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Periodontal disease definition may determine the association between periodontitis and pregnancy outcomes

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Abstract

Aim: The aim of this secondary analysis is to explore whether the application of different definition criteria of periodontitis, used in other similar studies, has an influence on the significance of the association between periodontitis and prematurity or low birth weight.

Material and Methods: Fourteen periodontitis definitions and more than 50 periodontal disease continuous measurements, found in 23 published studies, were applied to a cohort study that included 1296 pregnant women. The associations with adverse pregnancy outcomes were analysed using logistic regression analysis.

Results: Six of the 14 tested definitions of periodontitis resulted in statistically significant adjusted odds ratios (ORs) for some of the adverse pregnancy outcomes, while no significance was found for the other eight case definitions. Out of more than 50 periodontal continuous measurements tested, only 17 demonstrated statistically significant ORs.

Conclusions: Our results support the hypothesis that the significance of the association between periodontal disease and pregnancy outcomes may be determined by the periodontal disease definition or measurement used.

Studies on the role of periodontal disease as an independent risk factor for pre-term birth (PTB) or low birth weight (LBW) have yielded conflicting results. One of the major issues that have been deemed responsible for the inconsistency of the findings are the different methods used to assess or define periodontal disease

(Vettore et al. 2006, Xiong et al. 2006).This is mainly due to the fact that there is no uniform criteria to define periodontal disease, or to measure the extent and severity of it. Holbrook et al. (2004), Lunardelli & Peres (2005), Radnai et al. (2004, 2006) and Rajapakse et al. (2005) rely on probing pocket depth (PPD) to define periodontal disease in combination with gingival bleeding scores and plaque scores in some of the cases, while other authors use clinical attachment level (CAL) as the basis for their definition (Offenbacher et al. 1996, Jeffcoat et al. 2001, Goepfert et al. 2004, Cruz et al. 2005, Jarjoura et al. 2005, Bosnjak et al. 2006, Castaldi et al. 2006,

Wood et al. 2006, Bassani et al. 2007). On the other hand, authors such as Lopez et al. (2002), Marin et al. (2005), Offenbacher et al. (2001) choose a combination of PPD and CAL. Moreover, it is worth mentioning that the definition thresholds used for bleeding on probing (BOP), PPD and CAL as markers of disease are also different in most studies.

Furthermore, not all studies on the association between clinical parameters of periodontal disease and PTB or LBW use categorized definitions of periodontitis. Some authors look at the relationship of adverse pregnancy outcomes and continuous measurements of periodontal disease, like percentage of sites

with BOP, number or percentage of sites above a determined threshold of PPD or CAL, mean PPD, mean CAL, mean calculus and other clinical measurements (Mokeem et al. 2004, Buduneli et al. 2005, Moore et al. 2005, Moreu et al. 2005, Noack et al. 2005, Skuldbol et al. 2006). Likewise, the Community Periodontal Index of Treatment Needs (CPITN) (Dasanayake 1998, Davenport et al. 2002), the Extent and Severity Index (ESI) (Louro et al. 2001) or the Periodontal Screening and Recording System (PSR) (Alves & Ribeiro 2006) have also been used by others .

The aim of this secondary analysis is to explore whether the application of different definition criteria of periodontitis, used in other similar studies, has an influence on the significance of the association between periodontitis and prematurity or LBW.

Material and Methods

Study sample

The subject sample is derived from a cohort study that was conducted to evaluate the association between periodontal disease and PTB, LBW and premature low birth weight (PLBW). Detailed material and methods have been published elsewhere (Agueda et al. 2008). One thousand four hundred and ninety-three pregnant women who sought prenatal care at the University Hospital of Lleida (Spain) were invited to participate in the study. The invitation took place when they attended the hospital to undergo the 20th–24th gestational week routinary ultrasound examination. The women were recruited between March 2003 and January 2005. Out of 1493, 1404 signed the informed consent form and 89 refused to participate. Reasons given for not participating were time unavailability for interview and/or oral examination after the ultrasound examination (62), dental fear (11) and other reasons (16).

Demographic data and medical history were assessed by interview. One thousand three hundred and thirty-four women met the inclusion criteria (18–40 years of age, $\geqslant 18$ teeth, absence of multiple gestation, no diabetes history before pregnancy, absence of HIV infection, no history of alcoholism or drug abuse and no antibiotic indication due to invasive dental procedures) and underwent an oral examination. Thirty-four of

the women moved during pregnancy or gave birth at a different hospital, while four of them gave birth to a stillborn. Finally, complete data were registered for 1296 pregnant women and their newborns.

Most of the predisposing factors for PTB and LBW, documented in the medical literature, were assessed for each of the participants. The questionnaire included items on age, ethnicity [Caucasian, black, gipsy and others (Arab, Asian and Latin-American)], socioeconomic level (five categories), educational level (primary or less, high school and university), area of residence (rural, semi-rural and urban, depending on the number of inhabitants), smoking habits (five categories), alcohol intake (0 or $\geqslant 1$ drink/week), BMI (>20, 20–25, 25.1–30, 30.1–35 and >35), systemic diseases (anaemia and/or hypertension during pregnancy), obstetric history (number of previous pregnancies, previous pre-term delivery, previous low birth weight and previous spontaneous miscarriage and onset of prenatal care (up to the eighth week or later). The assessment of socioeconomic status was based on the employment of the woman and her partner (or the head of the family in the case of women without partners) and grouped into five categories, I being the highest and V the lowest. The smoking habit was divided into five categories: never smoked or former smoker before pregnancy, smoker of <15 cigarettes per day just until pregnancy, smoker of $\geqslant 15$ cigarettes just until pregnancy, smoker of <6 cigarettes during pregnancy and smoker of $\geqslant 6$ cigarettes during pregnancy. When necessary, further clinical data were obtained from the women's hospital records. The following variables were recorded from the hospital medical records shortly after delivery: newborn weight and gender, pregnancy duration, genitourinary tract infections, antibiotic intake during pregnancy, gestational diabetes, pregnancy complications (vaginal bleeding, placenta previa, emergency surgery) and type of delivery (vaginal or caesarean).

PTB was defined as delivery at <37 weeks of gestation. Gestational age was estimated from the last menstrual period and the results of the ultrasound examination. LBW was defined as delivery of an infant with a birth weight under 2500 g while PLBW was considered as delivery of an infant at <37 weeks of

gestation together with a birth weight under 2500 g.

Clinical examination

Clinical parameters were assessed using a UNC-15 periodontal probe by a single calibrated examiner at six sites/tooth excluding third molars. Plaque index (O'Leary et al. 1972), full mouth BOP, PPD and CAL were recorded. The oral examination also included number of untreated dental caries. A single examiner (A. A.) performed all measurements. At the beginning of the study, the examiner was calibrated against an expert periodontist who represented the gold standard (J. J. E.). The single designated examiner measured PPD and CAL. After 7 days, the examiner repeated the examination. Likewise the expert periodontists performed an additional examination. Upon completion of all measurements, intra-examiner and inter-examiner repeatability for PPD and CAL measurements was assessed. The weighted κ values for inter-examiner calibration were 0.79 (IC 95% 0.71–0.88) for PPD and 0.69 (IC 95% 0.55–0.85) for CAL, whereas intra-examiner calibration showed weighted κ values of 0.83 (0.69–0.97) for PPD and 0.88 (0.72–1.04) for CAL.

