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# Comparison and Agreement among Various Case Definitions of Periodontitis: A Secondary Data Analysis

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## Abstract

***Background and aims.*** A plethora of definitions has been used for periodontitis for epidemiological studies. The aim of this cross-sectional study was to assess the impact of different case definitions on the prevalence of periodontitis and to find the level of agreement among them.

***Materials and methods.*** Periodontal records of 300 subjects were randomly selected from the database of Oral Health Center, International Medical University. The prevalence of periodontitis was determined using six different case definitions of I, II, III, IV, Va and Vb previously used in various studies. The definition Va proposed by CDC Periodontal Disease Surveillance Workgroup was adopted as the gold standard to calculate sensitivity and specificity.

***Results.*** There were large variations in the prevalence of periodontitis based on different definitions, ranging from 28% to 76.7%. There was good agreement between definitions III and Vb (0.901) and definitions II and III (0.713). Definition II had the highest agreement with the gold standard (Va) among all the definitions. Excluding definition I, all had a high specificity to the gold standard.

***Conclusion.*** The prevalence of periodontitis is greatly influenced by the choice of the case definition. Prevalence rates with definition II could be more accurate if the true prevalence is determined by definition Va.

***Key words:*** **Case definitions, Epidemiology, Periodontitis, Prevalence.**

## *Introduction*

Periodontitis is a chronic inflammatory disease caused by infection of the supporting tissues around the teeth. The infection begins with colonization and growth of a small group of predominantly gram-negative anaerobic bacteria and spirochetes, notably *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Treponema denticola*.[1] These bacteria, embedded along with numerous other species in biofilms, extend apically along the surface of the tooth roots to induce formation of periodontal pockets and destruction of the alveolar bone and collagenous fibers of the periodontal ligament.[1] Generally, the clinical diagnosis of periodontitis is based on

measures of the presence and extent of periodontal pockets, loss of clinical attachment, the pattern and extent of alveolar bone loss, or a combination of these measures.

Many case definitions have been proposed to measure the extent and severity of periodontitis in epidemiological studies.[2–7] The most distinctive feature of these case definitions is their extreme variation and lack of uniformity in defining periodontal disease and this has led to conflicting results in relation to the prevalence of periodontitis.[4,5] Different criteria, including redness, suppuration, bone loss, probing depth (PD), clinical attachment level (CAL) and bleeding on probing (BOP), have been used to define periodontitis.[8,9] However, only PD and CAL can be constantly associated with periodontitis as they illustrate destructive components related to the disease and provide information on different aspects of periodontitis.[8] PD demonstrates the depth of periodontal pockets and may reflect the nature and activity of the disease.[3] While CAL is used to assess the severity of the disease, it reflects the lifetime accumulation of past disease.[3,4,8]

Some studies have adopted only PD[10,11] or CAL[12,13] as the sole indicator, whereas some other studies have adopted a combination of these two indicators to reflect both cumulative tissue destruction (CAL) and current pathology (PD).[8,14-17] To date, no consensus has been reached on the threshold values for PD and CAL or on the number of sites or teeth that must be affected to constitute disease. Selection of threshold values is critical as there are no standardized diagnostic criteria and this lack of consistency seriously affects the comparability of results among other studies.[3,5,18] A case should be easily distinguished from non-case. Minor changes in the threshold values for CAL, PD and the number of affected sites used in the case definitions result in major changes in the prevalence rates.[8,17,18] Even the slightest change can cause over- or under-estimation of prevalence and extent of the disease and hence the periodontal treatment need.[3,5,6,18] Eke et al[9] suggested that the National Health and Nutrition Examination Survey (NHANES), the sole source of assessment of periodontal prevalence in the US, underestimated the prevalence rate by 50% or more.

