analysis.<sup>[22]</sup> Similar results have been shown in other studies of socioeconomic status and periodontal disease.<sup>[20,23]</sup> It is well known that smoking is an important risk factor for periodontitis. The information retrieved from this database did not contain health-related behaviors or status such as smoking. Thus, the effects of smoking or the relation of this behavior and the severity of disease could not be demonstrated in this study.

In Taiwan, the Bureau of NHI routinely samples patient charts randomly to cross-check the quality of claims from all medical institutions, and bias from miscoding or misclassification could be minimized. The use of a nationwide population-based database can provide sufficient sample size, generalizability, and statistical power to assess the periodontal status in Taiwan. It may be beneficial to provide additional data analysis and assist in planning treatment strategies in this national medical care system in periodontal treatment.

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**Table 5**  
**Multivariate Poisson regression of urbanization and payroll bracket for periodontitis in Taiwan from 1997 to 2013.**

	Adjusted OR	95% CI
Urbanization		
Urban	1.00 (Ref)	—
Suburban	0.95	0.94, 0.97
Rural	0.97	0.95, 0.99
Monthly income, NTD\$		
<20,000	1.00 (Ref)	—
20,000–40,000	1.09	1.07, 1.11
>40,000	1.20	1.18, 1.23

Multivariate Poisson regression was adjusted for year, gender, and age groups. CI = confidence interval, NTD=New Taiwan Dollar, OR = odds ratio, Ref=reference group.

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