Validity of Partial Protocols to Assess the Prevalence of Periodontal Outcomes and Associated Socio Demographic and Behavior Factors in Adolescents and Young Adults

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Background: Most studies comparing prevalence of periodontal disease and risk factors by using partial protocols were performed in adult populations, with several studies being conducted in clinical settings.

Objectives: To assess the accuracy of partial protocols in estimating the prevalence of periodontal outcomes in adolescents and young adults from two population-based birth cohorts from Pelotas, Brazil and **to assess differences in the estimation and strength of the effect measures when partial protocols are adopted as compared to full-mouth examination.**

Methods: Gingival bleeding at probing among adolescents (*n*=339) and young adults (*n*=720), and dental calculus and periodontal pocket depth among young adults were assessed using full-mouth examinations and four partial protocols: Ramfjord Teeth (RT), Community Periodontal Index (CPI), and two random diagonal quadrants (1 and 3, and 2 and 4). Socioeconomic, demographic, and periodontal health-related variables were also collected. Sensitivity, absolute and relative bias, and inflation factors were calculated. Prevalence ratio for each periodontal outcome for the risk factors was estimated.

Results: Two diagonal quadrants showed better accuracy, RT had the worst while CPI presented an intermediate pattern when compared with full-mouth examination. For bleeding assessment in adolescence, RT and CPI underestimated by 18.4% and 16.2%, respectively, the true outcome prevalence while among young adults all partial protocols underestimated the prevalence. All partial protocols presented similar magnitude of association measures for all investigated periodontal potential risk factors.

Conclusions: Two diagonal quadrants protocol may be effective in identifying the risk factors for most relevant periodontal outcomes in adolescence and in young adulthood.

KEYWORDS

full-mouth assessment, **partial-mouth assessment, periodontal index,** epidemiologic studies, data collection.

Epidemiological studies of periodontal diseases present inherent difficulty concerning a plethora of case definitions and operational aspects, such as cost, time constraints, and exam protocol accuracy. A systematic review of the definition and the methods of periodontitis concluded that epidemiological studies of periodontal diseases are complicated by the diversity of methodologies and definitions used [1].

However, the usual clinical norm for a full-mouth examination (FM), the gold standard for clinical assessment of periodontal disease [2], involves the examination of six sites on all

existing teeth, involving up to 168 sites per mouth (excluding 3rd molars). Full-mouth examination may not be feasible in some epidemiologic studies, because it significantly increases the examination time [3]. Considering that periodontal diseases exhibit bilateral symmetry, partial record protocols (PRPs), defined as the clinical assessments on a "representative set" of teeth or sites within the subject[4], have been alternatively used. Several partial protocols have been proposed like the Ramfjord Teeth[5], the Community Periodontal Index (CPI) [6], and two random quadrants[7], among others. All of them have operational benefits along with some limitations, mainly the underestimation of the "true" prevalence of the diseases under investigation [8].

Large health surveys that include periodontal assessment, such as the National Health and Nutrition Examination Survey (NHANES), are performed periodically and have provided important information both to surveillance of the disease and in terms of periodontal risk factors. However, Eke et al.[8] found that partial protocols – two random quadrants - used in NHAMES - underestimated the prevalence of periodontal disease by 50%, which led Albandar [9] to propose an inflation factor to correct this underestimation and then allow the use of data provided by NHANES to estimate the prevalence of periodontal diseases.

In addition to the need of an accurate estimation of the prevalence of periodontal diseases from population-based health surveys, it is also necessary to identify the strength of association of different partial protocols when compared with full-mouth examination when analytical epidemiological studies are undertaken. Thomson and Williams [10] addressed this issue comparing the use of full-mouth protocol and partial records (two quadrants) to measure the prevalence of different periodontal outcomes and also calculated the magnitude of effect measures of periodontal risk factors. They found an underestimation of the prevalence of gingival recessions when they adopted a partial protocol. Moreover, they found different odds ratios for the association between periodontal disease and smoking status or patterns of dental visit. This means that in addition to underestimating the prevalence, the use of partial protocol may bias effect measures, which are of concern to analytical studies.

Most studies comparing prevalence of periodontal disease and risk factors by using partial protocols were performed in adult populations from high-income countries, with several studies being conducted in clinical settings. There is a lack of studies addressing this issue among adolescents or young adults in low-and middle-income countries. This is of concern because the accuracy of a disease assessment depends on the prevalence level of the disease when surveys are undertaken as well as of the population risk factor exposure levels [11], which vary across different countries [12,13,14,15].

This study aims to answer the following research questions: i) How accurate are partial protocols to estimate prevalence of periodontal outcomes in adolescents and young adults from Brazil? ii) Are there differences in the estimation and strength of the effect measures when partial protocols are adopted as compared to full-mouth examination?

METHODS

Oral health studies were carried out nested to the 1982 and 1993 Pelotas, Brazil, population-based birth cohort studies. Pelotas is a city with 327,778 inhabitants located in the extreme south of Brazil, close to the border with Uruguay. The economy of the city is based on livestock farming, agriculture, and commerce, besides Pelotas being a university center[16].

