Comparative evaluation of indices and partial-mouth periodontal protocols for epidemiological surveys

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Abstract

Objective: To compare the Community Periodontal Index (CPI), the CPI modified and three partial-mouth periodontal protocols for estimates of prevalence, severity and extent of periodontitis in populations.

Method: a convenience sample of 350 individuals (aged 35 to 74 years) from Sao Paulo underwent a full-mouth periodontal examination (FMPE) which assessed pocket depth (PD), clinical attachment level (CAL) and bleeding on probing on six sites per tooth. The CPI, CPI modified (CPIm) and three partial-mouth protocols examination (PMPE)-half-mouth 6 sites, full- and half-mouth 3 sites-were derived from the records of the FMPE and have been compared for sensitivity, absolute bias, relative bias and inflation factor in estimates of periodontitis.

Results: Significant differences were found in periodontitis prevalence estimates between PMPE, in different case definitions, with relative biases ranging from -10% to -55%. The CPIm had sensitivity of 100% for gingivitis and PD ≥4 mm prevalence, and 80% for moderate and severe periodontitis in relation to FMPE, while for CPI such estimates were 70% and 50%, respectively. The full-mouth 3 sites protocol was similar to the CPIm, regarding the prevalence estimate, but CPIm overestimated severity and extent of periodontitis. The random half-mouth protocols presented low sensitivity to estimate periodontitis prevalence, although they presented small biases for severity and extension (<2.0%).

Conclusion: The CPIm and the full-mouth 3 sites protocol presented satisfactory sensitivity to estimate prevalence of periodontitis in populations, being superior to the previous CPI and to the random half-mouth protocols. However, accuracy of estimates may vary with the case definition and population characteristics.

Keywords: periodontitis, periodontal indices, prevalence, epidemiological surveillance

Abbreviations: FMPE, full-mouth periodontal examination protocol; CPI, community periodontal index; CAL, clinical periodontal attachment loss; PD, probing depth; PMPE, partial-mouth periodontal examination protocol

Introduction

Epidemiological surveillance of periodontal disease is fundamental for identifying people at risk in the population, establishing preventive and therapeutic strategies and assessing their efficacy, as well as assessing the interactions between periodontitis and systemic diseases and their impact on quality of life.[1,2] However, the lack of uniform criteria for assessing periodontitis in populations and the considerable methodological variability in examination protocols and case definitions lead to difficulties with regard to the interpretation and comparability of findings from different studies.[3,4]

The optimal periodontal examination consists of a full-mouth assessment, in which the probing depth and clinical attachment level are obtained from six sites per tooth, resulting in a large amount of scores per individual. The logistics, execution time, costs and fatiguing work required for the full-mouth periodontal examination protocol (FMPE) make it impractical for large epidemiological surveys.[5] Consequently, several partial-mouth periodontal examination protocols (PMPE) have been proposed to assess periodontitis in populations, which vary with regard to the selection of specific teeth, sites or quadrants in the dental arch, often leading to biases.[6]

Several studies have been carried out to evaluate accuracy of partial-mouth periodontal protocols.[7] A recent consensus by the EU/

USA Periodontal Epidemiology Working Group[8] recommended three PMPEs for estimates of periodontitis in populations: the full-mouth 3-site protocol and the two quadrants (half mouth) protocols of 3 and 6 sites. On the other hand, the method recommended by the World Health Organization (WHO), widely used worldwide, is the Community Periodontal Index (CPI),[9] which is a simple, quick and universal test, however it has some limitations that may compromise its accuracy.[3,7,10,11] The current version of the CPI (named here as CPIm) presents a modification in the examination protocol, with assessment of probing depth in all the present teeth, instead of only in ten index teeth.[12] However, no studies have been identified that have evaluated the accuracy of CPIm in relation to the FMPE and other partial protocols.

The aim of the present study was to compare the Community Periodontal Index (CPI), the CPI modified and three partial-mouth periodontal protocols for estimates of prevalence, severity and extent of periodontitis in populations.