Periodontal disease definitions and measurements

The present study used 14 different definitions of periodontal disease, and at least 50 continuous clinical measurements of periodontal disease (Table 1). It should be noticed that, if we consider the different definitions and measurements of periodontal disease, while some authors use a full-mouth approach (excluding third molars) at six sites per tooth (Offenbacher et al. 1996, Jeffcoat et al. 2001, Lopez et al. 2002, Mokeem et al. 2004, Buduneli et al. 2005, Cruz et al. 2005, Lunardelli & Peres 2005, Moreu et al. 2005, Noack et al. 2005, Castaldi et al. 2006, Radnai et al. 2006, Skuldbol et al. 2006, Wood et al. 2006, Bassani et al. 2007), others include only four sites per tooth (Louro et al. 2001, Marin et al. 2005, Rajapakse et al. 2005, Bosnjak et al. 2006). On the contrary, some others just reflect on a sextant recording approach (Dasanayake 1998, Davenport et al. 2002, Goepfert et al. 2004) or even a partial recording approach (Holbrook et al. 2004, Jarjoura et al. 2005, Moore

Table 1. Clinical measurements and definitions of periodontal disease (PD) used by different authors to analyse the relationship between PD and PTB, LBW or PLBW

References	Study design Clinical examination	Definitions and measurements of PD used for analysis	Outcome Results: adjusted OR
Bassani et al. (2007)	Case–control Full mouth (six sites per tooth)	PD: ≥3 teeth with ≥1 site with CAL≥3 Categorized PD: Mild≥3 sites in different teeth with CAL≥3 mm, but not 3 sites with CAL≥5 mm Moderate ≥3 sites in different teeth with CAL≥5 mm, but not 3 sites with CAL≥7 mm Severe ≥3 sites in different teeth with CAL≥7 mm	LBW PD: NS Categorized PD: NS
Bosnjak et al. (2006)	Case–control Full mouth (four sites per tooth)	PD: Extent 4:60 (≥60% sites with CAL≥4 mm) % sites with BOP Mean PPD Mean CAL Extent 2: % sites with CAL≥2 Extent 3: % sites with CAL≥3 Extent 4: % sites with CAL≥4 Severity 2: Mean CAL sites with CAL≥2 Severity 3: Mean CAL sites with CAL≥3 Severity 4: Mean CAL sites with CAL≥4	PTB PD: OR 8.13 (2.73–45.9)
Buduneli et al. (2005)	Case–control Full mouth (six sites per tooth)	% of sites with BOP Mean PPD Number of sites with PPD≥4 mm Number of sites with PPD = 6–7 mm	PTB and/or LBW % sites BOP: NS Mean PPD: NS Number of sites PPD≥4 mm: NS Number of sites PPD = 6–7 mm: NS
Castaldi et al. (2006)	Cross-sectional Full mouth (six sites per tooth)	PD: ≥4 teeth with CAL≥3 mm	PTB, LBW PD: NS
Cruz et al. (2005)	Case–control Full mouth (six sites per tooth)	PD: ≥4 teeth with CAL≥4 mm	LBW PD: OR 3.98 (1.58–10.10) (Mothers <4 years schooling)
Dasanayake (1998)	Case–control Full mouth (sextants)	CPITN: Number of sextants in each category (0–4)[*]	LBW Number of sextants CPITN 0: OR 0.3 (0.12–0.72)
Davenport et al. (2002)	Case–control Full mouth (sextants)	Mean PPD calculated from the worst PPD for each tooth Mean CPITN calculated from the CPITN for each tooth[†] Mean Bleeding Index based on Bleeding index (0–3) for each tooth[‡]	PLBW Mean PPD: OR 0.79 (0.64–0.99) Mean CPITN: NS Mean Bleeding Index: NS
Goepfert et al. (2004)	Case–control Full mouth (sextants, six sites per tooth)	PD: CAL≥3 in any sextant Mild PD: CAL 3–5 in any one sextant Severe PD: CAL>5 mm in any one sextant % of sextants with CAL>3[§] % of sextants with CAL>5[§]	Early spontaneous PTB <32 weeks Severe PD: OR 3.4 (1.5–7.7)
Holbrook et al. (2004)	Cohort Ramfjord teeth (six sites per tooth)	PD: ≥4 sites with PPD≥4 mm	PTB PD: NS
Jarjoura et al. (2005)	Case–control Three sites per tooth (mesiobuccal, midbuccal, and distobuccal) in two randomly selected, diametrically opposed, quadrants	PD: ≥5 sites with CAL≥3 mm % sites with plaque % of sites with BOP Mean PPD Mean CAL % of teeth with PPD≥5 mm % of teeth with CAL≥3 mm	PTB, LBW PD: OR 2.75 (1.01–7.54) (PTB) PD: NS (LBW)

Table 1. (Contd.)

References	Study design Clinical examination	Definitions and measurements of PD used for analysis	Outcome Results: adjusted OR
Jeffcoat et al. (2001)	Cohort Full mouth (six sites per tooth)	PD: $\geqslant 3$ sites with CAL $\geqslant 3$ mm Generalized PD $\geqslant 90$ sites with CAL $\geqslant 3$ mm	PTB (<37 weeks, <35 weeks, <32 weeks) Generalized PD: OR 4.45 (2.16–9.18) (PTW <37 weeks)
Lopez et al. (2002)	Cohort Full mouth (six sites per tooth)	PD: $\geqslant 4$ teeth with $\geqslant 1$ site with PPD $\geqslant 4$ and with CAL $\geqslant 3$ mm at the same site % sites with BOP Mean PPD Mean CAL % teeth with PPD $\geqslant 4$ mm % teeth with CAL $\geqslant 3$ mm % teeth with CAL > 3 mm	PTB, LBW, PTB and/or LBW PD: RR 3.5 (1.5–7.9) (PTB and/or LBW) PD: RR 2.9 (1.0–8.1) (PTB) PD: RR 3.6 (1.1–12.2) (LBW)
Louro et al. (2001)	Case–control Full mouth (four sites per tooth)	Extent and Severity Index (ESI) Extent index: % sites with CAL > 1 Severity index: mean CAL in excess of 1 mm for sites with CAL > 1 mm	LBW Extent index: NS Severity index: NS
Lunardelli & Peres (2005)	Cross-sectional Full mouth (six sites per tooth)	PD: 1 site with PPD $\geqslant 3.5$ mm^3 PD: $\geqslant 4$ sites with PPD $\geqslant 3.5$ mm^3	PTB, LBW, PTB and/or LBW PD: NS PD: NS
Mokeem et al. (2004)	Case–control Full mouth (six sites per tooth)	% sites with BOP Mean PPD Number of sites with PPD $\geqslant 5$ mm Mean CPITN[¶] Mean calculus[‖]	PTB and/or LBW Mean CPITN: OR 4.21 (1.99–8.93)
Moore et al. (2005)	Case–control Two sites per tooth (maxillary teeth midbuccal and mesiobuccal sites, mandibular teeth midlingual and mesiolingual sites) One site per tooth (maxillary teeth mesiobuccal, mandibular teeth mesiolingual)	% sites with BOP Mean PPD Mean CAL Number of sites with PPD $\geqslant 4$ mm % of sites with PPD $\geqslant 5$ mm % of sites with CAL $\geqslant 2$ mm % of sites with CAL $\geqslant 3$ mm	PTB, LBW % sites BOP: NS Mean PPD: NS Mean CAL: NS % sites PPD $\geqslant 4$ mm: NS % sites PPD $\geqslant 5$ mm: NS % sites CAL $\geqslant 2$ mm: NS % sites CAL $\geqslant 3$ mm: NS
Moreu et al. (2005)	Cohort Full mouth (six sites per tooth)	% sites with BOP Mean PPD % sites with PPD > 3 mm	PTB, LBW % sites PPD > 3 mm OR 1.05 (p 0.003) (LBW)
Noack et al. (2005)	Case–control Full mouth (six sites per tooth)	% sites with BOP Mean PPD Mean CAL % sites with CAL $\geqslant 3$ mm	PLBW, high risk of PLBW % sites BOP: NS Mean PPD: NS % sites PPD > 3 mm: NS
Offenbacher et al. (1996)	Case–control Full mouth (six sites per tooth)	PD: Extent 3:60 ($\geqslant 60$% sites with CAL $\geqslant 3$ mm) Mean PPD Mean CAL Extent 2: % sites with CAL $\geqslant 2$ Extent 3: % sites with CAL $\geqslant 3$ Extent 4: % sites with CAL $\geqslant 4$ Severity 2: Mean CAL sites with CAL $\geqslant 2$ Severity 3: Mean CAL sites with CAL $\geqslant 3$ Severity 4: Mean CAL sites with CAL $\geqslant 4$	LBW and PTB or pre-term labour, or premature rupture of membranes PD: OR 7.5 (1.95–28.8)
Radnai et al. (2006)	Case–control Full mouth (six sites per tooth)	PD: $\geqslant 1$ site with PPD $\geqslant 4$ mm and 50% teeth with BOP 50% teeth with BOP $\geqslant 1$ site with PPD $\geqslant 4$ mm	LBW and/or: PTB or pre-term labour, or premature rupture of membranes PD: OR 3.32 (1.64–6.64) (PTB)

