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Impact of different periodontitis case definitions on periodontal research

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Abstract: Different periodontitis definitions have been used in periodontal research. This study assessed the impact of case definition on the prevalence and extent rates of periodontitis. A data set including 340 periodontal records, collected in Belo Horizonte, Brazil, was used. Periodontitis was defined as: 1) one site with probing depth (PD) ≥ 4 mm; 2) clinical attachment level (CAL) ≥ 5 mm in ≥ 4 sites + one site with PD ≥ 4 mm; 3) CAL ≥ 6 mm in ≥ 2 teeth + one site with PD ≥ 5 mm; 4) ≥ 4 teeth with ≥ 1 sites with PD ≥ 4 mm + CAL ≥ 3 mm; 5a) interproximal CAL or PD ≥ 4 mm at ≥ 2 sites, not on the same tooth; and 5b) interproximal CAL of ≥ 6 mm at ≥ 2 sites, not on the same tooth + PD ≥ 5 mm at ≥ 1 proximal site. Definition 5 was determined to be the gold standard and the definitions were compared by means of agreement, sensitivity, specificity, and positive and negative predictive values. Prevalence and extent rates greatly varied, from 13.8% to 65.3% and from 9.7% to 55.6%, respectively. The use of different case definitions has a great impact on the prevalence and extent rates of periodontitis. (J Oral Sci 51, 199-206, 2009)

Keywords: diagnostic criteria; epidemiology; extent; periodontitis; prevalence.

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Introduction

A large number of epidemiological studies in periodontology have demonstrated different rates of prevalence, severity, and extent of periodontitis among distinct populations (1-8). This difference in periodontitis estimates may be directly related to incongruities in the methodologies of data collection and case definitions adopted in periodontal research. Case definition of periodontitis is a fundamental requirement for population-based surveillance of the disease. However, an agreement of such definition criteria has not yet been established (9-15). Any measurement of prevalence or frequency of periodontitis is dependent on how the disease is defined; that is, the case definition. Diagnostic criteria proposed in dental literature use different thresholds to define the number of affected teeth, the clinical levels of gingival inflammation, and the clinical attachment level (9,15-19).

Therefore, a number of clinical risk indicators have been used for periodontitis case definition, including bleeding on probing, redness, suppuration, probing depth (PD), tooth mobility, clinical attachment level (CAL), and bone loss. However, only the latter two parameters cited can be consistently associated with periodontitis, as they describe destructive components related to the disease (15). In epidemiologic research of periodontal diseases, case definitions are crucial since they can affect the internal and external validity as well as conclusions reached by the study. In addition, they can seriously affect the comparisons among the results of other studies. One important aspect of this issue refers to the possibility of inducing over or underestimation of periodontal treatment needs (9,15,20). Although several studies assumed their own periodontitis

case definitions by adopting different clinical indicators of severity and extent, in general including measurements of PD, CAL, and the extent of bone loss, a lack of standardization and conflicts of definition can still be observed. Another important aspect concerning case definition is related to the ordinal threshold value for PD and/or CAL to determine true evidence of the destructive process in the periodontal site as well as the number of sites affected by that threshold necessary to establish the presence of the disease. This lack of uniformity comes across as a consequence of different diagnostic criteria with distinct cut off points for periodontitis definitions (2,10,15,21).

In this manner, periodontal research has been biased by difficulties in disease description, diagnosis, and score designation for clinical manifestations 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. Without a clear definition of the case, results and associations can be seriously impaired and brought into question (22). Therefore, the aim of the present study was to evaluate the impact of five different case definitions on the prevalence and extent rates of periodontitis as well as to determine the agreement and validity among such definitions.

Materials and Methods

Sampling strategy

Subjects were selected from a list of 1,720 patients awaiting dental treatment at the municipal public health service of the west region of Belo Horizonte City, Brazil from 2003 to 2005. The inclusion criteria included good systemic health, age ranging from 30 – 45 years, and no antibiotic use within 3 months prior to the examination. Sample size calculation was performed using statistical software (Epi info, version 4.0), based on a periodontitis prevalence rate of 30%. It was calculated according to the 95% confidence interval of these prevalence data and a power test estimation of 80%, adopting a variation of 5% around the prevalence rate. In this manner, after having applied the inclusion criteria, a data set including 340 periodontal records was randomly selected and used in the present study. The study sample comprised of subjects of both genders, of multiethinic groups, and of low socioeconomic and low education levels.

After obtaining written informed consent, subjects were asked about their medical history and demographic data. A clinical periodontal examination was then performed, and subjects presenting with specific periodontal treatment needs were referred to specialized dental public units for dental treatment.

