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ORIGINAL ARTICLE

Performance of the 2017 AAP/EFP case definition compared with the CDC/AAP definition in population-based studies

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Abstract

Background: Classification of the periodontal conditions is indispensable for epidemiological data in order to guide situational awareness and therapeutic strategies. The new classification of periodontal diseases and conditions introduced by the American Academy of Periodontology and the European Federation of Periodontology (AAP/EFP), however, has not yet been applied to population-based studies. The aim of the present study was to compare the prevalence of periodontitis between the AAP/EFP and the CDC/AAP classification system and to evaluate the accuracy of the new AAP/EFP classification system against the CDC/AAP case definition for population-based studies.

Methods: Epidemiological data from two cross-sectional studies were obtained. One of them was a population-based study on Chilean adults (1.456 individuals; 35–44 years; 65–74 years) and the other one a sample of adolescents (1.070 individuals; 15–19 years) from five countries; Argentina, Chile, Colombia, Ecuador, and Uruguay. All participants had undergone full-mouth periodontal examination by calibrated examiners. Epidemiological datasets were analyzed according to the AAP/EFP and the CDC/AAP case definitions. The accuracy of the AAP/EFP definition was examined by assessing the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the receiver operating curve (ROC) using the CDC/AAP case definition as the reference standard.

Results: According to the AAP/EFP, the prevalence of periodontitis in adolescents was 75.6%. The majority of the adolescents were classified either as Stage I (39.2%) or Stage II (28.2%). By using the CDC/AAP classification the prevalence of periodontitis in adolescents was 27.2%. The most common form of periodontitis with the CDC/AAP classification was moderate periodontitis (15.3%) followed by mild periodontitis (11.4%). The AAP/EFP revealed high sensitivity in moderate (95.7%) and severe periodontitis (100%) as well as a moderate (75%) to high specificity (92%) in moderate and severe periodontitis, respectively. The PPV was 41.6% in moderate and 5.7% in severe periodontitis whereas the NPV was high in both categories (moderate = 99%; severe = 100%). The AUC was

0.91 (95% CI = 0.89–0.93). In adults, the prevalence of periodontitis was 99% according to the AAP/EFP. The majority of adults were classified as Stage IV (81.3%) whereas Stage III amounted to 12.8%. By using the CDC/AAP classification, the prevalence of periodontitis in adults was 88.3% and the most common form of periodontitis was moderate periodontitis (57.2%) followed by severe periodontitis (29.7%). In adults, the AAP/EFP revealed high sensitivity for moderate (99.7%) and severe periodontitis (100%), but low specificity for both categories (moderate = 6.8%; severe = 8.3%). The PPV was 88.7% in moderate and 31.7% in severe periodontitis. The NPV was high in both categories (moderate = 76.5%; severe = 100%). The AUC was 0.57 (95% CI = 0.53–0.62).

Conclusions: This study revealed a clear discrepancy in the prevalence of periodontitis between the AAP/EFP and the CDC/AAP classification when using epidemiological data. The 2017 AAP/EFP classification system performs well when compared to the CDC/AAP case definition in identifying adolescents with periodontitis. The AAP/EFP system seems less accurate in adults with high prevalence of periodontitis.

KEYWORDS
epidemiology, periodontal diseases, population surveillance, risk factors

1 INTRODUCTION

Periodontitis represents a global and public health problem imposing a substantial economic burden on health-care systems.[1,2] Apart from the oral sequelae (including edentulism), it has been associated to systemic health consequences and even mortality.[3–5] Recently, a new classification scheme for periodontal diseases has been introduced by a joint Workshop between the American Academy of Periodontology (AAP) and the European Federation of Periodontology (EFP), as the previous system suffered from several shortcomings, including overlap and clear distinction between the different categories (e.g., aggressive versus chronic), imprecision, as well as implementation difficulties.[6,7]

The new AAP/EFP classification aims to identify clear clinical entities by incorporating operational elements including clinical attachment level (CAL), bleeding on probing (BOP), and probing pocket depth (PPD) to link diagnosis with prevention and treatment needs.[6–8] It recognizes three new clinical entities; (i) periodontal health; (ii) reduced but healthy periodontium and (iii) gingival inflammation in a periodontitis patient. If the patient is diagnosed with periodontitis, the new classification defines disease severity and assumes progression based on a two-vector system, namely stage and grade.[6–8] The four periodontitis stages (I-IV) describe the severity and complexity of the individual situation whereas the three grades of periodontitis (A, B, and C) describe the risk factor profile and the risk for further disease progression.[9] One goal of this classification is the early diagnosis of periodontal destruction by the detection of initial signs of attachment loss (Stage I). Another goal is to identify the more severe cases requiring complex periodontal therapies (Stage III) or more advanced periodontal and oral rehabilitations (Stage IV).[9] Considering that this classification has not been widely applied in large populations, its applicability and value in large epidemiologic datasets and population-based studies remains unclear.