Table 1. (Contd.)

References	Study design Clinical examination	Definitions and measurements of PD used for analysis	Outcome Results: adjusted OR
Rajapakse et al. (2005)	Cohort Full mouth (four sites per tooth)	% of sites with plaque > median value for the total cohort in combination % of sites with BOP > median value for the total cohort in combination Mean PPD > median value for the total cohort in combination PD: Combination of all three	LBW PD: NS % plaque > median: NS % BOP > median: NS Mean PPD > Median: NS
Skuldbol et al. (2006)	Case–control Full mouth (six sites per tooth)	Mean distance between de CEJ and the alveolar crest (X-ray)** % BOP Mean PPD % sites with PPD ⩾ 4 mm Categorized extent: 0 sites with PPD ⩾ 4 mm and BOP 1–5 sites with PPD ⩾ 4 mm and BOP 6–10 sites with PPD ⩾ 4 mm and BOP > 10 sites with PPD ⩾ 4 mm and BOP	Pre-term labour < 35 weeks % BOP: NS Mean PPD: NS % sites PPD ⩾ 4 mm: NS Extent PPD ⩾ 4 mm and BOP: NS
Wood et al. (2006)	Case–control Full mouth (six sites per tooth)	PD: Extent 3–5: ⩾ 5% sites with CAL ⩾ 3 OHI[††] % of sites with BOP Mean PPD Mean CAL % of sites with CAL ⩾ 3 mm	PTB < 35 weeks PD: NS

[*]Given that we have not measured calculus for each tooth, CPITN scores 1 and 2 could not be differentiated from each other. We have assumed that a non-bleeding sextant without pockets > 3 mm was a healthy sextant (CPITN score 0).
[†]Given that we have not measured calculus for each tooth, mean CPITN scores could not be calculated.
[‡]We used PPD ⩾ 4 mm.
[§]Denominator sextants in each group, not each individual.
[¶]We have not taken the Bleeding Index 0–3. This mean could not be calculated.
[‖]Given that we have not measured calculus for each tooth, mean calculus scores could not be calculated.
[**]X-rays were not taken; we have no data on distance between the CEJ and the alveolar crest.
[††]We have not taken Oral Hygiene Index. Mean calculus and debris could not be calculated.
BOP, bleeding on probing; CAL, clinical attachment loss; CPITN, Community Periodontal Index of Treatment Needs; NS, no statistical significant differences; PPD, probing pocket depth; PTB, pre-term birth; LBW, low birth weight; PLBW premature low birth weight.

et al. 2005). The present study has not included the definitions used in every article published on the relationship of clinical signs of maternal periodontitis and PTB or LBW, but rather, only the ones that were implemented in those studies that used a variety of periodontal indexes and clinical measurements that were applicable to the original data from this cohort study (Agueda et al. 2008). Owing to the nature of our registered periodontal data, the authors have been unable to reproduce the measurements of some authors (Alves & Ribeiro 2006). On the other hand, as indicated in Table 1, other studies could only be partially reproduced.

Statistical analysis

Data were entered into an Excel (Microsoft office 2003) database and were proofed for entry errors. The database was subsequently locked, imported into SPSS for Windows (SPSS Inc., version 12.0, Chicago, Illionis, USA) formatted and analysed.

Bivariate analysis was performed to establish the relationship between each predisposing factor and PTB, LBW, PLBW and PTB and/or LBW. Independent samples t-test was used for continuous variables (i.e. full-mouth mean PPD) while the χ^2 test was performed to analyse categorical variables (i.e. ethnicity). Statistical significance was set at $p < 0.05$.

The associations between the exposure, periodontal status and the dependent variables (PTB, LBW, PLBW and PTB and/or LBW) were assessed by constructing multivariate models for each dependent variable using non-conditional logistic regression analysis, controlling for confounding factors. All variables showing an association with the dependent variables, with a p value ⩽ 0.20, in the bivariate analysis, were included in a logistic regression model as covariates, taking into account the correlation among all variables introduced in the model. No correlations > 0.30 were detected among the independent variables included in the models. Adjusted odds ratios (ORs) and 95% confidence intervals (CI) were calculated.

Every case definition and every measurement of periodontal disease described was independently tested for association with each adverse pregnancy outcome. The level of statistical significance was set at 5%.

Results

The results of the primary analysis have been described by Agueda et al. (2008). The prevalence of adverse pregnancy outcomes were as follows: PTB 6.6%,

LBW 6%, PLBW 3.3% and PTB and/or LBW 9.3%.

The 14 case definitions of periodontal disease described in the 23 reviewed papers were applied to our cohort of pregnant women, and the resulting prevalences of periodontal disease are presented in Table 2. While most authors give a dichotomous case definition of periodontal disease, others use two or more levels of disease severity.

The distribution, applied to our study sample, of the 14 different case definitions of periodontal disease for PTB and LBW mothers compared with term ($\geqslant 37$ weeks) and normal weight infants' mothers ($\geqslant 2500$ g), respectively, are presented in Table 3. Higher prevalence of periodontal disease was found in mothers with PTB and LBW babies compared with mothers without PTB and LBW; however, only some cases showed statistically significant differences between groups (Cruz et al. 2005 and Lopez et al. 2002 for PTB, and Goepfert et al. 2004, Bosnjak et al. 2006 – mild form of disease – and Lopez et al. 2002 for LBW).