Method

A cross-sectional study was conducted involving an analysis of the clinical periodontal parameters of adult individuals (35 to 74 years) selected by convenience from a major study named Advento,[13] whose participants were from the metropolitan region of Sao Paulo, Brazil. The invitation to participate in an oral assessment was made by telephone and considered volunteers who had been included in the chronogram of examinations in the Advento Study in the previous six months and had at least four natural teeth present (not including third

molars). Individuals that had been submitted to periodontal treatment in the previous six months and those who had used antibiotics in the previous 30 days were excluded from the study. Based on these criteria, among the 586 eligible volunteers, those who consented to participate and appeared for the oral examination were included in this study (n=350).

After a previous interview, the participants were examined seated in a common chair, by four trained examiners that have been previously calibrated in the assessment of periodontal parameters. The level of inter-examiner agreement regarding the occurrence of periodontal pocket and bleeding on probing was above 85%. Reproducibility in measures of clinical periodontal attachment loss (CAL) and probing depth (PD) was verified using the Kappa coefficient, which ranged from 0.68 to 0.86.

A full-mouth periodontal examination protocol (FMPE) was performed at six sites per tooth (three buccal sites and three lingual sites). A standard millimeter probe (WHO model, with 0.5mm sphere) and a dental mirror were used to assess the following periodontal variables: probing depth of sulcus/pocket (PD), defined as the distance between the free gingival margin and base of the sulcus/pocket in millimeters; clinical attachment loss (CAL), defined as the distance between the cemento-enamel junction and base of the sulcus/pocket in millimeters; bleeding on probing (BOP), checked approximately 10 seconds after probing. The measurements of PD and CAL were rounded down to the nearest whole millimeter. It was considered the occurrence of one or more bleeding sites for estimate prevalence of BOP.

The data for the PMPEs were obtained based on the records of the FMPE in accordance with the characterization of each protocol, as shown in Table 1. The randomization of quadrants, when necessary, was done manually, by drawing cards numbered 1 to 4.

The variables evaluated were: BOP (at least one site); periodontal pocket (PD≥4mm); attachment loss (CAL≥4mm); mean PD and mean CAL for each participant and for the whole set, in millimeters (severity of periodontitis);mean frequencies of PD and CAL in different levels (<4mm, ≥4mm and ≥6mm), given by the proportion of affected teeth and/or sites in the total of teeth and/or sites examined and in the data set, by each one of the periodontal protocols (extent of periodontitis);Prevalence of Periodontitis (no, moderate and severe), based on different combinations of the assessed periodontal parameters.

Table 1 Characterization of periodontal protocols according to the evaluated teeth and sites

Type of protocol	Selected teeth	N° of teeth	Probing sites
Full mouth (FMPE)	All teeth	28	DB-B-MB-DL-L-ML* (n=168)
Community Periodontal Index (CPI)[a]	Index teeth: 17/16, 11, 26/27, 36/37, 41, 46/47	10	All (circumferential) 6 records
CPI Modified (CPIm)[b]	All teeth	28(PD)*10(CAL)	All (circumferential) 28 PD records; 6 CAL records
Full-mouth 3 (FM3)	All teeth	28	MB-B-DL (n=84)
Random Half-mouth 6 (HM6)	2 random quadrants**	14	DB-B-MB-DL-L-ML (n=84)
Random Half-mouth 3 (HM3)	2 random quadrants	14	MB-B-DL (n=42)

*PD, probing depth; CAL, clinical attachment level; DB, disto-buccal; B, buccal, MB, mesio-buccal; DL, disto-lingual; L, lingual; ML, mesio-lingual

All teeth from two randomly selected quadrants (one maxillary and one mandibular)

[a]World Health Organization, 1997; [b]World Health Organization, 2013

In the comparative analysis between CPI and CPIm, prevalence of periodontitis was based on a combination of scores that has been used for this index[14] considering for moderate periodontitis the occurrence of at least one site with PD ≥4mm and one site with CAL ≥4mm, and for severe periodontitis, one or more sites with PD ≥ 4mm and one or more sites with CAL ≥4mm. In the comparative evaluation between CPIm and other PMPEs, in relation to FMPE, three case definitions were used:

1. At least one site with PD or CAL ≥4mm.[7]

2. At least one site with PD ≥4mm and one site with CAL ≥4 mm.[14]

3. At least two sites with PD ≥4mm and two sites with CAL ≥4mm in different teeth.

Initially, a comparison was made between CPI and CPIm with regard to the prevalence of BOP, PD and CAL at levels of 4mm and 6mm, and the prevalence of moderate and severe periodontitis, based on the Pearson's chi-square test and the values of sensitivity of both indices in relations to the FMPE. Due to the lower accuracy found for the CPI in relation to its new version, the CPIm, only the latter was included in the comparisons with the three PMPEs evaluated.