1982 Pelotas Birth Cohort

In 1982, all hospital deliveries that occurred in the city were identified and the 5,914 children **from mothers living in the urban area of the city were included in the study and they** were weighted, measured, and their mothers interviewed. This cohort has been followed up several times since then. A detailed explanation about methodological procedures is available elsewhere [17].

In 1997, when all cohort participants completed 15 years of age, we randomly selected 900 cohort participants for a follow-up visit, of whom 888 (98.7%) took part in the first oral health study (OHS-97). **In the OHS-97 we did not analyzed periodontal diseases. All of the 888 participants** were contacted again in 2006, when they completed 24 years, and invited to participate in the second oral health study (OHS-06). Data collection included dental examination and a questionnaire. Dental examination was performed to assess several dental outcomes such as dental caries, soft tissue lesions, gingival bleeding, dental calculus, and periodontal pocket depth [18]. **The fieldwork team comprised six dentists and four advanced dental students, who each examined and interviewed similar numbers of participants.**

1993 Pelotas Birth Cohort

The Oral Health Study started in December 1998, the **year when the children completed 5 years of life,** as a cross-sectional study nested in the birth cohort. In the perinatal study (n = 5,249), **all** the five hospitals in Pelotas were visited twice a day by a team of medical students between January 1 and December 31, 1993. The adolescents identified accounted for 99% of the babies born to mothers living in the urban area of the city. In 1998, a sample of the original cohort, consisting of all low-birth-weight adolescents plus a random 20% of the remainder, was revisited. Of 1,460 eligible adolescents, 87% (1,270 adolescents) were located. A subsample (n = 400) drawn from this group was examined to estimate the prevalence of dental caries and malocclusion (OHS-99). Since low-birth-weight adolescents were overrepresented in the oral study sample (29.7% when compared with 10% in the original cohort), all analyses were weighed. The response rate was 89.7% (n = 359). Nonresponses were mainly because of families having moved out of the city [19].

All the 359 adolescents who participated in the OHS-99 were again visited in their homes in 2005 when they were 12 years old. The response rate was of 94.4% (n = 339). A structured interview including questions about dental services utilization, dental pain, and oral behaviors (toothbrushing, flossing, topical fluorides utilization) was applied. In addition, a short version of the Oral Impacts on Daily Performance [20] was also

administered. The dental exams included fluorosis diagnosis [21], dental trauma [22] and associated treatment needs, dental caries [21], malocclusion [21], and gingival bleeding after probing [21]. Artificial lights were used to improve visualization. **Four teams were formed, each consisting of an examiner and an interviewer.**

Periodontal Outcomes – Full-Mouth Examination

We assessed gingival bleeding at probing (12 years – OHS-99 and 24 years - OHS-06), dental calculus, and periodontal pocket (24 years- OHS-06). For the gingival assessments, at ages 12 and 24 years, calculus and periodontal pocket at 24 years, dental examination was performed at six sites in each presented tooth (mesiobuccal, midbuccal, distobuccal, distolingual, midlingual, and mesiolingual) using a ball-ended periodontal probe. Gingival bleeding and calculus were also recorded (as "present" or "absent"). Periodontal probing depth was measured as the distance (mm) from the free gingival margin to the base of the gingival **crevice** by using **depth** classification as follows: 0--3 mm was recorded **as absence of periodontal pocket**, between 4 and 5 mm was registered as **shallow** periodontal pocket, while a pocket equal to or deeper than 6 mm was recorded as **deep** periodontal pocket [21].

Examiner reliability was assessed by means of weighted kappa for categorical variables. The lowest value was 0.6 for gingival bleeding, while the majority of values were 1.0.

Partial Protocols

After the full mouth examination had been performed a data set was created. From the same data set we simulated four different partial protocols. This option was chosen because ethical concerns precluded five different examinations (full mouth and four partial protocols).

We estimated four different partial protocols among those more used in epidemiological studies of periodontal diseases: Ramfjord Teeth (RT), CPI, two random diagonal quadrants (1 and 3, and 2 and 4). RT utilizes teeth numbers **3, 8, 12, 19, 24, and 28**; CPI uses teeth numbers **2, 3, 8, 14, 15, 18, 19, 24, 30,** and two random quadrant protocols utilize examination of all teeth in the random quadrants, i.e., 1 and 3 and 2 and 4. The number of sites analyzed for each assessment of partial protocol was the same six used in the full-mouth examination [4].