In 2007, the Centers for Disease Control and Prevention (CDC) in conjunction with the AAP, proposed a case definition for population-based studies as a reference standard.[2] The 2017 World Workshop, however, recommended that epidemiologic surveys[6] of periodontitis also incorporate stage and grade to reflect the severity of the disease (stage) as well as the anticipated complexity of the treatment required.[8] The different parameters (eg, threshold values of CAL) for defining periodontitis in the two case definitions (AAP/EFP and CDC/AAP) may influence the epidemiological frequency of the disease. Thus, it is reasonable to suggest that the application of the new classification system might under- or overestimate the prevalence of periodontitis. However, the magnitude of these variations is currently unknown as little research has been done to evaluate the accuracy and performance of the AAP/EFP against the CDC classification. Classification systems are known to be imperfect, thus it seems prudent to determine the extent to which these systems are able to identify the likely presence or absence of a condition.

Although recent studies have reported the prevalence of gingival recessions and peri-implant diseases using the new AAP/EFP classification[10] there is a lack of population-based studies applying the new classification system for periodontitis as well as their comparison with previously accepted case definitions such as the CDC/AAP definition. This is clinically relevant, because policy makers as well as major stakeholders in the healthcare system should act upon the prevalence of the disease. A better understanding of the prevalence trends as well as a possible under- and overestimation of the disease could have major implications for the development of preventive as well as therapeutic strategies.

The aim of the present study was: (1) to compare the prevalence of periodontitis between the AAP/EFP and the CDC/AAP classification system; and (2) to evaluate the accuracy of the new AAP/EFP classification system against the CDC/AAP case definition.

2 | MATERIALS AND METHODS

2.1 | Study design

The present study was a secondary analysis of epidemiologic data obtained from two previous cross-sectional studies. One study gathered data from a sample of adolescents from different countries in South America. The other study gathered data from a representative sample of non-institutionalized Chilean adults. Both studies were approved by the human subjects ethics board of Committee of the Faculty of Medicine, at the University of Chile, Chile,[11,12] along with the other ethical committees[13] and were conducted in accordance with the Helsinki Declaration of 1975, as revised in 2013. Informed consent was obtained from all participants. Following the oral examination, all subjects were informed about their oral health status and if required, were referred to an appropriate oral health professional for periodontal care. This study conforms with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting cross-sectional studies.

The data for the sample of adolescents were obtained between 2010 and 2012 from different countries in South America, namely Argentina, Chile, Colombia, Ecuador and Uruguay. Detailed information about the sample has previously been published[13] and is presented in the Appendix. Briefly, a three-stage sampling was realized, using schools as sampling units. The sample size was calculated considering a rate of 4.5% of CAL ≥3 mm in ≥1 site in adolescents with 1.6% range of error. Thus, the study required a sample of 1032 subjects, plus an oversampling to allow better precision in estimate, resulting in a total of 1070 high school adolescents aged 15 to 19 years old to be examined.

The representative sample of Chilean adults was obtained during the First Chilean National Examination Survey conducted between 2007 and 2008.[11,12] In brief, a stratified, multistage probability design was applied to divide the Chilean population in two age cohorts (young adults aged 35 to 44 and senior adults aged 65 to 74). Study participants were recruited in 15 administrative regions. The sample size was calculated estimating an 80% prevalence of mild to severe periodontitis in Chile. In order to achieve a 95% precision rate with a range error of 0.02%, 1092 young adults and 469 senior adults were examined.[12] Further details about the examination and the dataset are presented in the Appendix.

To determine the impact additional factors on the periodontal status a personal interview was conducted in both cohorts. This interview encompassed socioeconomic, environmental, and behavioral factors. The type of school (public versus private) in adolescents and the years of education in adults, were considered as a proxy variables for socioeconomic status.[1312] The participants were also asked about their smoking habits and presence of diabetes. The data were presented in a dichotomous manner either as non-smokers or smokers or as non-diabetics or diabetics.