The distribution of different case definitions of periodontal disease in PLBW compared with non-PLBW mothers, and in PTB and/or LBW mothers compared with mothers of term, normal weight infants, are presented in Table 4. Overall, the prevalence of periodontal disease was

higher in the PLBW and PTB and/or LBW groups. Statistically significant differences were found between PLBW and non-PLBW groups using Bassani et al.'s (2007) definition of severe periodontal disease ($p = 0.027$, χ^2 test), and between PTB and/or LBW mothers and those who gave birth to term, normal weight infants using Bosnjak et al.'s (2006) ($p = 0.004$, χ^2 test) and Lopez et al.'s (2002) ($p = 0.011$, χ^2 test) case definitions.

When considering all reviewed measurements of periodontal disease, it became apparent that the indicators of periodontal disease showed higher values in pregnant women who gave birth to PTB or LBW infants, or both, although the differences between groups reached statistical significance for some of the compared measurements only (data not shown). When comparing PTB *versus* term birth, statistically significant differences were found for mean CAL for sites with CAL$\geqslant 2$ mm at six sites per tooth (independent samples t-test $p = 0.027$). On the other hand, for LBW *versus* $\geqslant 2500$ g, statistical significance was reached for mean CAL for sites with CAL$\geqslant 3$ mm at six sites per tooth (independent samples t-test $p = 0.042$) as well as at four sites per tooth ($p = 0.036$). In addition, statistically significant differences were found for the following clinical measurements taken at six sites per

tooth: mean CAL for sites with CAL$\geqslant 3$ mm when comparing PLBW *versus* non-PLBW (independent samples t-test $p = 0.022$) and percentage of sites and teeth with CAL$\geqslant 4$ mm (independent samples t-test $p = 0.030$ and 0.033, respectively) when comparing PTB and/or LBW *versus* term birth and $\geqslant 2500$ g.

Table 5 presents the ORs and the 95% CIs, adjusted for all significant variables, for the association between different case definitions of periodontal disease applied to our study sample and PTB, LBW, PLWB and PTB and/or LBW. A significant association between periodontal disease and PTB was found when applying to our sample the periodontal disease definition used by Bassani et al. (2007) (severe disease), Cruz et al. (2005), Goepfert et al. (2004) (severe disease), Lopez et al. (2002) and Lunardelli & Peres (2005). Other significant associations were found between periodontal disease (Bosnjak et al. 2006) and LBW, severe periodontal disease (Goepfert et al. 2004, Bassani et al. 2007) and PLBW, and periodontal disease (Lopez et al. 2002, Goepfert et al. 2004, Bosnjak et al. 2006) and either PTB or LBW. No statistically significant associations were found when using the definitions of periodontal disease used by Castaldi et al. (2006), Holbrook et al. (2004), Jar-

Table 2. Periodontal disease (PD) prevalence in our sample according to the PD case definition of the different authors

References	PD definition	PD prevalence	
		n	(%)
Bassani et al. (2007)	PD: $\geqslant 3$ teeth with $\geqslant 1$ site with CAL$\geqslant 3$	804	62.1
	Mild$\geqslant 3$ sites in different teeth with CAL$\geqslant 3$ mm, but not 3 sites with CAL$\geqslant 5$ mm	597	46.1
	Moderate$\geqslant 3$ sites in different teeth with CAL$\geqslant 5$ mm, but not 3 sites with CAL$\geqslant 7$ mm	179	13.8
	Severe$\geqslant 3$ sites in different teeth with CAL$\geqslant 7$ mm	28	2.2
Bosnjak et al. (2006)	PD: Extent 4:60 ($\geqslant 60\%$ sites with CAL$\geqslant 4$ mm)	41	3.2
Castaldi et al. (2006)	PD: $\geqslant 4$ teeth with CAL$\geqslant 3$ mm	765	59.1
Cruz et al. (2005)	PD: $\geqslant 4$ teeth with CAL$\geqslant 4$ mm	337	26.0
Goepfert et al. (2004)	PD:CAL$\geqslant 3$ in any sextant	917	70.8
	Mild PD: CAL 3–5 in any one sextant	756	58.4
	Severe PD:CAL> 5 mm in any one sextant	161	12.4
Holbrook et al. (2004)	PD: $\geqslant 4$ sites with PPD$\geqslant 4$ mm	384	29.7
Jarjoura et al. (2005)	PD: $\geqslant 5$ sites with CAL$\geqslant 3$ mm	642	49.6
Jeffcoat et al. (2001)	PD: $\geqslant 3$ sites with CAL$\geqslant 3$ mm	853	65.9
	Generalized PD$\geqslant 90$ sites with CAL$\geqslant 3$ mm	222	17.1
Lopez et al. (2002)	PD: $\geqslant 4$ teeth with $\geqslant 1$ site with PPD$\geqslant 4$ and with CAL$\geqslant 3$ mm at the same site	338	26.1
Lunardelli & Peres (2005)	PD: 1 site with PPD$\geqslant 3.5$ mm*	586	45.3
	PD: $\geqslant 4$ sites with PPD$\geqslant 3.5$ mm*	535	41.3
Offenbacher et al. (1996)	PD:Extent 3:60 ($\geqslant 60\%$ sites with CAL$\geqslant 3$ mm)	188	14.5
Radnai et al. (2004, 2006)	PD: $\geqslant 1$ site with PPD$\geqslant 4$ mm and 50% teeth with BOP	336	25.9
Rajapakse et al. (2005)	PD:% plaque and % BOP and mean PPD$>$ median value for the total cohort	333	25.7
Wood et al. (2006)	PD:Extent 3–5: $\geqslant 5\%$ sites with CAL$\geqslant 3$	768	59.3

*We used PPD$\geqslant 4$ mm.

BOP, bleeding on probing; CAL, clinical attachment loss; PPD, probing pocket depth.

Table 3. Distribution of different case definitions of periodontal disease (PD) by PTB *versus* term birth, and by LBW *versus* ⩾2500 g (%)