Explanatory Variables

A face-to-face questionnaire was administered to assess *socioeconomic, demographic, toothbrushing habits, dental visit, and smoking variables. Socioeconomic and demographic variables*: i) participants´ sex (male and female), ii) participants´ **self-reported** skin color, according to Brazilian census categories (white, lighter-skinned black, darker-skinned black, yellow-Asian descendants, and indigenous) – the categories yellow-Asian descendants and indigenous were excluded because of their very low frequency in the sample; iii) *Per capita* family monthly income in Reais (R$ -Brazilian currency) at participant´ birth was obtained by dividing the family income (continuous variable) by the number of inhabitants per household and was then categorized according to the number of Brazilian Minimum Wage (BMW) as: ≤1, 1.1--3, ≥3.1 (One BMW was US$ 200,00 in

2006), iv) maternal schooling at participants´ birth was categorized according to the number of years of study: ≥ 12, 9--11, 5--8, and ≤ 4.

Toothbrushing habits, dental visit, and smoking **were recorded as following**: **i) how many times a day do you toothbrush?** and then was dichotomized into yes and no; ii) **Did you have a dental appointment in the last 12 months?** after dichotomized into yes and no, and iii) **Have you smoked at least one cigarette in the last 30 days?** which was dichotomized into yes and no (smoking at 12 years was not collected).

Statistical Analysis

Data were analyzed with STATA 11.0. The prevalence of all periodontal outcomes investigated – gingival bleeding for 12 and 24 years and dental calculus and periodontal pocket for each protocol were calculated. The RT, CPI, half-mouth quadrants 1 and 3, and half-mouth quadrants 2 and 4 were compared with the full-mouth protocol used here as "gold-standard" allowing to assess the sensitivity [(Prevalence in tested protocol / True Prevalence according to full-mouth protocol) x 100], absolute bias (absolute difference between prevalence = Prevalence in the tested protocol – True prevalence according to full-mouth protocol), relative bias [percentage of underestimation of true prevalence = (absolute difference / True prevalence according to full-mouth protocol) x 100], and finally, inflation factor (True prevalence according to full-mouth protocol/ Prevalence in the tested protocol) calculation [8]. Finally, we estimated the prevalence ratio (PR) of each periodontal outcome for the risk factors using Poisson regression analyses [23] with robust adjustment of the variance.

RESULTS

The response rate was 94.4% in the **1993 Pelotas birth cohort at 12-year-old oral health study,** totaling 339 adolescents, and 81.1% in the **1982 Pelotas birth cohort study** at 24-year-old oral health study, totaling 720 adults. At 12 years, 1.5% of adolescents presented at least one tooth loss (Mean 0.02, SD 1.8) and at 24 years tooth loss achieved 47.2% (Mean 0.98, SD 1.4) of the studied sample (data not shown).

Table 1 presents a description of sociodemographic characteristics, daily toothbrushing habit, use of dental services, and smoking in the **sampled population**. In both studies, **male's** participation was slightly higher than women. In relation to skin color, most of the participants were white **in both studies**. The percentage of **subjects** who attended the dentist in the previous year was higher among adults (55.6%) than among adolescents (35.0%). The proportion of mothers with low education level was higher in the 1982 birth cohort (32.3%) when compared with the 1993 birth cohort (28.3%). **Approximately of one quarter of 24 years-old participants were smokers**.

The prevalence of periodontal diseases at 12 and 24 years according to different protocols are presented in Table 2. Under the gold standard protocol (full-mouth protocol), the prevalence of bleeding on probing in adolescents was **much** higher than in adults. The prevalence of dental calculus and periodontal pockets were, respectively, 87.4% (95% CI 84.7--89.7) and 3.3% (95% CI, 2.1--4.9), according to the full-mouth protocol. At the 12 years, among the protocols tested, the lowest prevalence of bleeding on probing was found in the RT protocol and the highest in the half-mouth protocol for quadrants 1 and 3. In

adults, the lowest prevalence of bleeding on probing was achieved with the RT protocol and the highest with the half-mouth protocol for quadrants 2 and 4. In relation to dental calculus, a different prevalence was found only between the gold standard and the RT protocol. The same situation occurred with periodontal pockets - lower prevalence was found with RT protocol when compared with full-mouth protocol.

Table 3 presents the sensitivity, absolute bias, relative bias, and inflation factor of different protocols in comparison with the gold standard. There was a high sensitivity (above 80%) for bleeding at 12 years; however, the RT protocol showed the largest error, underestimated in 18.4% the true prevalence of this condition. Bleeding at 24 years, according to RT protocol, showed low sensitivity, while for the other protocols the sensitivity ranged from 74.8% (95% CI 69.2--79.9) for the CPI to 79.6% (95% CI 74.3--84.3) for the half-mouth quadrants 2 and 4. The RT protocol underestimated in 43.5% the true prevalence of this condition, which is approximately twice that observed in other tested protocols. A high sensitivity, ranging from 92.7% to 96.8% was observed for the dental calculus prevalence estimation. The smallest error for this condition was obtained in the CPI protocol, with 1.5% of real prevalence underestimation and highest with RT protocol that presented 7.3% of underestimation. The lowest sensitivities were observed for periodontal pocket status. Once again, the RT protocol presented the worst performance, underestimating approximately 70% of the real prevalence. The inflation factor of this condition ranged from 1.38 (half-mouth protocol quadrants 1 and 3) to 3.30 (RT).