The comparison among prevalence rates was based on sensitivity, absolute bias, relative bias and ainflation factor, calculated as described by several studies,[11,15,16] as follows:

$$\text{Sensitivity} = \frac{\text{PMPE prevalence}}{\text{FMPE prevalence}} \times 100$$

$$\text{Absolute bias} = \text{FMPE prevalence} - \text{PMPE prevalence}$$

$$\text{Relative bias} = \frac{\text{PMPE prevalence} - \text{FMPE prevalence}}{\text{FMPE prevalence}} \times 100$$

$$\text{Inflation factor} = \frac{\text{FMPE prevalence}}{\text{PMPE prevalence}}$$

As the data for PMPEs were obtained from the FMPE, there was no possibility of occurrence of false positives, which results in a specificity calculation of 1 for all PMPE that is why this indicator was not presented in the results.

Statistical comparison of the prevalence rates estimated by the different examination protocols was made by Pearson's chi-square test; the Cochran's Q test was used for the comparisons among the different case definitions; the Wilcoxon test was used to compare mean frequencies of PD and CAL between the FMPE and each PMPE (severity and extent of periodontitis). In all analyzes, a level of statistical significance of 5% (p<0.05) was considered. Statistical Package for the Social Sciences (SPSS) v.22 (IBM®) was used to process and analyze the data.

This study received approval from the Human Research Ethics Committee of the Menino Jesus Municipal Hospital, Sao Paulo (certificate number: 1.177.8730), and all participants signed a statement of informed consent.

Results

The total sample comprised 350 individuals, from 35 to 74 years (mean: 52.8±10.5 years), and more than half of the participants (58%) were younger than 55 years. The female sex predominated (59.7%) and also the university education (45.4%), followed by a high school education (32.3%).More than half of the sample (58.3%) had one to four missing teeth (mean: 5.4±9.0),and about 65% of the participants presented all sites with PD <4 mm (data not shown in table).

The prevalence of BOP was 40.6%, moderate periodontitis 22.0% and severe periodontitis 8.2%, according to the FMPE. Table 2 presents a comparative evaluation of the periodontal parameters estimated by the CPI and the CPIm, in relation to the FMPE. CPI underestimated all parameters, presenting a sensitivity of 50% in estimating prevalence of periodontitis. CPIm was similar to FMPE to detect BOP and periodontal pocket, but it underestimated CAL by approximately 10%, with sensitivity of 80% to estimate moderate and severe periodontitis, with greater accuracy than its previous version.

As shown in Table 3, significant differences were found in the estimates of prevalence of periodontitis among the different examination protocols and the different case definitions considered (p<0.001). Absolute and relative biases demonstrated that all PMPE underestimated the prevalence of periodontitis for each of the case definition, with the relative bias ranging from -10.7 to -54.7% in relation to the real prevalence (FMPE). CPIm and FM3 protocol presented the highest sensitivity in relation to FMPE (p<0,05) and were similar to each other (p>0,05). The worst sensitivity was that of the HM3 protocol. Both the HM6 and HM3 protocols differed significantly from the CPIm. The inflation factor required for adjustment of prevalence rates was less than 1.5 for CPIm and for FM3 in any case definition, and for HM6 in definition 1. As the case definition was more rigorous in the criteria, there were significant reduction in the sensitivity of all PMPE, and greater inflation factor was required.