The present study was approved by the Federal University of Minas Gerais Research Ethics Committee (COEP-UFMG).

Periodontal clinical examination

Circumferential periodontal probing was manually performed with a University of North Carolina (UNC)-15 periodontal probe (Hu Friedy, Chicago, IL, USA) at the mesial, buccal, distal, and lingual sites of each tooth. Measurements of probing depth from the gingival margin and measurements of clinical attachment level from the cementoenamel junction were subsequently recorded. Interproximal sites were examined on buccal and lingual sides, and the highest measurement was recorded. In an attempt to minimize errors during the periodontal probing process, some exclusion criteria were adopted: third molars; teeth presenting unsatisfactory restorations, extensive caries lesions, or fractures; teeth where the cementoenamel junction could not be properly determined; and areas presenting great gingival morphological alterations (23).

All measurements were performed by one trained and calibrated periodontist. As part of the calibration process, periodontal examinations were repeated in 10% of the sample within 14 days and intraexaminer reliability scores were tested. Unweighted kappa (k) scores, for values lower and higher than 4 mm, were 0.81 for PD and 0.79 for CAL. An intraclass correlation coefficient of 0.79 was also attained.

Diagnostic criteria for periodontitis definition

Five periodontitis case definitions, summarized in Table 1, were adopted in the study. To determine the extent of periodontitis in each definition, the following classification was used: 1) localized form: presence of ≤ 30% of sites affected by the definition requirements of PD and/or CAL; or 2) generalized form: presence of > 30% of sites affected by the definition requirements of PD and/or CAL (9).

Statistical analysis

Data descriptive analysis was performed and prevalence rates of periodontitis (absolute and relative frequencies) for each definition were reported. Agreement among definitions was tested through an unweighted Kappa test. In addition, definition 5a was determined to be the gold standard, and the sensitivity (ST), specificity (SP), and positive (PPV) and negative (NPV) predictive values were calculated for each definition. Estimates were then compared among definitions. All analyses were performed using statistical software (STATA 9.0, Stata Corporation,

Table 1 Different periodontitis case definitions

Periodontitis case definition	Requirements		
	Clinical attachment level (CAL)		Probing depth (PD)
Definition 1 (Hujoel et al. 2006)			at least 1 site with PD ≥ 4mm
Definition 2 (Beck et al. 1990)	4 or more sites with CAL ≥ 5mm	and	at least 1 site with PD ≥ 4mm
Definition 3 (Machtei, 1992)	2 or more teeth with CAL ≥ 6mm	and	1 site with PD ≥ 5mm
Definition 4 (López et al. 2002)	4 or more teeth with at least one site with CAL ≥ 3mm	and	4 or more teeth with at least one site with PD ≥ 4mm
Definition 5a (Page and Eke, 2007)	≥ 2 sites with interproximal CAL ≥ 4mm not on the same tooth	or	≥ 2 sites with interproximal PD ≥ 4mm not on the same tooth
Definition 5b (Page and Eke, 2007)	≥ 2 sites with interproximal CAL ≥ 6mm not on the same tooth	and	≥ 1 sites with interproximal PD ≥ 6mm

Table 2 Periodontal status of the sample: prevalence of affected sites with different thresholds for CAL and PD (n = 340 individuals; n = 7140 sites)

Periodontal Parameters	Sites < 3mm		Sites ≥ 3 ≤ 5mm		Sites > 5 < 7mm		Sites ≥ 7mm	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Clinical attachment level (CAL)	4737	66.35 (3.1 - 22.3)	1820	25.49 (18.2 - 50.3)	405	5.67 (4.9 - 11.8)	178	2.49 (1.8 - 5.3)
Probing depth (PD)	4096	57.37 (15.7 - 20.8)	2180	30.54 (24.5 - 57.3)	643	9.0 (6.6 - 14.3)	221	3.09 (2.2 - 6.7)

College Station, TX, USA).