References	PD definition	PTB n 85 6.6 (%)	⩾37 weeks n 1211 % 93.4 (%)	*p*-value χ^2 test	LBW n 78 % 6.0 (%)	⩾2500 g n 1218 % 94.0 (%)	*p*-value χ^2 test
Bassani et al. (2007)	PD: ⩾3 teeth ⩾1 site CAL ⩾3	62.4	62.1	0.958	59.0	62.3	0.559
	Mild PD: ⩾3 teeth CAL ⩾3 mm, but not 3 sites CAL ⩾5 mm	41.2	46.4	0.346	35.9	46.8	0.062
	Moderate PD: ⩾3 teeth CAL ⩾5 mm, but not 3 sites CAL ⩾7 mm	16.5	13.6	0.464	17.9	13.6	0.276
	Severe PD: ⩾3 teeth with CAL ⩾7 mm	4.7	2.0	0.095	5.1	2.0	0.063
Bosnjak et al. (2006)	PD: Extent 4:60	5.9	3.0	0.139	9.0	2.8	0.003
Castaldi et al. (2006)	PD: ⩾4 teeth CAL ⩾3 mm	62.4	58.8	0.525	59.0	59.1	0.985
Cruz et al. (2005)	PD: ⩾4 teeth CAL ⩾4 mm	35.3	25.4	0.044	33.3	25.6	0.129
Goepfert et al. (2004)	PD: CAL ⩾3 in any sextant	69.9	70.9	0.769	64.1	71.2	0.179
	Mild PD: Any CAL 3–5 mm	51.8	58.8	0.201	46.2	59.2	0.024
	Severe PD: Any CAL >5 mm	17.6	12.1	0.132	17.9	12.1	0.128
Holbrook et al. (2004)	PD: ⩾4 sites PPD ⩾4 mm	34.1	29.3	0.351	34.6	29.3	0.322
Jarjoura et al. (2005)	PD: ⩾5 sites CAL ⩾3 mm	51.8	49.4	0.676	52.6	49.4	0.586
Jeffcoat et al. (2001)	PD: ⩾3 sites CAL ⩾3 mm	64.7	66.0	0.815	61.5	66.1	0.405
	Generalized PD ⩾90 sites CAL ⩾3 mm	16.7	16.7	0.106	19.2	17.0	0.614
Lopez et al. (2002)	PD: ⩾4 teeth ⩾1 site PPD ⩾4 and CAL ⩾3 mm at same site	36.5	25.4	0.024	35.9	25.5	0.042
Lunardelli & Peres (2005)	PD: 1 site PPD ⩾3.5 mm*	54.1	44.6	0.089	50.0	44.9	0.385
	PD: ⩾4 sites PPD ⩾3.5 mm*	45.9	41.0	0.376	43.6	41.2	0.674
Offenbacher et al. (1996)	PD: Extent 3:60	18.8	14.2	0.244	17.9	14.3	0.375
Radnai et al. (2006)	PD: ⩾1 site PPD ⩾4 mm and 50% teeth BOP	26.0	25.9	0.989	21.8	26.8	0.388
Rajapakse et al. (2005)	PD: % plaque, % BOP and mean PPD > median value cohort	31.8	25.3	0.187	30.8	25.4	0.202
Wood et al. (2006)	PD: Extent 3:5	60.0	59.3	0.893	59.4	57.7	0.765

*We used PPD ⩾4 mm.
BOP, bleeding on probing; CAL, clinical attachment loss; PPD, probing pocket depth; LB; low birth weight; PTB, pre-term birth.

joura et al. (2005), Jeffcoat et al. (2001), Offenbacher et al. (1996), Radnai et al. (2006), Rajapakse et al. (2005) and Wood et al. (2006) (data not shown).

Table 6 presents the ORs and the 95% CIs, adjusted for all significant variables, for the association between different continuous periodontal measurements, applied to our sample, and adverse pregnancy outcomes. All the indicators that show a statistically significant association with time of gestation or birth weight are based on CAL.

Table 7 displays the results obtained when applying to our sample all the continuous periodontal measurements used by different authors. When using the periodontal continuous parameters as in the studies by Buduneli et al. (2005), Dasanayake (1998), Davenport et al. (2002), Mokeem et al. (2004), Moreu et al. (2005) and Skuldbol et al. (2006), no significant associations were found between any periodontal disease continuous measurement and any adverse pregnancy outcomes. On the contrary, some of the continuous measurements used in the rest of the included studies (Offenbacher et al. 1996, Louro et al. 2001, Lopez et al. 2002, Goepfert et al. 2004, Jarjoura *et al*. 2005, Moore et al. 2005, Noack *et al*. 2005, Bosnjak et al. 2006, Wood *et al*. 2006) showed a statistically significant association with some of the adverse pregnancy outcomes. Again, all the indicators that showed a statistically significant association with PTB of LBW were based on CAL.

Discussion

The results of this secondary analysis have demonstrated that (i) the prevalence of periodontitis among our sample of pregnant women has depended, entirely, on the case definition of periodontitis applied from the variety of case definitions used in other studies and (ii) the statistical significance of the association between periodontitis and adverse pregnancy outcomes is directly determined by the case definition of periodontitis or the periodontal indicator used in the analysis. To the best of our knowledge, this is the first study specifically aimed at evaluating the relevance of the definition of a threshold or a measurement of perio-

dontal disease in relation to the variation in adverse pregnancy outcomes. This study has confirmed what Tonetti & Claffey (2005) have previously discussed: that a 'part of the variation in ORs can be attributed to inconsistency in utilization of thresholds, rendering data interpretation difficult' in analytical epidemiological studies of periodontitis.

In this study, 23 publications dealing with the relationship between periodontal disease and adverse pregnancy outcomes were selected. These studies were included with the intention to use their definition and assessment of periodontitis and to apply it to our original sample. Additional efforts were directed towards selecting studies that implemented different periodontal recording systems and periodontal indicators, with the objective of having as many different methods of assessment of periodontitis as possible. Essentially, and whenever possible, we replicated our original study, in which we used the definition of periodontitis according to Lopez et al. (2002), using each one of the definitions of periodontitis that have previously been implemented by other authors in similar studies.

Table 4. Distribution of different case definitions of periodontal disease (PD) by PLBW *versus* non-PLBW, and by PTB and/or LBW *versus* term birth and weight $\geqslant 2500$ g (%)

References	PD definition	PLBW n 43 % 3.3 (%)	Non PLBW n 1253 % 96.7 (%)	p-value χ² test	PTB and/ or LBW n 120 % 9.3 (%)	Term and $\geqslant 2500$ n 1276 % 90.7 (%)	p-value χ² test
Bassani et al. (2007)	PD: $\geqslant 3$ teeth $\geqslant 1$ site CAL$\geqslant 3$	58.1	62.2	0.588	61.7	62.1	0.921
	Mild PD: $\geqslant 3$ teeth CAL$\geqslant 3$ mm, but not 3 sites CAL$\geqslant 5$ mm	34.9	46.5	0.133	40.0	46.7	0.159
	Moderate PD: $\geqslant 3$ teeth CAL$\geqslant 5$ mm, but not 3 sites CAL$\geqslant 7$ mm	16.3	13.7	0.635	17.5	13.4	0.220
	Severe PD: $\geqslant 3$ teeth with CAL$\geqslant 7$ mm	7.0	2.0	0.027	4.2	2.0	0.113
Bosnjak et al. (2006)	PD: Extent 4:60	7.0	3.0	0.090	7.5	2.7	0.004
Castaldi et al. (2006)	PD: $\geqslant 4$ teeth CAL$\geqslant 3$ mm	58.1	59.1	0.899	61.7	58.8	0.544
Cruz et al. (2005)	PD: $\geqslant 4$ teeth CAL$\geqslant 4$ mm	37.2	25.6	0.089	33.3	25.3	0.055
Goepfert et al. (2004)	PD: Any CAL$\geqslant 3$	65.1	61.1	0.4046	67.5	71.1	0.404
	Mild PD: Any CAL 3–5	44.2	58.9	0.055	50.8	59.1	0.078
	Severe PD: Any CAL>5	20.9	12.6	0.086	16.7	12.0	0.140
Holbrook et al. (2004)	PD: $\geqslant 4$ sites PPD$\geqslant 4$ mm	37.2	29.4	0.270	33.3	29.3	0.354
Jarjoura et al. (2005)	PD: $\geqslant 5$ sites CAL$\geqslant 3$ mm	53.5	46.5	0.602	51.7	49.4	0.630
Jeffcoat et al. (2001)	PD: $\geqslant 3$ sites CAL$\geqslant 3$	66.0	62.8	0.665	63.3	66.1	0.530
	Generalized PD$\geqslant 90$ sites CAL$\geqslant 3$ mm	16.6	23.3	0.279	20.8	16.8	0.260
Lopez et al. (2002)	PD: $\geqslant 4$ teeth $\geqslant 1$ site PPD$\geqslant 4$ and CAL$\geqslant 3$ mm at same site	37.2	25.7	0.092	35.8	25.1	0.011
Lunardelli & Peres (2005)	PD: $\geqslant 1$ site PP$\geqslant 3.5$*	55.8	44.9	0.157	50.8	44.7	0.197
	PD: $\geqslant 4$ sites PPD$\geqslant 3.5$*	46.5	41.1	0.481	44.2	41.0	0.501
Offenbacher et al. (1996)	PD: Extent 3:60	20.9	14.2	0.225	17.5	14.2	0.330
Radnai et al. (2006)	PD: $\geqslant 1$ site PPD$\geqslant 4$ mm and 50% teeth BOP	27.9	25.9	0.765	22.5	26.3	0.366
Rajapakse et al. (2005)	PD: % plaque, % BOP and mean PD$>$median value cohort	30.2	25.6	0.491	31.7	25.1	0.117
Wood et al. (2006)	PD: Extent 3–5: $\geqslant 5$% sites with CAL$\geqslant 3$%	55.8	59.4	0.636	60.0	59.2	0.636