Table 2 Comparison of estimates of prevalence of bleeding on probing, periodontal pockets and attachment loss, according to full-mouth protocol examination (FMPE), Community Periodontal Index (CPI) and Community Periodontal Index modified (CPIm). Sao Paulo, 2016

Periodontal measures	FMPE		CPI			CPIm		
	n	%	n	%	sensitivity	n	%	sensitivity
Bleeding on probing	142	40.6	106	30,3*	0.7	142	40.6	1.0
Probing depth								
PD ≥4mm	94	26.8	63	18.0*	0.7	94	26.8	1.0
PD ≥6mm	28	8.3	19	5,4*	0,7	28	8.3	1.0
Attachment loss								
CAL ≥4mm	122	34.8	91	26*	0.7	91	26.0*	0.7
CAL ≥6mm	38	10.8	27	7,7*	0.7	27	7.7*	0.7
Moderate periodontitis[a]	77	22.0	40	11.4*	0.5	63	18.0*	0.8
Severe periodontitis[b]	31	8.8	16	4,2*	0.5	25	7.1*	0.8

*p<0,05 (Pearson's Chi-square test)

[a]at least one tooth with PD ≥4mm and one tooth with CAL ≥4mm

[b]at least one tooth with PD ≥4mm and one tooth with CAL ≥6mm

Table 3 Comparison of estimates of periodontitis prevalence based on three case definitions according to full-mouth and partial-mouth periodontal examination protocols. Sao Paulo, 2016

	FMPE	CPIm	FM3	HM6	HM3
Definition I[a]					
Prevalence	122(34.8%)	109 (31.1%)	107 (30.6%)	95 (27.1%)*	78 (22.4%)*
Sensitivity (%)		89.3	87.8	77.8	63.9
Absolute bias		13	15	27	44
Relative bias (%)		-10.7	-12.2	-22.2	-36.1
Correction factor		1.1	1.1	1.3	1.6
Definition 2[b]					
Prevalence	77 (22.0%)	63 (18.0%)	62 (17.7%)	50 (14.3%)*	38 (10.8%)*
Sensitivity (%)		81.8	80.5	64.9	49.3
Absolute bias		14	15	27	39
Relative bias (%)		-18.2	-19.5	-35.1	-50.7
Correction factor		1.2	1.2	1.5	2.0
Definition 3[c]					
Prevalence	66 (18.8%)	48 (13.7%)	46 (13.1%)	37 (10.6%)*	29 (8.3%)*
Sensitivity (%)		72.7	69.7	57.8	45.3
Absolute bias		18	20	27	35
Relative bias (%)		-37.3	-30.3	-42.2	-54.7
Correction factor		1.4	1.5	1.7	2.2

p<0.001 between full-mouth protocol and all partial protocols (Pearson's chi-square test) and among definitions (Cochran's Q test); *p<0,001 in relation to CPIm (Pearson's chi-square test)

FMPE, Full-mouth protocol examination; CPIm, Community Periodontal Index modified (WHO, 2013); FM3, Full-mouth three (MB, B, DL sites in all teeth); HM6, Half-mouth six (six sites in 2 random quadrants); HM3, Half-mouth three sites (MB, B and DL sites in 2 random quadrants)

[a]at least one site with PD ≥4mm OR one site with CAL ≥4mm

[b]at least one site with PD ≥4mm AND one site with CAL ≥4mm

[c]at least two or more sites with PD ≥4mm AND two or more sites with CAL ≥4mm;

The participants presented on average 6.2% of teeth with BOP in at least one site (Table 4). BOP frequencies were similar among FMPE, CPIm and FM3, but were underestimated by HM6 and HM3 (p <0.05). Mean PD and mean CAL in the sample were less than 1.5mm. In the comparative evaluation of periodontitis severity estimates by M-PD and M-CAL, the FM3 and HM6 protocols were similar to FMPE (p>0.05); CPIm and FM3 differed significantly from FMPE (p<0.01), and the CPIm overestimated M-PD by 31.8% and M-CAL by 66.6%. Proportion of affected periodontal sites was low in the sample, and about 95% of the evaluated sites had PD and CAL lower than 4mm. Both site and tooth ratios at the three PD and CAL levels were similar among FMPE, FM3 and HM6 protocols, but underestimated by the HM3 protocol (p<0.01). The CPIm does not apply for estimates of extent of affected sites because the index records only one site per tooth. Regarding to the proportion of affected teeth, the CPIm was similar to FMPE in periodontal pockets extension, but overestimated CAL ≥4mm and ≥6mm (p <0.01).