Results

Of the 340 subjects, 172 (50.6%) were males and 168 (49.4%) were females. The subjects were of low socioeconomic status (family monthly income ≤ USD $300) and low educational levels (average of 6.5 ± 2.1 years of formal education). The periodontal status of the sample is detailed in Table 2. Of the 7,140 sites evaluated, the proportions of CAL ≥ 3 and ≤ 5 mm, > 5 and < 7 mm, and ≥ 7 mm were 25.4%, 5.6%, and 2.5% respectively, while the proportions of PD ≥ 3 and ≤ 5 mm, > 5 and < 7 mm, and ≥ 7 mm were 30.5%, 9.0%, and 3.1%, respectively. Prevalence rates of periodontitis based on the cut off points of each definition are displayed in Fig. 1. It could be observed that frequencies of periodontitis for definition 1, 2, 3, 4, 5a and 5b were 65.3%, 23.8%, 16.5%, 38.6%, 41.2%, and 13.8%, respectively. Prevalence rates emerging from definition 2, 3, and 5b were lower than those emerging from definition 1, 4, and 5a. Kappa scores (k) indicating agreement between definitions are displayed in Table 3. Satisfactory agreement between definition 1 and 4 (k = 0.72; 95% CI 0.69 - 0.77), 1 and 5a (k = 0.73; 95% CI 0.71 - 0.79), 2 and 3 (k = 0.72; 95% CI 0.68 - 0.75), 3 and 5b (k = 0.69; 95% CI 0.61 - 0.74), and 4 and 5a (k = 0.71; 95% CI 0.68 - 0.76) were observed. Extent of periodontitis according to the definition adopted for localized and generalized forms is displayed in Fig. 2. A great variability among the criteria could be observed. Prevalence rates for localized periodontitis varied from 9.7% to 55.6%, and generalized periodontitis from 4.1% to 11.0%. When

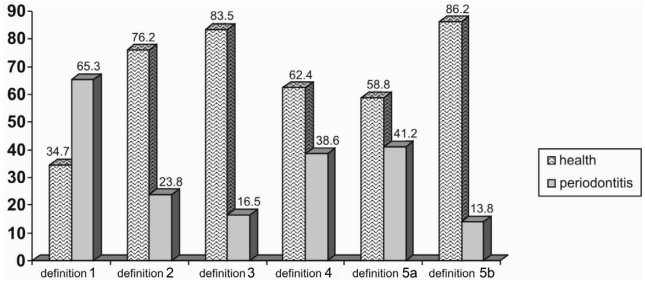

Fig. 1 Periodontal status (health and periodontitis) determined by case definitions (percent).

Table 3 Agreement among definitions [kappa coefficients (95%CI)]

	Definition 1	Definition 2	Definition 3	Definition 4	Definition 5a
Definition 2	0.28	-	-	-	-
	(0.17-0.31)				
Definition 3	0.19	0.72	-	-	-
	(0.15-0.21)	(0.68-0.75)			
Definition 4	0.72	0.39	0.29	-	-
	(0.69-0.77)	(0.33-0.45)	(0.23-0.34)		
Definition 5a	0.73	0.37	0.35	0.71	-
	(0.71-0.79)	(0.32-0.45)	(0.32-0.41)	(0.68-0.76)	
Definition 5b	0.17	0.62	0.69	0.27	0.52
	(0.15-0.21)	(0.54-0.66)	(0.61-0.74)	(0.18-0.32)	(0.49-0.61)

$P < 0.001$ for all k coefficients

Table 4 Distribution of periodontitis and diagnostic values for different case definitions in comparison with definition 5a (gold standard)

Definition	Sensibility (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence of periodontitis (n = 340)	Number of subjects affected (n = 340)
Definition 1	100% (91.2 - 100)	20.3% (3.8 – 23.4)	48% (41.6 – 53.2)	100% (71.2 – 100)	65.3%	222
Definition 2	100% (91.2 – 100)	33.7% (17.2 – 38.9)	56.7% (47.8 – 64.7)	100% (82.1 – 100)	23.8%	81
Definition 3	100% (91.2 – 100)	7.5% (4.3 – 11.2)	21% (17.8 – 26.7)	100% (72,8-1000	16.5%	56
Definition 4	100% (91.2 – 100)	88.3% (73.5 – 91.2)	92.9% (78.1 – 95.7)	100% (91.5 – 100)	38.6%	131
Definition 5a	-	-	-	-	41.2%	140
Definition 5b	100% (91.2 – 100)	6.2% (3.8 – 10.1)	18.3% (15.2 – 21.6)	100% (68.8 – 100)	13.8%	47

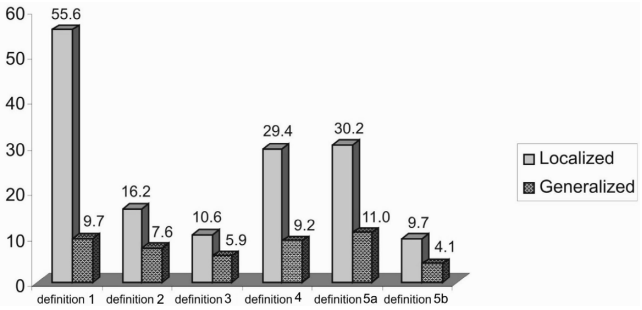

Fig. 2 Extent rates of localized and generalized forms of periodontitis according to different case definitions (percent).