Table 4 shows PR for gingival bleeding according to independent variables assessed by different protocols for adolescents and adults. In general, for gingival bleeding in 12 and 24-year–olds, there was similarity in the estimation of PR according to different protocols. However, few statistical differences were found: in adolescents, only CPI protocol identified higher prevalence of bleeding in darker-skinned blacks; in adults, only half-mouth 2/4 protocol identified a higher prevalence for lighter-skinned blacks. When analyzing income and education, RT protocol and half-mouth protocol quadrants 1 and 3 differed only in one category of mother' schooling (≥12 years of study) and for family income, we observed difference with RT (category 1.1--3 BMW) and CPI (category ≥3 BMW) protocols.

Prevalence ratios (PR) for dental calculus and probing depth in adult subjects are shown in Table 5. Similar to gingival bleeding, few differences were found for skin color, mother's education, and family income. For dental calculus, the only difference was found with RT protocol in lighter-skinned blacks. Probing depth presented statistical difference between mother' schooling (category 5--8 years) with CPI and half-mouth 2/4 protocols; for income, we found difference only in the category 1.1--3 BMW for both half-mouth protocols.

DISCUSSION

The main findings of this study indicate that, in general, two diagonal quadrants showed better accuracy, RT had the worst while CPI presented an intermediate pattern when compared with full-mouth examination. For bleeding assessment in adolescents, RT and CPI underestimated by 18.4% and 16.2%, respectively, the true outcome prevalence while among young adults all partial protocols underestimated the prevalence when compared with the full-mouth examination. These findings have important implications for the

estimation of periodontal conditions on national surveys conducted according to these protocols. It is noticeable that the prevalence of gingival bleeding was 80% among adolescents and around 30% among adults. For dental calculus and periodontal pockets, only RT protocol biases prevalence estimates while for periodontal pocket assessment, all partial protocols showed low sensitivity. However, these later outcomes had a very low prevalence. Contrary to the common belief that sensitivity and specificity are fixed properties of the test itself (partial protocols in this case), regardless of the characteristics of the study population, these properties depend on the prevalence of the condition under study [24]. This is particularly true for conditions based on continuous scale that is more or less arbitrarily changed into a binary variable as is the case of periodontal pocket. For continuous trait, the probability of misclassifying a true-positive as a negative tends to be higher for individuals whose true values are near the chosen cutoff value (such as perio). Thus, the sensitivity and specificity of a given definition of a condition does depend on the distribution of the severity on the condition [24], which was not assessed in our study.

The underestimation of true prevalence of most common periodontal outcomes corroborated previous studies undertaken among older adults [8, 9, 10]. This is of concern because international agencies such as the World Health Organization recommended the use of the CPI, a partial protocol, to assess both prevalence and extension of periodontal diseases at population level [21]. However, for analytical studies, we noticed that all protocols presented similar magnitude of association measures for all investigated periodontal outcome potential risk factors when unadjusted analysis were performed . Similar to earlier studies [2, 10], we found modest difference in the prevalence ratio estimates of risk factors. Therefore, partial protocols are acceptable for use when analytical epidemiological studies are undertaken. **Partial protocols gather sufficient information to measure the association of periodontal diseases and socio demographic and behavior factors among adolescents and young adults. However, this pattern would be different for older population or for young population with higher levels of risk factors and/or periodontal diseases.** This is an important finding once Dowset et al. [2] estimated that a full-mouth examination of six sites per tooth to assess periodontal pocket and clinical attachment loss performed by experienced periodontologists takes 17 min when compared with 8.5 min when half-mouth protocols are used. Time, cost, participant's discomfort, and examiner fatigue may be significantly reduced by using half-mouth protocols. Therefore, along with efficiency, ethical concerns may reinforce the use of partial protocols in large epidemiological studies. It is important to highlight that this recommendation may not be done for longitudinal studies, in which site-specific incidence is one aim to be reached.

The similarity of the dental caries distribution in both the left and right sides of the mouth is very well known [25-28]. Nevertheless, regarding periodontal outcomes, this pattern is not easily identifiable because some periodontal outcomes, such as gingival recession and gingival bleeding, rely on the effectiveness and power of mechanical toothbrushing, which differ between a right- and left-handed person. For example, for a right-handed person, the prevalence of gingival recession is more prevalent on the left side of the mouth [10]. In contrast, our findings indicated a very similar prevalence pattern of periodontal outcomes when two diagonal protocols were used (1 and 3 versus 2 and 4). This lack of difference may be due to relatively young population under investigation and because we did not assess gingival recession.

Strengths and Weaknesses

Our studies used data from two large samples of population-based birth cohort studies, had high examiner reliability, and the examiners were blinded to the main research questions. We are unaware of any study comparing the use of different protocols to assess prevalence of periodontal outcomes and their associated factors in adolescence and young adulthood in home-based settings.