*We used PPD$\geqslant 4$ mm.
BOP, bleeding on probing; CAL, clinical attachment loss; PPD, probing pocket depth; PTB, pre-term birth; LBW, low birth weight; PLBW, premature low birth weight.

Table 5. Adjusted odds ratios (ORs) of the association between definitions of periodontal disease and adverse pregnancy outcomes (only statistically significant results shown)

References	PD definition	PTB* OR (95% CI)	LBW[†] OR (95%CI)	PLBW[‡] OR (95%CI)	PTB and/or LBW[§] OR 95%CI
Bassani et al. (2007)	PD: $\geqslant 3$ teeth $\geqslant 1$ site CAL$\geqslant 3$				
	Mild PD: $\geqslant 3$ teeth CAL$\geqslant 3$ mm, but not 3 sites CAL$\geqslant 5$ mm				
	Moderate PD: $\geqslant 3$ teeth CAL$\geqslant 5$ mm, but not 3 sites CAL$\geqslant 7$ mm				
	Severe PD: $\geqslant 3$ teeth with CAL$\geqslant 7$ mm	3.37 (1.08–10.46)		4.46 (1.19–16.77)	
Bosnjak et al. (2006)	PD: Extent 4:60		2.81 (1.10–7.22)		2.44 (1.06–5.62)
Cruz et al. (2005)	PD: $\geqslant 4$ teeth CAL$\geqslant 4$ mm	1.85 (1.11–3.06)			
Goepfert et al. (2004)	Mild PD: CAL 3–5 in any sextant				0.62 (0.41–0.93)
	Severe PD: CAL>5 mm in any sextant	2.17 (1.15–4.09)		2.70 (1.19–6.15)	1.78 (1.02–3.10)
Lopez et al. (2002)	PD: $\geqslant 4$ teeth $\geqslant 1$ site PPD$\geqslant 4$ and CAL$\geqslant 3$ mm at same site	1.80 (1.10–2.95)			1.54 (1.00–2.36)
Lunardelli & Peres (2005)	PD: 1 site PPD$\geqslant 3.5$ mm[¶]	1.69 (1.05–2.73)			

*OR adjusted by: Age, place of residence, race, smoking habit, systemic disease, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy, type of delivery, untreated dental decay and plaque index.
[†]OR adjusted by: Age, race, smoking habit, systemic disease, BMI, previous low birth weight, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy, type of delivery, untreated dental decay and time since last oral prophylaxis.
[‡]OR adjusted by: Age, race, smoking habit, systemic disease, X-rays during pregnancy, previous low birth weight, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy and type of delivery.
[§]OR adjusted by: Age, place of residence, race, smoking habit, systemic disease, BMI, previous low birth weight, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy, type of delivery, and time since last oral prophylaxis.
[¶]We used PPD$\geqslant 4$ mm.
CAL, clinical attachment loss; PPD, probing pocket depth; PTB, pre-term birth; LBW, low birth weight; PLBW, premature low birth weight; CI, confidence interval.

Table 6. Adjusted odds ratios (ORs) of the association between different periodontal measurements (most of them continuous) and adverse pregnancy outcomes (only statistically significant results shown)

Clinical examination	Clinical measurement	PTB* OR (95% CI)	LBW† OR (95% CI)	PLBW‡ OR (95% CI)	PTB and/or LBW§ OR (95% CI)
Full mouth six sites per tooth	% sites CAL ⩾ 3 mm	1.00 (1.00–1.02)			
	% sites CAL ⩾ 4 mm	1.02 (1.00–1.03)		1.51 (1.11–2.10)	1.51 (1.11–2.10)
	% teeth CAL ⩾ 4 mm	1.01 (1.00–1.02)		1.01 (1.00–1.02)	1.01 (1.00–1.02)
	Severity CAL ⩾ 2 mm	1.51 (1.11–2.10)			
	Severity CAL ⩾ 3 mm			1.84 (1.03–3.28)	
	Severity CAL ⩾ 4 mm			2.21 (1.02–4.81)	
Full mouth four sites per tooth	% sites CAL ⩾ 3 mm	1.01 (1.00–1.02)			
	% sites CAL ⩾ 4 mm	1.02 (1.00–1.03)			1.02 (1.00–1.03)
	Severity CAL ⩾ 1 mm¶	1.54 (1.12–2.14)			
	Severity CAL ⩾ 2 mm	1.51 (1.11–2.10)			
	Severity CAL ⩾ 3 mm			1.91 (1.03–3.55)	
	Severity CAL ⩾ 4 mm			2.34 (1.03–5.28)	
Full mouth sextants	% sextants CAL > 3 mm	1.01 (1.00–1.02)		1.01 (1.00–1.02)	
	% sextants CAL > 5 mm	1.02 (1.00–1.03)		1.02 (1.00–1.03)	1.01 (1.00–1.02)
Partial recording three buccal sites/tooth two diametrically opposed quadrant	% sites CAL ⩾ 3 mm	1.00 (1.00–1.02)			
Partial recording two sites per tooth maxillary midbuccal and mesiobuccal mandibular midlingual and mesiolingual	% sites CAL ⩾ 3 mm	1.01 (1.00–1.02)			
Partial recording one site/tooth maxillary mesiobuccal mandibular mesiolingual	% sites CAL ⩾ 3 mm	1.00 (1.00–1.01)			

*OR adjusted by: Age, place of residence, race, smoking habit, systemic disease, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy type of delivery, untreated dental decay and plaque index.

†OR adjusted by: Age, race, smoking habit, systemic disease, BMI, previous low birth weight, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy, type of delivery, untreated dental decay and time since last oral prophylaxis.

‡OR adjusted by: Age, race, smoking habit, systemic disease, X-rays during pregnancy, previous low birth weight, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy, gestational diabetes and type of delivery.

§OR adjusted by: Age, place of residence, race, smoking habit, systemic disease, BMI, previous low birth weight, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy and type of delivery.

¶Severity index: mean CAL in excess of 1 mm for sites with CAL > 1 mm.