2.2 | Clinical examination

PPD, recession depth (REC), and BOP measurements were recorded at six sites per tooth. CAL was calculated as the sum of PPD plus REC. These assessments were performed in the same manner in both cohorts with a manual periodontal probe‖.

2.3 | Reproducibility of the measurements

All examiners received theoretical information, clinical training, and calibration regarding the measurements. The training was repeated until a consistency with kappa values above 0.80 were achieved.[14]

2.4 | American Academy of Periodontology and the European Federation of Periodontology (AAP/EFP) case definition[6]

The participants were categorized as having periodontitis according to the following case definition:

Interdental detectable CAL loss in at least two non-adjacent teeth, or
Buccal or oral CAL loss ≥ 3 mm with PPD > 3 mm

Thereafter, periodontitis patients were categorized according to the stage of the disease by means of CAL. A CAL of 1-2 mm defined Stage I, 3-4 mm Stage II, and ≥ 5 mm Stage III-IV. In order to discriminate between Stage III and IV, the number of occluding pairs of teeth was calculated, and in case of < 10 occluding pairs the diagnosis was Stage IV. In addition, PPD was included as a complexity factor. According to the extent of the most severe stage, a generalized type was considered when ≥30% of the teeth were affected, otherwise a localized type was defined. If the PPD shifted the stage to a higher level, the extension was considered localized.[7]

2.5 | Grading

For grading the periodontitis patient, there was no available direct evidence of progression (radiographic bone loss or CAL). Therefore a moderate rate of progression was assumed (Grade B).[8] Furthermore, a Grade B was assumed in all participants who reported diabetes because the HbA1c values were not available. Only heavy-smokers (> 10 cigarettes per day) were upgraded to Grade C.

2.6 | Centers for Disease Control and Prevention and the American Academy of Periodontology (CDC–AAP) case definition[15,16]

Participants were categorized as having periodontitis according to the following case definitions:

- Mild periodontitis was defined as ≥2 interproximal sites with CAL ≥3 mm and ≥ 2 interproximal sites with PD ≥4 mm (not on the same tooth) or one site with PPD ≥5 mm.
- Moderate periodontitis was defined as ≥2 interproximal sites with CAL ≥4 mm (not on the same tooth) or ≥ 2 interproximal sites with PPD ≥5 mm, also not on the same tooth.
- Severe periodontitis was defined as having ≥2 interproximal sites with CAL ≥6 mm (not on the same tooth) and ≥ 1 interproximal site with PPD ≥5 mm.

2.7 | Statistical analysis

Descriptive statistics were calculated for all variables including the different periodontal conditions and expressed as frequencies and percentages. Categorical variables were analyzed with chi-square tests. The accuracy of the AAP/EFP definition was examined by assessing the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the receiver operating curve (ROC) using the CDC/AAP case definition as the reference standard. For the calculations, AAP/EFP Stage I as well as CDC/AAP healthy and mild categories were considered as a non-periodontitis case. Sensitivity and specificity values were defined as low level (<60%); moderate level (60% to 79%); or high level (>80%).[17] The accuracy was considered to be low (0.50 to 0.70); useful (0.71 to 0.90); and high (>0.90).[18]

Logistic regression analyses were used to assess the influence of predictors on occurrence of periodontitis (reference: no periodontitis) in adolescents and of periodontitis Stage IV (reference: all the other participants) in adults, both assessed applying the AAP/EFP classification. In South American adolescents, the tested predictors were: age, sex, attending public, or private school, smoking status (current smoker or non-smoker), diabetes (yes or no), BOP (<10% or ≥10%; <25% or ≥25%), PI (<30% or ≥30%; <40% or ≥40%) and city. In Chilean adults, the tested predictors were: age, sex, education (≤12 years or ≥13 years), smoking status (current smoker or non-smoker), diabetes (yes or no), BOP (<10% or ≥10%; <25% or ≥25%) and PI (<30% or ≥30%; <40% or ≥40%). Thereafter, a multivariable analysis model was constructed and only exposures showing in the univariate analysis associations with $P \leq 0.25$ were included.[19] The final model only included variables which resulted statistically significant associated in the multivariable analysis. A 95% level of confidence was considered as representing statistical significance ($P < 0.05$). The statistical analyses were performed using a spreadsheet[1] and a statistical analysis[2] software.