comparing all definitions to definition 5a, which was considered the gold standard, satisfactory ST and NPV were obtained. However, satisfactory SP and PPV were obtained only for definition 4 (SP = 88.3; 95% CI [73.5 - 91.2]; PPV = 92.9; 95% CI [78.1 - 95.7]). Values of SP and PPV for the definitions increased in the following sequence: 5b, 3, 1, 2, and 4. This order can be interpreted as an increase in the capacity of each definition to accurately identify subjects with and without periodontitis with regard to definition 5a (Table 4).

Discussion

Numerous epidemiological studies conducted in different

populations have reported different prevalence rates of periodontitis. These differences can be attributed to two important aspects: 1) non-standardized definition of the disease, and 2) the influence of biological, social, and behavioral risk variables, particularly smoking, socio-economic level, diabetes, age, ethnicity, and access to oral health services (3,7,9,16,24). The present study showed that the differences in periodontitis prevalence rates related to case definition were largely significant: 65.3% (definition 1), 23.8% (definition 2), 16.5% (definition 3), 38.6% (definition 4), 41.2% (definition 5a), and 13.8% (definition 5b).

It is important to note that these prevalence rates were not methodologically associated with risk variables. These variables greatly vary within the populations and directly interfere with the disease prevalence rates reported. The use of a cross-sectional data set of periodontal records in the present study, with no evaluation of risk variables, did not influence the comparisons and results, since all definitions were applied in the same data set. In addition, subjects in a restricted age range (30 – 45 years) were included to minimize the influence of this variable on the estimates of prevalence. It has been established that age can directly influence the prevalence rates in different populations, since it can reflect the cumulative amount of attachment loss during life (2,12,22,25).

It can be hypothesized that the higher prevalence rates found in the present study are related to sample characteristics such as low socioeconomic and educational levels, and limited access to oral health services (3,6,22,25,26). However, the main points of concern from the present study are the differences obtained exclusively by the periodontitis case definition, the use of clinical indicators PD or CAL in a single manner or in combination, the number of affected sites required, the threshold values for PD and/or CAL, and the site/surface of measurement.

It must be recognized that use of a universally accepted criteria for periodontitis case definition is decisive, since this lack of uniformity has a great impact on the prevalence rates of periodontitis reported in the present study. Comparing these questions with other studies, periodontal research and therapeutic approaches can be seriously biased.

The present study verified, in relation to definition 1 (≥ 1 site with PD ≥ 4 mm), a high prevalence of periodontitis (65.3%). Although similar to other reports in dental literature (1,12,25,26), the findings showed that this definition appears to be less rigid concerning thresholds of PD and extent requirements of the disease. The application of extent parameters in this definition (cut off point: 30% of affected sites) led to a higher discrepancy between localized (55.6%) and generalized (9.7%) forms of the disease. In addition, the use of PD measurements with no relation to CAL can induce errors in interpretation regarding false periodontal pockets, since PD is well recognized as an indicator of periodontitis with low predictability (7,9,27). For this reason, our judgment is that this definition should be used with caution in periodontal research.

Lower prevalence rates for periodontitis were reported by definition 2 (23.8% = CAL ≥ 5 mm at ≥ 4 sites + one site with PD ≥ 4 mm), definition 3 (16.5% = CAL ≥ 6 mm at ≥ 2 sites + one site with PD ≥ 5 mm), and definition 5b (13.8% = interproximal CAL ≥ 6 mm at ≥ 2 sites on different teeth + PD ≥ 5 mm at one proximal site – advanced periodontitis). These findings differ from a number of large epidemiologic studies that have used similar definitions (9,13,16,21,28).

In this manner, it can be inferred that these definitions adopt rigid cut off points for PD and CAL and, as a result, can underestimate the real prevalence of periodontitis within the populations. In addition, similarities in the prevalence rates reported by these definitions may be explained by the 1-mm difference between the thresholds for PD and CAL within the criteria. Another important issue is the similar extent indicators applied by these definitions, although a more rigid parameter was adopted by definition 3. Definition 5b is quite similar to definition 3, but the requirement of attachment loss occurs at interproximal sites. Consequently, differences in prevalence rates reported by definitions 3 and 5b can be related to the strictness of definition 5b.