Discussion

This study made a comparative evaluation of three partial-mouth periodontal examination protocols recently recommended for epidemiological surveys,[8] and of the last two versions of the Community Periodontal Index (CPI and CPI modified), from WHO,[9,12] which were not yet investigated together. The findings showed the superiority of the modified CPI in relation to its previous version. It was similar to the FMPE for estimates of bleeding on probing and periodontal pockets and showed 80% sensitivity to estimate prevalence of moderate and severe periodontitis, contrasting with 50% in the previous CPI.

The best performance of CPIm was probably due to the assessment of probing depth on all the present teeth. However, CAL continues to be assessed on 10 index teeth, which makes the two versions similar regarding this variable. If the greatest measure of CAL on each tooth was recorded as for PD, its sensitivity would be 100%.

Table 4 Comparison of extent and severity of periodontitis based on mean frequency of the assessed periodontal parameters according to full-mouth and partial-mouth periodontal examination protocols. Sao Paulo, 2016

Variable	FMPE	CPIm	FM3	HM6	HM3
Bleeding on probing (% teeth±SD)	6.2±12.0	6.2±12.0	5.9±10.0	4.2±6.1	3.9±8.2
Probing depth (X±SD)					
Mean PD (mm)	1.16±0.38	1.35±0.56	1.18±0.37	1.16±0.38	1.18±0.42
$p*$	ref.	<0.01	0.01	0.13	0.03
% sites PD<4mm	96,9±11,5	NA	97.1±10.5	97.0±13.19	97.5±12.23
% sites PD≥4mm	3,2±8,7	NA	2.9±8.2	3.0±11.1	2.5±5.4
% sites PD≥6mm	0.7±3,3	NA	0.6±3.2	0.6±3.7	0.5±4.3
$p*$	ref.		0.42	0.77	0.04
% teeth PD<4mm	95,2±12,4	95.2±12.4	95.7±10.4	95.8±10.7	97.0 ±12.23
% teeth PD≥4mm	4,8±10,3	4.8±10.3	4.3±11.1	4.2±10.1	3.0±8.9
% teeth PD≥6mm	1,0±7,5	1.0±8.2	0.8±2.4	0.8±3.4	0.4±3.6
$p*$	ref.	1.0	0.77	0.65	0.25
Attachment loss (X±SD)					
Mean CAL (mm)	1.38±0.49	1.53±0.66	1.37±0.48	1.38±0.49	1.37±0.47
$p*$		<0.01	<0.01	0.47	0.54
% sites CAL<4mm	95,9± 5,5	NA	96.2±11.2	96.4±12.6	97.1±10.9
% sites CAL≥4mm	4,1±8,8	NA	3.8± 8.5	3.6±9.4	2.9± 9.1
% sitesCAL≥6mm	0,9±3,8	NA	0.8±3.3	0.7±3.9	0.6±3.7
$p*$	ref.		0.78	0.25	0.02
% teeth CAL<4mm	94,0±12,4	92.4±13.4	94.2±11.3	1,0±2.1	96.3±10.9
% teeth CAL≥4mm	6,0±11,4	7.6±11.1	4.4±8.6	4.2±9.6	3.7± 9.0
% teeth CAL≥6mm	1,3±4,5	1.8±7.5	1.4±6.2	1.3±6.2	0.8±4.2
$p*$	ref.	<0,01	0.95	0.06	<0.01

FMPE, full-mouth protocol examination; CPIm, community periodontal index modified (WHO, 2013); FM3, full-mouth three sites (MB, B, DL sites in all teeth); HM6, half- mouth six sites (six sites in 2 random quadrants); HM3, half-mouth three sites (MB, B and DL sites in 2 random quadrants)

Total of probing sites: FMPE=168; FM3 and HM6=84; HM3=42

Total of probing teeth: FMPE=28; CPIm=28 (PD) and 10 (CAL); FM3 and HM6=28; HM3=14

*Wilcoxon test between FMPE and each partial protocol considering all cases with PD/CAL≥4mm together.