On the other hand, we measured periodontal pocket using a categorical scale and not a continuous one; we did not collect gingival recession or clinical attachment loss, **more severe cases of periodontal diseases were little frequent and we used tobacco status as a binary variable**. In addition, our analysis focused on the prevalence estimation and the assessment of the association measurement between periodontal outcomes and potential risk factors. The extension and severity of the periodontal outcomes were not taken into consideration in this work. The use of several measures of different dental outcomes is not always possible in multidisciplinary cohort studies due to logical and ethical reasons. The Pelotas studies have a very busy assessment protocol undergone by cohort members, which means that there is no time to more detailed dental examination [17].

In short, we conclude that some partial protocols, such as two diagonal quadrants, may be useful and effective in identifying potential risk factors for most relevant periodontal outcomes in adolescence and in young adulthood. On the other hand, partial protocols may underestimate the true prevalence of periodontal outcomes and its validity depends on the population age. This is particularly valid among adolescents and younger adults than in older adults, where the number of sites to be examined in the former is much higher than that in the latter due to the high rates of tooth loss; however, there is a lower level of disease to be detected in younger individuals. **Definitely, periodontal diseases are not a major problem in adolescents and young adults. However, as we intend to follow up these two birth cohorts until adulthood the assessment of early stages of periodontal diseases is useful to improve our understanding of its development.**

CONFLICT OF INTEREST AND SOURCES OF FUNDING STATEMENT

We declare we have no conflict of interest.

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Table 1 – Sample characteristics at 12 and 24 years old. 1982 and 1993 Pelotas Birth Cohort studies, Brazil.

Variables	12 years old		24 years old	
	n	% (95%CI)	n	% (95%CI)
Sex				
Males	182	53.7 (48.4; 59.0)	375	52.8 (49.1; 56.5)
Females	157	46.3 (41.0; 51.6)	335	47.2 (43.4; 50.9)
Skin colour				
White	265	78.2 (73.8; 82.6)	505	71.2 (67.7; 74.5)
Dark skinned blacks	49	14.4 (10.7; 18.2)	75	10.6 (8.4; 13.1)
Lightener skinned blacks	25	7.4 (4.6; 10.2)	129	18.2 (15.4; 21.2)
Mother schooling (years)				
≤ 4	96	28.3 (23.5; 33.1)	229	32.3 (28.9; 35.9)
5 to 8	165	48.7 (43.3; 54.0)	318	44.9 (41.2; 48.7)
9 to 11	56	16.5 (12.5; 20.5)	74	10.5 (8.3; 12.9)
≥ 12	22	6.5 (3.9; 9.1)	87	12.3 (10.0; 14.9)
Family income (BMW)*				
≤ 1	61	18.0 (13,9; 22,1)	63	9.1 (7.0; 11.4)
1.1 to 3	150	44.2 (38,9; 49,6)	283	40.7 (37.0; 44.4)
≥ 3.1	128	37.8 (32,6; 42,9)	350	50.2 (46.4; 53.9)
Daily toothbrushing				
Yes	329	97.3 (95.6; 99.1)	711	98.7 (97.6; 99.4)
No	9	2.7 (0.9; 4.4)	9	1.3 (0.6; 2.4)
Dental visit in the last one year				
Yes	156	35.0 (28.9; 41.1)	384	55.6 (51.8; 59.3)
No	84	65.0 (58.9; 71.1)	307	44.4 (40.6; 48.2)
Current Smokers				
Yes	-	-	537	22.8 (19.8; 26.1)
No	-	-	159	77.2 (73.8; 80.2)

*BMW – Brazilian Minimum Wage. R$ 300.00 in 2005 (R$ 1.00 = U$ 2.50) and R$ 350.00 in 2006 (R$ 1.00 = U$ 2.20).

Table 2 – Prevalence of periodontal diseases at aged 12 and 24 years according to different protocols. 1982 and 1993 Pelotas Birth Cohorts, Brazil.

Protocols	Prevalence of periodontal outcomes							
	Gingival bleeding at probing at aged 12 years (*n*=339)		Gingival bleeding at probing at aged 24 years (*n*=720)		Dental calculus at aged 24 years (*n*=720)		Periodontal pocket at aged 24 years (*n*=720)	
	n	% (95%CI)	N	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Full-Mouth	298	87.9 (84.4; 91.4)	270	37.5 (33.9; 41.1)	629	87.4 (84.7; 89.7)	24	3.3 (2.1; 4.9)
Ramfjord Teeth	243	71.7 (66.8; 76.5)	153	21.2 (18.3; 24.4)	583	81.0 (77.9; 83.8)	7	1.0 (0.4; 2.0)
CPI	250	73.7 (69.0; 78.5)	202	28.1 (24.8; 31.5)	620	86.1 (83.4; 88.5)	16	2.2 (1.3; 3.6)
Half-mouth Quadrants 1 and 3	270	79.6 (75.3; 84.0)	204	28.3 (25.1; 31.8)	609	84.6 (81.7; 87.1)	17	2.4 (1.4; 3.7)
Half-mouth Quadrants 2 and 4	273	80.5 (76.3; 84.8)	215	29.9 (26.5; 33.3)	608	84.4 (81.6; 87.0)	14	1.9 (1.1; 3.2)

Table 3 – Estimates of sensitivity (SE), absolute and relative bias, and inflation factor of different protocols comparing with the Full-Mouth protocol at aged 12 and 24 years. Pelotas 1982 and 1993 Birth Cohorts, Brazil.