CAL, clinical attachment loss; PTB, pre-term birth; LBW, low birth weight; PLBW, premature low birth weight; CI, confidence interval.

Fourteen of the selected publications provided a dichotomized definition of periodontal disease that allowed for calculations on the prevalence of periodontitis in our study sample according to the different indexes. As a result of this analysis, extreme variations on the estimate of the prevalence were obtained. Prevalences ranged from 3.2% (Bosnjak et al. 2006) to 70.8% (Goepfert et al. 2004); however, this latter author made a distinction between moderate and severe periodontal disease, whose prevalences were 58.4% and 12.4% in our sample, respectively. In a recent paper, Page & Eke (2007) pointed out that 'minor changes in the threshold values for CAL, PPD, and the number of affected sites used in the case definitions (of periodontitis) result in major changes in the prevalence scores'. The results of our study confirm this statement and draw attention to the fact that the lack of consistency in the case definition of periodontitis does not allow

for global comparisons between populations of similar studies.

The analysis of the association between periodontal disease and PTB, LBW, PLBW and PTB and/or LBW in our sample, after the use of all case definitions and indicators of periodontitis registered in the reviewed studies, shows that, in general, the prevalence of periodontitis was higher in the adverse pregnancy outcomes groups; however, the statistical significance of this association was only reached in a few cases, most of them when the measurements were based in the assessment of CAL.

As a part of the analysis, logistic regression multivariate models were carried out – adjusting for all significant variables – to test the association of each case definition or measurement of periodontitis and PTB, LBW, PLBW and PTB and/or LBW. Interestingly, we have observed statistically significant ORs only when using the definitions of Bassani et al. (2007) (severe perio-

dontitis), Bosnjak et al. (2006), Cruz et al. (2005), Goepfert et al. (2004) (mild and severe periodontitis), Lopez et al. (2002) and Lunardelli & Peres (2005) and with some continuous periodontal measurements based in CAL. Our results clearly differ from the results obtained by other studies where different measurements and definitions of periodontal disease were used to test their behaviour as risk factors for systemic diseases. Amdriankaja et al. (2006) tested the association of four measurements and four case definitions of periodontitis with risk of myocardial infarction, and found that regardless of the measurement of the exposure used, the estimates of the associations remained statistically significant. Likewise, Lopez & Baelum (2003) found that five different criteria to assess periodontitis in adolescents gave a wide variation in the prevalence estimates, but did not substantially change the significance of the OR of the relation-

Table 7. Adjusted ORs of the relationships between adverse pregnancy outcomes and continuous periodontal measurements used by different authors and applied to our study sample

References PD definition	PTB*	LBW[†]	PLBW[‡]	PT and/or LBW[§]
Bosnjak et al. (2006) Full mouth (four sites per tooth)	% BOP: NS Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: OR 1.01 (1.00–1.02) Extent 4: OR 1.02 (1.00–1.03) Severity 2: 1.51 (1.11–2.10) Severity 3: NS Severity 4: NS	% BOP: NS Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: NS Extent 4: NS Severity 2: NS Severity 3: NS Severity 4: NS	% BOP: NS Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: NS Extent 4: NS Severity 2: NS Severity 3: OR 1.91 (1.03–3.55) Severity 4: OR 2.34 (1.03–5.28)	% BOP: NS Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: NS Extent 4: OR 1.02 (1.00–1.03) Severity 2: NS Severity 3: NS Severity 4: NS
Buduneli et al. (2005) Full mouth (six sites per tooth)	% BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 4 mm: NS Number sites PPD = 6–7 mm: NS	% BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 4 mm: NS Number sites PPD = 6–7 mm: NS	% BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 4 mm: NS Number sites PPD = 6–7 mm: NS	% BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 4 mm: NS Number sites PPD = 6–7 mm: NS
Dasanayake (1998) Full mouth (sextants)	Number of sextants CPITN 0: NS Number of sextants CPITN 3: NS Number of sextants CPITN 4: NS	Number of sextants CPITN 0: NS Number of sextants CPITN 3: NS Number of sextants CPITN 4: NS	Number of sextants CPITN 0: NS Number of sextants CPITN 3: NS Number of sextants CPITN 4: NS	Number of sextants CPITN 0: NS Number of sextants CPITN 3: NS Number of sextants CPITN 4: NS
Davenport et al. (2002) Full mouth (sextants)	Mean PPD (worst PPD for each tooth: NS	Mean PPD (worst PPD for each tooth: NS	Mean PPD (worst PPD for each tooth: NS	Mean PPD (worst PPD for each tooth: NS
Goepfert et al. (2004) Full mouth divided into sextants (six sites per tooth)	% Sextants CAL > 3: OR 1.01 (1.00–1.02) % Sextants CAL > 5: OR 1.02 (1.00–1.03)	% Sextants CAL > 3: NS % Sextants CAL > 5: NS	% Sextants CAL > 3: OR 1.01 (1.00–1.02) % Sextants CAL > 5: OR 1.02 (1.00–1.03)	% Sextants CAL > 3: NS % Sextants CAL > 5: OR 1.01 (1.00–1.02)
Jarjoura et al. (2005) Three sites per tooth (mesiobuccal, midbuccal, and distobuccal) in 2 randomly selected, diametrically opposed, quadrants)	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD $\geqslant$ 5 mm: NS % CAL $\geqslant$ 3 mm: OR 1.01 (1.00–1.02)	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD $\geqslant$ 5 mm: NS % CAL $\geqslant$ 3 mm: NS	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD $\geqslant$ 5 mm: NS % CAL $\geqslant$ 3 mm: NS	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD $\geqslant$ 5 mm: NS % CAL $\geqslant$ 3 mm: NS
Lopez et al. (2002) Full mouth (six sites per tooth)	% BOP: NS Mean PPD: NS Mean CAL: NS % teeth PPD $\geqslant$ 4 mm: NS % teeth CAL $\geqslant$ 3 mm: NS % teeth CAL > 3 mm ($\geqslant$ 4 mm): OR 1.01 (1.00–1.02)	% BOP: NS Mean PPD: NS Mean CAL: NS % teeth PPD $\geqslant$ 4 mm: NS % teeth CAL $\geqslant$ 3 mm: NS % teeth CAL > 3 mm ($\geqslant$ 4 mm): NS	% of sites with BOP: NS Mean PPD: NS Mean CAL: NS % teeth PPDL $\geqslant$ 4 mm: NS % teeth CAL $\geqslant$ 3 mm: NS % teeth CAL > 3 mm ($\geqslant$ 4 mm): OR 1.01 (1.00–1.02)	% BOP: NS Mean PPD: NS Mean CAL: NS % teeth PPD $\geqslant$ 4 mm: NS % teeth CAL $\geqslant$ 3 mm: NS % teeth CAL > 3 mm ($\geqslant$ 4 mm): OR 1.01 (1.00–1.02)
Louro et al. (2001) Full mouth (four sites per tooth)	Extent index: % sites with CAL > 1: NS Severity index: mean CAL in excess of 1 mm sites CAL > 1 mm: OR 1.54 (1.12–2.14)	Extent index: % sites with CAL > 1: NS Severity index: mean CAL in excess of 1 mm sites CAL > 1 mm: NS	Extent index: % sites with CAL > 1: NS Severity index: mean CAL in excess of 1 mm sites CAL > 1 mm: NS	Extent index: % sites with CAL > 1: NS Severity index: mean CAL in excess of 1 mm sites CAL > 1 mm: NS
Mokeem et al. (2004) Full mouth (six sites per tooth)	% BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 5 mm: NS	% sites with BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 5 mm: NS	% sites with BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 5 mm: NS	% sites with BOP: NS Mean PPD: NS Number sites PPD $\geqslant$ 5 mm: NS

Table 7. (Contd.)

