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 ± standard deviation with periodontitis from 1997 to 2013 was 54.46 ± 14.47 and 45.51 ± 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

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.\[1\] 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.\[2–6\] Smoking, inadequate oral hygiene, stress, and lifestyle-related comorbidities are well-known risk factors for periodontitis.\[7\] Studies have also shown that irregular or no use of dental health services and low education level are important factors associated with periodontitis.\[8–10\]

Currently, in Taiwan, periodontitis is reported to have affected more than half of the adult population with the definition of community periodontal index ≥3.\[11\] 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.\[12\] 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 NHIRD dataset. 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 NHF 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 NHF’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 >NTDS$40,000. The urbanization of the locations of NHF 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.\textsuperscript{[13]}

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 population of periodontitis was presented annually. The age-specific estimates and prevalence rates by age distribution which divided into 6 subgroups (≤25, 26–35, 36–45, 46–55, 56–65, and ≥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
(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).[14]

### 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±SD of patients with periodontitis in Taiwan from 1997 to 2013 was demonstrated in Table 1. The mean age±SD with periodontitis from 1997 to 2013 was 54.46±14.47 and 45.51±16.58 years old, respectively. In addition, the mean age±SD in male group from 1997 to 2013 was 55.87±15.21 and 45.83±16.72 years old, respectively. The mean age±SD in female group from 1997 to 2013 was 53.27±15.70 and 45.35±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 in female (\( P = .03 \)). The age effect showed significant differences in both gender, indicating the age groups

### Table 1

| 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              | 4951          | 54.46       | 14.71             | 2201 | 55.87       | 14.58             | 2650   | 53.27       | 14.27             | .0001|
| 1998 | 42,565              | 6227          | 54.33       | 14.60             | 2894 | 55.55       | 14.81             | 3333   | 53.41       | 14.45             | .0001|
| 1999 | 44,036              | 6614          | 53.97       | 14.81             | 3066 | 55.21       | 14.90             | 3548   | 52.93       | 14.68             | .0001|
| 2000 | 44,680              | 6668          | 53.68       | 14.90             | 3038 | 55.10       | 15.21             | 3630   | 52.65       | 14.59             | .0001|
| 2001 | 46,564              | 7577          | 52.59       | 15.11             | 3523 | 53.46       | 15.38             | 4054   | 51.88       | 14.87             | .0001|
| 2002 | 47,228              | 7655          | 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       | 15.29             | .0001|
| 2004 | 52,973              | 8381          | 51.03       | 15.60             | 3833 | 51.96       | 15.70             | 4548   | 50.24       | 15.47             | .0001|
| 2005 | 53,568              | 8820          | 50.29       | 15.71             | 4037 | 51.02       | 15.74             | 4783   | 49.69       | 15.67             | .0001|
| 2006 | 53,716              | 8990          | 49.96       | 16.13             | 4187 | 50.40       | 16.32             | 4803   | 49.56       | 15.95             | .0138|
| 2007 | 54,240              | 9484          | 49.34       | 16.06             | 4361 | 50.12       | 16.27             | 5123   | 48.69       | 15.84             | .0001|
| 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             | .0001|
| 2010 | 54,777              | 10,452        | 47.34       | 16.25             | 4822 | 47.81       | 16.41             | 5630   | 46.90       | 16.08             | .017 |
| 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 |

Chi-squared test was conducted for statistical analysis.
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 reported in France,[2] German,[3] China,[15] the United States,[4,5] and Taiwan.[6,7] 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 based on the ICD-9 codes recorded in the NHIRD.

## 4. Discussion

The nationwide survey of the prevalence of periodontitis had been reported in France,[3] Germany,[1] China,[11] and the United States[10] and Taiwan.[11] Several studies of the trends in periodontal conditions had been reported in France,[3] Germany,[1] China,[11] the United States,[4,5] and Taiwan.[6,7] 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 based on the ICD-9 codes recorded in the NHIRD. In this study, 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.[1,3,10,11,15] The reasons may be explained as following. In this study, the collected data regarding the diagnose 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.[12,13] Therefore, prevalence and severity of
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. [13,20,21] 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 utilization of NHI in Taiwan. However, in a systematic review, socioeconomic variables were less important when smoking was included in the analysis. [22] Similar results have been shown in other studies of socioeconomic status and periodontal disease. [20,21] 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.

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

| Urbanization | Adjusted OR | 95% CI |
|--------------|-------------|--------|
| Urban        | 1.00 (Ref)  |        |
| Suburban     | 0.95        | 0.94, 0.97 |
| Rural        | 0.97        | 0.95, 0.99 |

| Monthly income, NT$ | Adjusted OR | 95% CI |
|---------------------|-------------|--------|
| <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. NT$ = New Taiwan Dollar. OR = odds ratio. Ref = reference group.

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