Kassab et al[4] and Manau et al[5] analyzed the effect of different periodontitis case definitions among postpartum mothers. They found that different case definitions or measurements of periodontitis yield different results and may determine the statistical significance on association between periodontitis and adverse pregnancy outcomes. Lopez and Baelum[19] found different prevalence estimates based on four different definitions among adolescents but did not substantially change the significance of the OR of the relationship with several determinants of the case status. Likewise, Ioannidou et al[20] and Andriankaja et al[21] revealed differences in the magnitude of association between periodontal case definitions and systemic infections in patients with kidney transplants and myocardial infarction. Therefore in epidemiological studies, case definitions can hamper the credibility as well as the conclusion reached by the studies.[2]

Periodontal research has been biased by difficulties in disease description, diagnosis and score designation for clinical manifestation of periodontitis. Regardless of the study design, be it experimental or observational, the clinical entity under investigation needs to be defined in such a way that subjects or sites can be consistently categorized as affected or unaffected by the disease.[8] It is important to form a uniform criterion for defining periodontitis, without a clear definition of the case; results and associations can be seriously impaired and brought into question. Thus, it is crucial to find the impact of case definition on the prevalence of periodontitis. Therefore the aim of this study was to estimate and compare the prevalence of periodontitis based on five different case definitions and to find the level of agreement among five different case definitions in a Malaysian population.

## *Materials and Methods*

A cross-sectional study of secondary patient data was conducted in Oral Health Center (OHC), International Medical University, Kuala Lumpur, Malaysia between January 2010 and December 2013. The study was conducted upon obtaining approval from the IMU Joint Committee for Research and Ethics (BDS/1/2010(02)2013).

### *Participants*

Data of 300 subjects were randomly selected by a computer-generated sequence from a list of 7124 patients who attended the oral health center between 2008 and 2012. The inclusion criteria consisted of good systemic health, age range of 18–80, presence of at least 20 teeth and presence of at least one site with probing depth of ≥4 mm. Exclusion criteria consisted of patients with antibiotic use during the last three months prior to examination, third molars, teeth presenting unsatisfactory restoration, extensive carious lesions, fractures, teeth in which the cementoenamel junction (CEJ) could not be properly de-

termined and areas presenting gingival morphological alteration. Both male and female patients of all ethnicities were included in this study. As secondary data was used for the study, patients' confidentiality was maintained throughout the study.

*Sample Size Calculation*

Sample size calculation was performed using statistical software (Version 5, Raosoft Inc, Seattle, WA, USA.). Based on periodontitis prevalence rate of 25%[22] and confidence interval of 95% with a 5% margin of error, the sample size was 294, which was rounded to 300.

*Periodontal Examination*

All the examinations were conducted by a single trained examiner (T. P. S). Full-mouth PD and CAL was obtained from six sites around each tooth, which included mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual and disto-lingual sites of the selected subjects, yielding a total of 168 sites in a fully dentate subject. PD was measured from the free gingival margin to the bottom of the gingival sulcus/periodontal pocket. CAL was measured from the CEJ to the base of the gingival sulcus/pocket. The distance was rounded down to the nearest whole millimeter for both measurements. No inter-examiner reliability of the examining dentist was possible due to the nature of this study on secondary data. The oral health data were thus based on existing computerized dental charts.

*Definition of Periodontitis*

Six definitions were selected to define periodontitis using single or combined criteria of PD and CAL for the analysis of the selected subject data.

1. ≥1 site with PD ≥4 mm.[10]
2. ≥4 sites with CAL ≥5 mm + ≥1 site with PD ≥4 mm.[14]
3. ≥2 teeth with CAL ≥6 mm + ≥1 site with PD ≥5 mm.[15]
4. ≥4 teeth with ≥1 sites CAL ≥3 mm + ≥4 teeth with ≥1 sites PD ≥4 mm.[16]
5. a) ≥2 interproximal sites with CAL ≥4 mm, not on the same tooth or ≥2 interproximal sites with PD ≥5 mm, not on the same tooth.[17]
   b) ≥2 interproximal sites with CAL of ≥6 mm, not on the same tooth + ≥1 interproximal site PD ≥5 mm.[17]

*Statistical Analysis*

Analysis was carried out using statistical software (SPSS Version 17.0, SPSS Inc., Chicago, IL, USA.). Prevalence rate of periodontitis for each definition was calculated. Agreement among definitions was tested using unweighted Kappa test. Definition Va was adopted as the gold standard against which sensitivity and specificity were calculated for other definitions.