Periodontal diseases assessed by different protocols	SE (95% CIB) [a]	Absolute bias [b]	Relative bias [c]	Inflation factor [d]
Gingival bleeding at probing at aged 12 years				
Ramfjord Teeth (*n*=243)	81.5 (76.7; 85.8)	- 16.2	18.4	1.23
CPI (*n*=250)	83.9 (79.2; 87.9)	- 14.4	16.2	1.19
Half-mouth Quadrants 1 and 3 (*n*=270)	90.6 (86.7; 93.7)	- 8.3	9.4	1.10
Half-mouth Quadrants 2 and 4 (*n*=273)	91.6 (87.9; 94.5)	- 7.4	8.4	1.09
Gingival bleeding at probing at aged 24 years				
Ramfjord Teeth (n=153)	56.7 (50.5; 62.7)	- 16.3	43.5	1.77
CPI (n=202)	74.8 (69.2; 79.9)	- 9.4	25.1	1.33
Half-mouth Quadrants 1 and 3 (n=204)	75.6 (70.0; 80.6)	- 9.2	24.5	1.32
Half-mouth Quadrants 2 and 4 (n=215)	79.6 (74.3; 84.3)	- 7.6	20.3	1.25
Dental calculus at aged 24 years				
Ramfjord Teeth (*n*=583)	92.7 (90.4; 94.6)	- 6.4	7.3	1.08
CPI (*n*=620)	98.6 (97.3; 99.3)	- 1.3	1.5	1.02
Half-mouth Quadrants 1 and 3 (*n*=609)	96.8 (95.1; 98.0)	- 2.8	3.2	1.03
Half-mouth Quadrants 2 and 4 (*n*=608)	96.7 (94.9; 97.9)	- 3.0	3.4	1.03
Periodontal pocket at aged 24 years				
Ramfjord Teeth (*n*=7)	29.2 (12.6; 51.1)	- 2.3	69.7	3.30
CPI (*n*=16)	66.7 (44.7; 84.4)	- 1.1	33.3	1.50
Half-mouth Quadrants 1 and 3 (*n*=17)	70.8 (48.9; 87.4)	- 0.9	27.3	1.38
Half-mouth Quadrants 2 and 4 (*n*=14)	58.3 (36.6; 77.9)	- 1.4	42.4	1.74

[a] **SE** = Sensitivity = (Prevalence in the tested protocols/ Prevalence in the "gold-standard" Full-mouth protocol) x 100.
[b] **Absolute bias** = Absolute difference between prevalence= Prevalence in the tested protocols – Prevalence in the "gold standard" Full-mouth protocol.
[c] **Relative bias** = Percent of true prevalence underestimation = (Absolute difference in the prevalence / Prevalence in the "gold standard" Full mouth protocol) x 100.
[d] **Inflation factor** = Prevalence in the "gold standard" Full-mouth protocol/ Prevalence in the tested protocol.

Table 4. Prevalence ratios (95% CI) of gingival bleeding for independent variables and different protocols at age 12 and 24 in subjects from Pelotas Birth Cohorts, Brazil.