References PD definition	PTB*	LBW†	PLBW‡	PT and/or LBW§
Moore et al. (2005) One or two sites per tooth (maxillary teeth midbuccal and mesiobuccal sites, mandibular teeth midlingual and mesiolingual sites)/ One site per tooth (maxillary teeth mesiobuccal sites, mandibular teeth mesiolingual sites)	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD ⩾ 3 mm: NS % PPD ⩾ 4 mm: NS % PPD ⩾ 5 mm: NS % CAL ⩾ 2 mm: NS % CAL ⩾ 3 mm: OR 1.0 (1.00–1.02)	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD ⩾ 3 mm: NS % PPD ⩾ 4 mm: NS % PPD ⩾ 5 mm: NS % CAL ⩾ 2 mm: NS % CAL ⩾ 3 mm: NS	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD ⩾ 3 mm: NS % PPD ⩾ 4 mm: NS % PPD ⩾ 5 mm: NS % CAL ⩾ 2 mm: NS % CAL ⩾ 3 mm: NS	% BOP: NS Mean PPD: NS Mean CAL: NS % PPD ⩾ 3 mm: NS % PPD ⩾ 4 mm: NS % PPD ⩾ 5 mm: NS % CAL ⩾ 2 mm: NS % CAL ⩾ 3 mm: NS
Moreu et al. (2005) Full mouth	% BOP: NS Mean PPD: NS % PPD > 3 mm: NS	% BOP: NS Mean PPD: NS % PPD > 3 mm: NS	% BOP: NS Mean PPD: NS % PPD > 3 mm: NS	% BOP: NS Mean PPD: NS % PPD > 3 mm: NS
Noack et al. (2005) Full mouth (six sites per tooth)	% BOP: NS Mean PPD: NS Mean CAL: NS % CAL ⩾ 3 mm: OR 1.01 (1.00–1.02)	% sites with BOP: NS Mean PPD: NS Mean CAL: NS % CAL > 3 mm: NS	% sites with BOP: NS Mean PPD: NS Mean CAL: NS % CAL > 3 mm: NS	% sites with BOP: NS Mean PPD: NS Mean CAL: NS % CAL > 3 mm: NS
Offenbacher et al. (1996) Full mouth (six sites per tooth)	Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: OR 1.01 (1.00–1.02) Extent 4: OR 1.02 (1.00–1.03) Severity 2: 1.51 (1.11–2.10) Severity 3: NS Severity 4: NS	Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: NS Extent 4: NS Severity 2: NS Severity 3: NS Severity 4: NS	Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: NS Extent 4:OR 1.01 (1.00–1.03) Severity 2: NS Severity 3: OR 1.84 (1.03–3.28) Severity 4: OR 2.21 (1.02–4.81)	Mean PPD: NS Mean CAL: NS Extent 2: NS Extent 3: NS Extent 4: OR 1.01 (1.00–1.03) Severity 2: NS Severity 3: NS Severity 4: NS
Radnai et al. (2006) Full mouth (six sites per tooth)	Mean PPD: NS	Mean PPD: NS	Mean PPD: NS	Mean PPD: NS
Skuldbol et al. (2006) Full mouth (six sites per tooth)	% BOP: NS Mean PPD: NS % PPD ⩾ 4 mm: NS	% BOP: NS Mean PPD: NS % PPD ⩾ 4 mm: NS	% BOP: NS Mean PPD: NS % PPD ⩾ 4 mm: NS	% BOP: NS Mean PPD: NS % PPD ⩾ 4 mm: NS
Wood et al. (2006) Full mouth (six sites per tooth)	% BOP: NS Mean PPD: NS Mean CAL: NS % CAL ⩾ 3 mm: OR 1.01 (1.00–1.02)	% BOP: NS Mean PPD: NS Mean CAL: NS % CAL ⩾ 3 mm: NS	% BOP: NS Mean PPD: NS Mean CAL: NS % CAL ⩾ 3 mm: NS	% BOP: NS Mean PPD: NS Mean CAL: NS % CAL ⩾ 3 mm: NS

*OR adjusted by: Age, place of residence, race, smoking habit, systemic disease, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy, type of delivery, untreated dental decay and plaque index.

†OR adjusted by: Age, race, smoking habit, systemic disease, BMI, previous low birth weight, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy, type of delivery, untreated dental decay and time since last oral prophylaxis.

‡OR adjusted by: Age, race, smoking habit, systemic disease, X-rays during pregnancy, previous low birth weight, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy and type of delivery.

§OR adjusted by: Age, place of residence, race, smoking habit, systemic disease, BMI, previous low birth weight, previous prematurity, spontaneous miscarriage, number of pregnancies, onset of prenatal care, complications of pregnancy and type of delivery.

BOP, bleeding on probing; CAL, clinical attachment loss; PPD, probing pocket depth; PTB, pre-term birth; LBW, low birth weight; PLBW, premature low birth weight; CI, confidence interval.

ship with several determinants of the case status.

Beck & Offenbacher (2002) have previously suggested that the use of different assessments of periodontitis should be used when the disease is considered as an outcome or as an exposure, as is the case in our study. They related different measurements of periodontitis (PDD, CAL and BOP) to two systemic inflammatory markers of cardiovascular disease, and found that BOP was the periodontal parameter best related to serum soluble intercellular adhesion molecule, while PDD was more robust in estimating C-reactive protein. They state that when studying the role of periodontal disease as an exposure for systemic disease, it is necessary to choose the measure of periodontitis according to the nature of the outcome of interest. This may be one of the reasons for the differences that we found in the relationship between mea-

surements of periodontal disease and adverse pregnancy outcomes. However, the goal of the present study was not to demonstrate whether or not the association of periodontitis and adverse perinatal outcomes is real. Rather, our objective is to call the attention of the reader about the different results that may be obtained in epidemiological studies depending on the definition or measurement of periodontitis, up to the extend of determining their statistical significance in some cases.

In conclusion, the results of this secondary analysis support the hypothesis that the significance of the association between periodontal disease and pregnancy outcomes may be determined by the periodontal disease definition or measurement used. It becomes apparent that there is a need to adopt a uniform criteria regarding the assessment and definition of periodontitis in order to reach a common interpretation of the findings of different research groups (Borrell & Papapanou 2005).

Acknowledgements

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Clinical Relevance

Scientific rationale for the study: The association between periodontitis and PTB and LBW has been broadly studied; however, to date, the results have been controversial. The use of different criteria to assess the extent and severity of periodontal disease may be responsible for the inconsistency of the findings. While the definition of PTB or LBW is agreed upon, the cut-off point to define periodontal disease depends on the author's choice.

Principal findings: Our findings support the hypothesis that the measurement of periodontitis has a direct influence on its association with PTB/LBW, up to the point of determining the statistical significance of the relationship.

Practical implications: Clinicians need reliable evidence of the role of periodontitis as risk factor for systemic diseases. This goal may be jeopardized by the difficulty to reach a consensus on uniform criteria to define what we understand by periodontal disease.