## *Results*

Of 300 subjects analyzed 167 (55.7%) were male

**Table 1. Prevalence based on different thresholds for CAL and PD (n=300)**

| Probing depth | n | CAL % (95% CI) | n | PPD % (95% CI) |
|---|---|---|---|---|
| **3** | 7966 | 61.07 (60.23–61.90) | 7674 | 74.5 (73.3–75.3) |
| **4** | 1989 | 15.25 (14.64–15.85) | 1156 | 11.22 (10.62–11.84) |
| **5** | 1567 | 12.01 (11.46–12.58) | 1047 | 10.17 (9.6–10.77) |
| **6** | 660 | 5.06 (4.7–5.45) | 155 | 1.51 (1.28–1.75) |
| **≥7 mm** | 862 | 6.61 (6.2–7.05) | 268 | 2.6 (2.31–2.93) |
| **Total** | 13044 | 100 | 10300 | 100 |

CAL: clinical attachment level; PPD: periodontal pocket depth

**Table 2. Sensitivity, specificity and prevalence of periodontitis based on each definition in comparison with definition Va**

| Definition | Number of subjects (N=300) | Prevalence of periodontitis (%) | Sensitivity (%) (CI) | Specificity (%) (CI) |
|---|---|---|---|---|
| **Definition I** | 230 | 76.70 | 85.65 (80.09–89.90) | 46.43 (35.59–57.59) |
| **Definition II** | 123 | 41.00 | 56.48 (49.58–63.15) | 98.81 (92.63–99.94) |
| **Definition III** | 84 | 28 | 38.89 (32.42–45.76) | 100 (94.55–100) |
| **Definition IV** | 109 | 36.30 | 50.46 (43.62–57.29) | 100 (94.55–100) |
| **Definition Va** | 216 | 72.00 | | |
| **Definition Vb** | 84 | 28.00 | 38.24 (31.97–45.30) | 98.81 (92.63–99.94 |

and 133 (44.3%) were female, with almost equal age distribution.

*Periodontal Status and Prevalence of Periodontitis*

The prevalence rate and sensitivity and specificity for each definition are summarized in Tables 1 and 2. The proportions of CAL = 4 mm, 5 mm, 6 mm and ≥7 mm were 15.25%, 12.01%, 5.06% and 6.61%, respectively, while the proportions of PD = 4 mm, 5 mm, 6 mm and ≥7 mm were 11.22%, 10.17%, 1.51% and 2.60%, respectively. It could be noticed that the prevalence of periodontitis based on definitions I, II, III, IV, Va and Vb were 76.7%, 41%, 28%, 36.3%, 72% and 28%, respectively (Table 1). The prevalence based on definitions I and Va were much higher than prevalence based on definitions II, III, IV and Vb. Compared to definition Va, which was the gold standard, satisfactory specificity was obtained for definitions II, III, IV, and Vb. However, lower specificity (SP = 46.43%, CI = 35.59–57.59) was obtained only for definition I. Sensitivity for definitions increased in the following order: Vb, III, IV, II, I (Table 2). This order illustrates the increasing trend for each definition to correctly identify the true positive values.

*Agreement Scores*

Kappa scores showed agreements between definitions. Satisfactory to good agreement was observed between definitions II and III (0.718, CI = 0.635–0.802), definitions III and Vb (0.703, CI = 0.614–0.703) and definitions III and Vb (0.901, CI = 0.846–0.956). Since definition Va was selected as the gold standard, closest agreement was observed for definition II (0.413, CI= 0.316–0.511) compared to any other definition (Table 3).

## *Discussion*

The purpose of this study was to determine the effect of different measures of periodontal disease on the prevalence rates and to find the level of agreement among these definitions. The issue of case definition has been controversial and still remains the central theme in periodontology. Periodontal epidemiological studies have shown different prevalence, extent and severity rates of periodontitis among the world population.[23] These dissimilarities can be attributed to no standardized case definition of the disease, no threshold or cut-off point for the disease indicator and no assessment of risk variables, especially systemic health, genetics, smoking, age, ethnicity, access to services and socioeconomic status.[2–5] Studies that can provide data on population characteristics, prevalence estimates, pattern of distribution and associated etiologic and risk factor for periodontal disease would be crucial for evaluating methods for prevention and control.[2]