Variables	Protocols				
	FM	**RT**	**CPI**	**HM-1/3**	**HM-2/4**
Sex					
Male	1.00	1.00	1.00	1.00	1.00
Female (12)	0.98 (0.91; 1.07)	0.91 (0.80; 1.05)	0.93 (0.81; 1.05)	1.01 (0.91; 1.13)	0.95 (0.85; 1.06)
Female (24)	0.98 (0.81; 1.19)	1.03 (0.78; 1.37)	1.10 (0.87; 1.39)	1.01 (0.80; 1.28)	0.93 (0.74; 1.16)
Skin Color					
White	1.00	1.00	1.00	1.00	1.00
Lightener skinned black (12)	1.00 (0.86; 1.17)	0.96 (0.73; 1.27)	1.00 (0.77; 1.29)	1.01 (0.82; 1.24)	1.00 (0.82; 1.23)
Dark skinned black (12)	1.03 (0.92; 1.14)	1.13 (0.96; 1.33)	1.16 (1.00; 1.34)	1.03 (0.89; 1.19)	1.08 (0.95; 1.13)
Lightener skinned black (24)	1.17 (0.92; 1.48)	1.29 (0.92; 1.82)	1.13 (0.84; 1.52)	1.22 (0.91; 1.62)	1.30 (1.00; 1.70)
Dark skinned black (24)	1.19 (0.89; 1.59)	1.14 (0.73; 1.80)	1.07 (0.73; 1.57)	1.25 (0.88; 1.77)	1.15 (0.80; 1.64)
Mother schooling (yrs)					
≤4	1.00	1.00	1.00	1.00	1.00
5 to 8 (12)	1.01 (0.93; 1.11)	1.02 (0.88; 1.17)	1.03 (0.89; 1.18)	1.02 (0.91; 1.14)	1.02 (0.91; 1.14)
9 to 11 (12)	0.99 (0.87; 1.12)	0.81 (0.63; 1.03)	0.90 (0.73; 1.12)	0.89 (0.74; 1.07)	0.86 (0.71; 1.03)
≥12 (12)	0.82 (0.63; 1.07)	0.67 (0.43; 1.03)	0.79 (0.55; 1.14)	0.66 (0.45; 0.98)	0.71 (0.49; 1.02)
5 to 8 (24)	0.81 (0.65; 0.99)	0.85 (0.62; 1.17)	0.82 (0.63; 1.06)	0.86 (0.66; 1.12)	0.75 (0.59; 0.97)
9 to 11 (24)	1.00 (0.74; 1.35)	1.03 (0.65; 1.64)	0.91 (0.61; 1.35)	0.99 (0.67; 1.46)	0.93 (0.65; 1.34)
≥12 (24)	0.66 (0.46; 0.95)	0.68 (0.40; 1.16)	0.63 (0.40; 0.99)	0.77 (0.50; 1.17)	0.54 (0.34; 0.85)
Family Income (BMW)					
≤1	1.00	1.00	1.00	1.00	1.00
1.1 to 3 (12)	1.00 (0.90; 1.11)	0.98 (0.83; 1.17)	1.08 (0.91; 1.29)	1.05 (0.90; 1.22)	1.00 (0.88; 1.15)
≥3.1 (12)	0.98 (0.87; 1.10)	0.89 (0.74; 1.08)	0.96 (0.79; 1.17)	0.97 (0.83; 1.14)	0.90 (0.77; 1.04)
1.1 to 3 (24)	0.82 (0.61; 1.11)	0.57 (0.38; 0.85)	0.86 (0.59; 1.26)	0.83 (0.57; 1.21)	0.74 (0.53; 1.05)
≥3.1 (P24)	0.70 (0.52; 0.95)	0.49 (0.33; 0.73)	0.73 (0.50; 1.07)	0.68 (0.47; 0.99)	0.63 (0.45; 0.89)
Daily toothbrushing					
No	1.00	1.00	1.00	1.00	1.00
Yes (12)	0.88 (0.84; 0.91)	0.92 (0.65; 1.32)	1.11 (0.70; 1.77)	0.79 (0.75; 0.84)	0.80 (0.76; 0.85)
Yes (24)	0.55 (0.34; 0.89)	0.31 (0.19; 0.50)	0.50 (0.27; 0.91)	0.50 (0.28; 0.91)	0.44 (0.27; 0.71)
Visit the dentist last year					
No	1.00	1.00	1.00	1.00	1.00
Yes (12)	1.01 (0.91; 1.12)	0.99 (0.83; 1.19)	1.02 (0.86; 1.22)	1.02 (0.87; 1.18)	0.88 (0.77; 1.01)

Yes (24)	0.76 (0.62; 0.92)	0.58 (0.43; 0.78)	0.74 (0.58; 0.94)	0.69 (0.54; 0.88)	0.69 (0.54; 0.87)
Current smokers					
No	1.00	1.00	1.00	1.00	1.00
Yes (12)	-	-	-	-	-
Yes (24)	1.02 (0.81; 1.29)	1.07 (0.77; 1.51)	1.28 (0.99; 1.66)	1.00 (0.76; 1.33)	1.13 (0.87; 1.46)

Protocols: FM – Full Mouth; RT – Ramjford Teeth; CPI – CPITN; HM-1/3 – Half-mouth quadrants #1 and #3; HM-2/4 – Half-mouth quadrants #2 and #4.
(12) – At age 12; (24) – At age 24
*Family income in Brazilian Minimum Wages (BMW) = one BMW was US$ 200.00 in 2006.

Table 5. Prevalence ratios (95% CI) of dental calculus (C) and probing depth (PD) for independent variables and different protocols at age 24 in subjects from Pelotas Birth Cohorts, Brazil.