All the PMPE protocols underestimated prevalence of periodontitis when compared to the FMPE for all case definitions employed, with high relative biases. The CPIm exhibited the best sensitivity and minor bias, which was similar to that found for the FM3 protocol (p>0.05). Both methods involve the examination of all teeth, differing in the number of sites examined and recorded. The protocols involving only two quadrants (HM6 and HM3) had significantly higher biases in comparison to CPIm and FM3, although previous studies report good levels of accuracy with these protocols.[5,16] This divergence may be due to the low severity and extent of periodontitis in the present sample, as 65.7% of the participants had all sites evaluated with PD/CAL <4mm and less than 5% of the teeth per individual had altered periodontal variables. These rates are much lower than those reported in other studies.[10,17,18] The low frequency of affected teeth must have exerted an influence on the detection of cases, especially when using protocols in which fewer sites were examined. The influence of the level of periodontitis in the population on the sensitivity of a PMPE protocol has been described previously, as well as the case definition.[5,7,18]

In the present study, three case definitions were considered in increasing order of criterion requirements, which exhibited significant differences according to the PMPE used. These findings are in agreement with data described by Eke et al.,[19] who reported relative biases ranging from 29.0% to 70.0% when comparing the prevalence estimates by PMPE protocols used in official surveys in the USA

based on different case definitions. The more altered parameters are required to define a case, the greater biases in PMPE estimates, which is due to the number of sites examined.

Although there has been a lot of discussion and considerable controversy about a standard case definition, a definition proposed by the Centers for Disease Control and Prevention and American Academy of Periodontology (CDC/AAP) has been recommended.[8,20] In the USA, it has been adopted, along with the FMPE, for the updating of official epidemiological data on periodontal disease.[21,22] In the present study it was not used because this is a case definition with quite strict criteria wichlimitateits use withpartial protocols. With regard to CPI/CPIm, proximal sites are not identifiable; in PMPEs, the use of only proximal sites considerably reduces the number of registered sites, which would possibly result in greater bias.

In an attempt to minimize bias, some studies have proposed a reduction in the criteria required for the definition of a case proportionally to the number of sites examined when a PMPE protocol is used.[6,11] Although there is no standardization for that conduct, the differences found in this study regarding the three hypothetical case definitions employed has shown that relation. The inflation factor is another means of adjustment for prevalence rates estimated by PMPE protocols[5,14] and this study showed the increase in that factor with the increase of a criterion in the case definition, as well as with the reduction in the number of sites/teeth examined.

Although accuracy of PMPE protocols in estimating periodontitis prevalence has been widely investigated in the literature, biases related to the estimates of severity and extent of the disease when using partial protocols have been little evaluated.[7] In the present study, mean PD, mean CAL and proportions of affected sites were evaluated. These aspects varied little in the majority of PMPE protocols and were not influenced by the case definition, unlike what occurred with prevalence of the disease. These findings are in agreement with data described by Vettore et al.[23] and Kingman et al.[5] who found low bias in estimates of severity and extension of periodontal it is by PMPEs.

The CPIm exhibited good sensitivity regarding the estimate of periodontit is prevalence, although this index had the highest biases regarding the estimates of M-PD (>30%) and M-CAL (>60%) and it overestimated the extent of CAL ≥4 mm by approximately 30%. The high levels of overestimates by CPIm for these variables may be explained by the fact that this protocol only records the highest parameter of each tooth, as the means are calculated based on the sum of the scores and the total number of sites examined. Thus, the use of CPIm for estimating proportion of affected sites per individual as well as M-PD and M-CAL is considered unviable. Therefore, regarding severity and extent of periodontitis, the PMPEs were better than the CPIm, with the FM6 protocol achieving similar results to the FMPE and the other protocols exhibiting low levels of bias, which is in agreement with other studies.[5,23]

The present study refers to a specific population in which the occurrence and severity of periodontitis were relatively low, being its main limitation. Thus, the validity of the findings needs to be confirmed in population-based studies. As the characteristics of populations with varied levels of disease severity constitute an important aspect of the performance of partial protocols, a good measure would be to perform a complete periodontal examination on a random subsample of the population to be evaluated to obtain direct evidence of the probable

magnitude of the biases incurred when a given PMPE is used in this population. Thus, the calculation of an inflation factor could bring the estimates closer to the real parameters.

Conclusion

The CPIm and the full-mouth 3 sites protocol presented satisfactory sensitivity to estimate prevalence of periodontitis in populations, being superior to the previous CPI and to the random half-mouth protocols. However, accuracy of estimates may vary with the case definition and population characteristics.

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Conflict of interest

The authors declares that there is no conflict of interest.

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