The definition should first enable the utilization of a sensitive case definition (inclusive of incipient cases) and second should allow a more specific case definition (to identify only cases with substantial extent and severity).[7] In this study five definitions proposed by Hujoel et al,[10] Beck et al,[14] Machtei et al,[15] Lopez et al,[16] and Page and Eke et al[17] were used. All the definitions used a combination of PD and CAL except for definition I (only PD). An assessment of disease presence requires measurement of probing pocket depth while past experience requires another measurement like attachment loss. Other studies have used an array of disease indicators like bleeding on probing,[24] radiographic assessment of alveolar bone loss[25] and tooth loss.[26] Another issue is the use of full- or partial-mouth recording of PD and/or CAL for defining a case. In the present study full-mouth recording of PD and CAL was carried out. Periodontitis is site-specific and not evenly distributed in the mouth and partial-mouth recording would lead to an underestimation of disease prevalence.[6,27] NHANES III and NHANES 2001–04 used partial-mouth recording by examining two or three fixed sites per tooth from two quadrants of the mouth as this may be representative of the full-mouth status.[28] It was shown that the survey might have underestimated the prevalence rate by almost 50%, although it can be corrected by calculating an inflation factor for a sub-population under study.[9] Still no

**Table 3. Agreement between each definition**

| | Definition I | Definition II | Definition III | Definition IV | Definition Va |
|---|---|---|---|---|---|
| **Definition II** | 0.349 (0.250–0.448) | | | | |
| **Definition III** | 0.212 (0.120–0.303) | 0.718 (0.635–0.802) | | | |
| **Definition IV** | 0.296 (0.199–0.393) | 0.635 (0.545–0.723) | 0.553 (0.451–0.655) | | |
| **Definition Va** | 0.338 (0.209–0.467) | 0.413 (0.316–0.511) | 0.263 (0.169–0.357) | 0.363 (0.266–0.46) | |
| **Definition Vb** | 0.212 (0.120–0.303) | 0.703 (0.614–0.788) | 0.901 (0.846–0.956) | 0.523 (0.418–0.627) | 0.252 (0.157–0.346) |

consensus has been reached, based on which representative sites can be selected for partial-mouth examination. Currently the gold standard is the use of full-mouth clinical examination for the diagnosis of periodontitis.[29]

The main aim of this study was to determine differences in prevalence rates, acquired particularly by periodontitis case definitions which differed on the following: the site of measurement, the use of clinical indicators PD or CAL or combination of both, the number of affected site(s), and the threshold value for PD or CAL. The present study showed significant differences in prevalence rates of periodontitis obtained based on different case definitions using the same set of samples: 76.7% (definition I), 41% (definition II), 28% (definition III), 36.3% (definition IV), 72% (definition Va) and 28% (definition Vb). Similar variations in prevalence rates due to different periodontal definitions were seen earlier in different populations.[2,4,5,19–21] The high prevalence rate observed in the present study might be due to the selection of a population who were seeking dental treatment with poor oral hygiene. Hence, all the observed periodontal destruction can be attributed to plaque-induced periodontitis.

Definition I (≥1 site with PD ≥4 mm) proposed by Hujoel et al[10] shows high prevalence of periodontitis (76.7%). This definition indicates the presence of true periodontal pocket and the presence of ongoing active disease. Similar results were observed in other studies.[3,11,31] Albandar et al[30] and Bergstrom et al[31,32] used this definition as mild periodontitis to find association between smoking and periodontal disease. Our findings show that this definition appears to be less stringent regarding the threshold of PD and the extent parameter. Andriankaja et al[21] found it to be the weakest definition among the four definitions used to find an association between periodontal disease and myocardial infarction. Hence, this definition was considered unreliable as periodontitis cannot be assessed by a single variable. Pseudo-pockets may also be misdiagnosed as periodontitis, especially among younger individuals.[23] Another concern is in older population because as gingival recession occurs PD fails to keep pace with an increase in CAL and the disease severity could be underestimated by measurement of PD solely.[8] The accepted measure of cumulative lifetime experience of periodontitis is attachment loss; therefore, this measure should be the primary outcome variable used in studies.