Variables	Protocols				
	FM	RT	CPI	HM-1/3	HM-2/4
Sex					
Male	1.00	1.00	1.00	1.00	1.00
Female (C)	0.97 (0.92; 1.02)	0.95 (0.88; 1.02)	0.97 (0.91; 1.03)	0.95 (0.89; 1.01)	0.96 (0.90; 1.02)
Female (PD)	1.34 (0.59; 3.07)	0.83 (0.19; 3.72)	1.44 (0.54; 3.82)	1.12 (0.42; 2.95)	1.12 (0.36; 3.44)
Skin Color					
White	1.00	1.00	1.00	1.00	1.00
Lightener skinned black (C)	1.07 (1.00; 1.14)	1.10 (1.02; 1.19)	1.08 (1.00; 1.15)	1.08 (1.00; 1.15)	1.07 (0.99; 1.14)
Dark skinned black (C)	1.00 (0.91; 1.10)	1.02(0.91; 1.15)	1.00 (0.91; 1.11)	1.00 (0.91; 1.12)	1.02(0.92; 1.13)
Lightener skinned black (PD)	1.56 (0.62; 3.96)	5.21 (1.18; 23.05)	1.96 (0.68; 5.63)	1.96 (0.68; 5.63)	2.24 (0.66; 7.53)
Dark skinned black (PD)	0.45 (0.06; 3.35)	**	0.67 (0.09; 5.19)	0.67 (0.09; 5.19)	0.96 (0.12; 7.72)
Mother schooling (yrs)					
≤4	1.00	1.00	1.00	1.00	1.00
5 to 8 (C)	1.02 (0.95; 1.07)	0.98 (0.90; 1.07)	1.00 (0.93; 1.07)	0.99 (0.92; 1.06)	1.02 (0.95; 1.09)
9 to 11 (C)	1.07(0.99; 1.15)	1.08 (0.97; 1.19)	1.06(0.98; 1.15)	1.08 (0.99; 1.18)	1.10 (1.00; 1.20)
≥12 (C)	0.92 (0.82; 1.93)	0.96 (0.84; 1.09)	0.93 (0.83; 1.04)	0.93 (0.83; 1.05)	0.96 (0.85; 1.08)
5 to 8 (PD)	0.26 (0.08; 0.81)	**	0.36 (0.10; 1.18)	0.16 (0.03; 0.73)	0.58 (0.16; 2.12)
9 to 11 (PD)	1.12 (0.37; 3.43)	0.77 (0.08; 6.82)	1.16 (0.32; 4.26)	1.03 (0.29; 3.71)	1.24 (0.24; 6.25)
≥12 (PD)	0.72 (0.20; 2.51)	1.31 (0.25; 7.06)	0.33 (0.04; 2.59)	0.58 (0.13; 2.66)	0.53 (0.06; 4.44)
Family Income (BMW)					
≤1	1.00	1.00	1.00	1.00	1.00
1.1 to 3 (C)	1.00 (0.91; 1.10)	0.96 (0.86; 1.09)	0.97 (0.89; 1.08)	1.01 (0.90; 1.13)	1.01 (0.90; 1.13)
≥3.1 (C)	0.96 (0.87; 1.06)	0.95 (0.84; 1.07)	0.95 (0.87; 1.05)	0.96 (0.86; 1.08)	1.00 (0.89; 1.12)
1.1 to 3 (PD)	0.31 (0.12; 0.80)	**	0.26 (0.08; 0.85)	0.45 (0.14; 1.43)	0.39 (0.12; 1.29)
≥3.1 (PD)	0.18 (0.06; 0.49)	**	0.18 (0.05; 0.60)	0.23 (0.06; 0.82)	0.14 (0.03; 0.59)
Daily toothbrushing					
No	1.00	1.00	1.00	1.00	1.00
Yes (C)	0.98 (0.78; 1.24)	1.04 (0.73; 1.48)	0.97 (0.77; 1.22)	0.95 (0.75; 1.20)	0.95 (0.75; 1.20)
Yes (PD)	0.29 (0.04; 1.93)	**	**	**	0.16 (0.02; 1.26)
Visit the dentist last year					

No	1.00	1.00	1.00	1.00	1.00
Yes (C)	0.93 (0.88; 0.99)	0.90 (0.84; 0.97)	0.92 (0.87; 0.98)	0.94 (0.88; 1.00)	0.89 (0.84; 0.95)
Yes (PD)	0.57 (0.26; 1.27)	0.60 (0.14; 2.66)	0.36 (0.13; 1.04)	0.71 (0.28; 1.82)	0.44 (1.15; 1.31)
Current smokers					
No	1.00	1.00	1.00	1.00	1.00
Yes (C)	1.10 (1.04; 1.16)	1.15 (1.07; 1.23)	1.11 (1.05; 1.17)	1.14 (1.07; 1.20)	1.13 (1.06; 1.20)
Yes (PD)	0.89 (0.34; 2.34)	0.56 (0.07; 4.64)	0.48 (0.11; 2.10)	1.04 (0.34; 3.14)	0.92 (0.26; 3.26)

Protocols: FM – Full Mouth; RT – Ramjford Teeth; CPI – CPITN; HM-1/3 – Half-mouth quadrants #1 and #3; HM-2/4 – Half-mouth quadrants #2 and #4.
(C) – Dental Calculus; (PD) – Probing depth ≥4mm
*Family income in Brazilian Minimum Wages (BMW). One BMW was US$ 200.00 in 2006.

** Insufficient number of subjects to data analyzes