[1] Microsoft Excel for Mac, 2019 version, Microsoft, Redmond, WA, USA
[2] Stata 16, Stata-Corp, College Station, TX, USA

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TABLE 1 Characteristics of the samples

Variables			
Adolescents	**Categories**	**N**	**%**
Sample size		1070	100
Sex	Female	555	51.9
	Male	515	48.1
Age	15 years old	341	31.9
	16 years old	248	23.2
	17 years old	225	21
	18 years old	156	14.6
	19 years old	100	9.3
School	Private	511	47.8
	Public	559	52.2
Smoking	No	776	72.5
	Yes	294	27.5
Diabetes	No	1048	98.2
	Yes	19	1.8
Chilean adults			
Sample size		1561	100
Edentulous		105	6.7
Sex[a]	Female	814	55.9
	Male	642	44.1
Age[a]	35-44 years old	1087	74.7
	65-74 years old	369	25.3
Education[b]	≥13 years	276	19.1
	≤12 years	1171	80.9
Smoking[a]	No	941	64.6
	Yes	515	35.4
Diabetes[a]	No	1297	89.1
	Yes	159	10.9

[a]Dentate subjects ($n = 1456$).
[b]Data available of 1447 subjects.

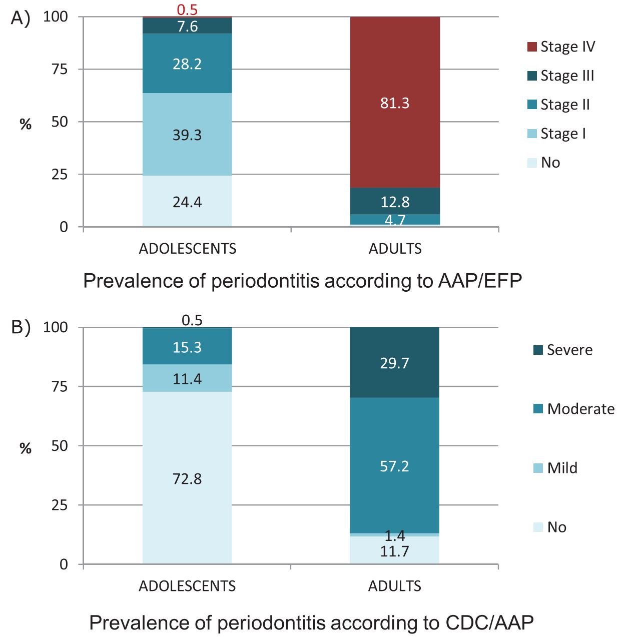

FIGURE 1 Stacked bar charts showing the prevalence of periodontitis in adolescents and adults according to the AAP/EFP (A) and CDC/EFP (B) classification. There were significant differences in periodontitis between adolescents and adults with both classifications (< 0.001, Chi^2)

3 | RESULTS

3.1 | Overall sample

The adolescent cohort (15–19 years old) included 1070 participants (Table 1). From these 1070 participants, 51.9% were females and 52.2% attended a public school. 27.5% of the adolescents reported to be current smokers and 1.8% reported being diabetics. The adult cohort included 1561 participants, 1092 young adults (35–44 years) and 469 senior adults (65–74 years) (Table 1). From this cohort, 105 participants were edentulous, therefore, only 1456 participants provided data for this study. Out of these 1456 participants, 55.9% were females and 80.9% had less than 13 years of education. In addition, 35.4% were smokers and 10.9% reported to have diabetes.

3.2 | Prevalence of periodontitis in adolescents

Table 2 displays the adolescent cohort according to the AAP/EFP and the CDC/AAP classification. According to the AAP/EFP, the prevalence of periodontitis was 75.6%. The majority of the adolescents were classified either as Stage I (39.3%) or Stage II (28.2%) (Figure 1A). Stage III amounted to 7.6% and Stage IV to 0.5%. The most common form of periodontitis was Stage I localized Grade B (18.2%), followed by periodontitis Stage I generalized Grade B (14.8%) (see Supplementary Table S1 in online *Journal of Periodontology*). In contrast, by using the CDC/AAP classification the prevalence of periodontitis changed to 27.2% (Table 2). The most common form of periodontitis with the CDC/AAP classification was moderate periodontitis (15.3%) followed by mild periodontitis (11.4%) (Figure 1B). Severe periodontitis amounted to 0.5%.