Definitions 4 and 5a, reporting prevalence rates of 38.6% and 41.2%, respectively, proved to be similar and resulted in prevalence rates which were more compatible with previous reports (11,18,26,29). It is important to highlight that definitions 5a and 5b are more prone to avoid errors from attachment loss measurements due to reasons other than periodontitis, as they employ interproximal measurements. Finally, a prevalence rate of 41.2% was reported by definition 5a (interproximal CAL ≥ 4 mm at ≥ 2 sites, not on the same tooth, proposed by the Periodontal Disease Surveillance Workgroup of the Division of Oral Health at the Center for Disease Control and Prevention – CDC) (15). It is important to note that this definition was proposed to define moderate periodontitis. To defined advanced periodontitis, the Periodontal Disease Surveillance Workgroup has proposed interproximal attachment loss ≥ 6 mm at ≥ 2 sites, not on the same tooth + one site with interproximal PD ≥ 5 mm. As a result, the authors of this study believe that definition 5b is too robust and can exclude real cases of periodontitis (15).

Many authors have recognized the cut off point of 30% of the affected sites as adequate in differentiating localized from generalized forms of periodontitis (9,30,31). When analyzing the extent of periodontitis in the present study, based on these criteria associated with different definitions, findings showed a great variability among definitions concerning extent rates. Although the number of affected sites required by each definition impacts the definition per se, this number did not influence the extent of 30% adopted in the present study. It was reinforced by findings that demonstrated that subjects under different case definitions were mixed up in the same pattern of extent. This observed variation may reflect the threshold of PD and/or CAL (higher values for definitions 4 and 5a) and/or threshold values for probing measurements (higher values for definitions 2 and 3). Within these definitions, a lower difference between localized and generalized prevalence rates could be observed. Differences within definition 1 ($\geq$ 1 site with PD $\geq$ 4 mm) were of great impact (localized = 55.6%, and generalized = 9.7%).

The Kappa test presented a satisfactory agreement between definitions 1 and 4 (0.72), 1 and 5a (0.73), 2 and 3 (0.72), 4 and 5a (0.71), and 3 and 5b (0.69) ($P < 0.001$). It can be inferred that the satisfactory agreement between definitions 1 and 4, and between definitions 1 and 5a, may be related to the low strictness of definition 1. It can also be inferred that the good agreement between definitions 4 and 5a, as well as between definitions 3 and 5b, may be related to similarities of extent and severity parameters of periodontal attachment loss.

Based on the state of the art related to definitions of periodontitis, the authors of the present study considered it reasonable to elect a recently published and well-founded definition that required PD or CAL measurements in interproximal sites (minimizing errors from attachment loss due to reasons other than periodontitis) as well as extent (two sites not on the same tooth) and severity (PD $\geq$ 5 mm or CAL $\geq$ 4 mm) as the gold standard criterion. Therefore, the definition proposed by the CDC Periodontal Disease Surveillance Workgroup (15), and supported by the American Academy of Periodontology, to define moderate periodontitis was selected among the eligible definitions (definition 5a) as the gold standard. The definition proposed by the same group to define severe periodontiits (definition 5b) was avoided because we share the same opinion as the CDC Workgroup that this definition can exclude real cases of periodontitis for being too robust.

In accordance with the agreement findings, it was observed that definition 4 (18) presented the best SP and PPV in relation to the gold standard which adopted similar requirements. When analyzing the validity of definitions – that is, their capacity of distinguishing health from periodontitis – it was noted that only definition 4 presented satisfactory values of SP (88.3, 95% CI 73.5 - 91.2) and PPV (92.9, 95% CI 78.1 - 95.7). In this manner, criterion 4 showed higher capacity of correctly identifying periodontally healthy individuals as well as those with periodontitis.

One important topic related to the main theme of the present study is related to association studies. Several studies of the last decade have associated periodontal status to systemic conditions, such as cardiovascular diseases, pulmonary disorders, and adverse pregnancy outcomes (29,32-36). A great number of studies, showing controversial findings, highlighted that periodontal definition criteria strongly influenced the risk estimates of the associations under investigation (14,35). As such studies have a great audience inside and outside the dental field, and if the results are really affected by the periodontitis definition used, the adoption of a universal standard definition is crucial. Beck et al. (33) stated that a periodontitis definition may include reliable extent and severity indicators of attachment loss. Efforts should be directed towards standardizing periodontitis definitions in these types of studies.

It was therefore concluded that different case definitions can have a great impact on the prevalence and extent rates of periodontitis. In this manner, it can influence the results and associations presented in studies as well as over or underestimate the real need for periodontal treatment. Hence, the use of more valid criteria, such as definition 4 and 5a, for the standardization of periodontitis case definitions in periodontal research, is of utmost importance.

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