The definitions II, III and IV used a combination of CAL and PD, and the number of teeth and sites examined. The purpose of combining CAL and PD was to identify true periodontal pocket and exclude gingival overgrowths or pseudo-pockets, and deepened gingival crevices related to gingivitis or gingival recession. These definitions exhibited lower prevalence rates compared to definition I and followed a robust cut-off point regarding the number of affected sites and threshold of PD and CAL. As a result, these definitions may underestimate the prevalence of periodontitis within the population to some extent. Definition II was proposed by Beck et al.[14] Various authors have used this definition.[2,3] Definition III proposed by Machtei et al[15] exhibited the lowest prevalence rate. A similar observation was reported by Rodrigues et al.[33] Definition IV was proposed by Lopez et al[16] in a clinical trial to find association between preterm low birth weight and periodontal disease. Previous studies by Kassab et al,[4] Al-Zahrani et al,[34] Arbes et al,[35] and Cota et al[36] have used this definition. Definition III (28%) and definition Vb (28%) have shown a similar prevalence rate of periodontitis as a result of subtle differences between the threshold of PD and CAL.

Definitions Va and Vb were proposed by CDC Periodontal Disease Surveillance Workgroup and American Academy of Periodontology. Definition Va was proposed to define moderate periodontitis, with definition Vb for severe periodontitis.[19] The authors considered it necessary to elect a recently published definition that measures PD and CAL at interproximal sites. Proximal sites and non-adjacent teeth are specified in order to minimize the likelihood of including attachment loss affecting buccal/lingual sites or adjacent inter-dental sites for reasons other than periodontitis such as tooth brushing traumas, and tobacco-related chewing habits. According to the present study, the authors believe that definition Vb was too rigid and may underestimate the prevalence of periodontitis in the population by having a low sensitivity and excluding real cases. Hence, the definition of moderate periodontitis (definition Va) was selected as the gold standard. Definition Va is more sensitive compared to definition Vb, showing higher prevalence rates. Tonetti and Claffey[37] proposed similar definition of using interproximal sites of non-adjacent teeth. But this definition was only based on the level of attachment while diagnosis of periodontitis requires additional measurement of pockets and/or bleeding on probing. Similar results were reported by Ioannidou et al[20] among Americans, Bealum and Lopez[24] among rural Keyans, Cyrino et al[29] among Brazilian population and Holtfreter et al[38] among German population. Kassab et al[4] used definition for moderate periodontitis among postpartum

mothers and found a prevalence rate of 15.9%. As true periodontitis is plaque-induced, it is important to consider only interproximal sites for the definition of periodontitis; however, Baelum and Lopez[24] proposed that plaque-induced periodontitis can occur on buccal and lingual sites as well, and case definition based only on interproximal site can result in inevitable underestimation of prevalence rate and misclassification of cases as non-periodontal cases.

Kappa test revealed satisfactory agreement between definitions II and III (0.718), definitions II and Vb (0.703) and definitions III and Vb (0.901). The agreement between definitions II, III and Vb may be related to the similar extent and severity criteria of periodontal attachment loss. According to kappa test, definition II exhibited the highest agreement compared to the gold standard definition Va (0.413). It was noted that definition II showed high specificity (98.81%). In this context, definition II showed high capacity to exclude non-periodontitis individuals. However, definition II showed a lower prevalence rate of periodontitis because it had low sensitivity (56.48%). Hence, definition II should be used with caution. Prevalence data based on definition II will not be pointless because it was shown to be in closer agreement to the gold standard in the present study. Therefore, further research is needed to identify the correction factor between definition II and definition Va. A correction factor should be calculated so that comparison of the results with other surveys could be more meaningful. By applying a well-founded correction factor, we can identify the true prevalence of periodontitis on studies which adopted definition II as criteria.

The limitations of the study were: selection of a sample which included young adults, in whom the prevalence and the severity of disease may be defined differently than that in the general population; lack of calibration of examiner and exclusion of third molars could have contributed to underestimation of prevalence. Another concern is that the definition used in the present study lacked radiographic evidence of bone loss and were single-point in time measurements, although it would be a difficult task in epidemiological studies.

## *Conclusion*

The findings of the present study suggest that different definitions of periodontitis can influence the prevalence of periodontitis. It can over- or underestimate the true need of periodontal treatment as well as hamper the results and association between studies. Hence, we propose the use of a definition given by Beck et al[14] and Eke et al[17] for easy use and comparability among epidemiological studies. Nevertheless we still acknowledge the search for a newer definition that is based on certain genetic profile, local inflammatory mediators and behavioral and demographic characteristics or a combination of these as supplement or alternative to the present invasive examination protocol. Valid laboratory and chair-side assays would further minimize measurement errors and promote specificity. In addition, this finding should be repeated in other populations to clarify the validity of the results.

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