3.3 | Prevalence of periodontitis in adults

Table 3 displays the adult cohort according to the AAP/EFP and CDC/AAP classification. According to the AAP/EFP, the prevalence of periodontitis was 99%. The majority of

TABLE 2 Prevalence of periodontitis in adolescents according to the AAP/EFP and CDC/AAP classification

AAP/EFP			*n*	%
	Health/gingivitis		261	24.4
	Periodontitis		809	75.6
		Periodontitis Stage I	420	39.3
		Periodontitis Stage II	302	28.2
		Periodontitis Stage III	82	7.6
		Periodontitis Stage IV	5	0.5
CDC/AAP	No periodontitis		779	72.8
	Periodontitis		291	27.2
		Mild	122	11.4
		Moderate	164	15.3
		Severe	5	0.5

TABLE 3 Prevalence of periodontitis in Chilean adults according to the AAP/EFP and CDC/AAP classification

Classification **AAP/EFP**			*n*	%
	No periodontitis		15	1.0
	Periodontitis		1441	99.0
		Periodontitis Stage I	2	0.1
		Periodontitis Stage II	68	4.7
		Periodontitis Stage III	187	12.8
		Periodontitis Stage IV	1184	81.3
CDC/AAP	Health/gingivitis		170	11.7
	Periodontitis		1286	88.3
		Mild	20	1.4
		Moderate	833	57.2
		Severe	433	29.7

adults were classified as Stage IV (81.3%) whereas Stage III amounted to 12.8% (Figure 1A). Stage II amounted to 4.7% and Stage I amounted to 0.1%. The most common form of periodontitis was Stage IV localized Grade B (38.9%), followed by periodontitis Stage IV generalized Grade B (34.6%) (see Supplementary Table S2 in online *Journal of Periodontology*). By using the CDC/AAP classification, the prevalence of periodontitis changed to 88.3%. In this case, the most common form of periodontitis was moderate periodontitis (57.2%) followed by severe periodontitis (29.7%) (Figure 1B).

3.4 | Comparison between adolescents and adults

A comparison in the prevalence of periodontitis between adolescents and adults revealed significant differences between both cohorts and irrespective of the classification system ($P < 0.001$).

3.5 | Accuracy of the AAP/EFP classification relative to the CDC/AAP classification

The accuracy of the AAP/EFP classification in adolescents using the CDC/AAP system as a reference is shown in Table 4. The AAP/EFP classification revealed a high sensitivity for moderate (95.7%) and severe periodontitis (100%). Regarding the specificity, this was moderate (75%) for moderate periodontitis and high (92%) for severe periodontitis. Although the PPV was 41.6% for moderate periodontitis and 5.7% for severe periodontitis, the NPV was high for both categories (moderate = 99%; severe = 100%). The AUC was 0.91 (95% CI = 0.89–0.93) and the optimal cut-off on the curve was Stage II (see Supplementary Figure S1 in online *Journal of Periodontology*).

The accuracy of the AAP/EFP classification in Chilean adults is shown in Table 5. The AAP/EFP classification revealed a high sensitivity for moderate (99.7%) and severe

TABLE 4 Diagnostic performance of AAP/EFP classification for moderate and severe categories in adolescents (reference: CDC/AAP classification)

	CDC/AAP						
	No	**Yes**	**Total**	**SN**	**SP**	**PPV**	**NPV**
AAP/EFP	No/Mild	(Moderate/Severe)					
Moderate				96	75	41.6	99
No (No/Stage I)	674	7	681				
Yes (Stage II/III/IV)	227	162	389				
Total	901	169	1070				
	No	Yes	Total				
	No/Mild/Moderate	(Moderate/Severe)					
Severe				100	92	5.7	100
No (No/Stage I)	983	0	983				
Yes (Stage II/III/IV)	82	5	87				
Total	1065	5	1070				

Abbreviations: SN, sensitivity; SP, specificity; PPV, positive predictive value; NPV, negative predictive value.

TABLE 5 Diagnostic performance of AAP/EFP classification for moderate and severe categories in Chilean adults (reference: CDC/AAP classification)

	CDC/AAP						
	No	**Yes**	**Total**	**SN**	**SP**	**PPV**	**NPV**
AAP/EFP	No/Mild	(Moderate/Severe)					
Moderate				99.7	6.8	87.7	76.5
No (No/Stage I)	13	4	17				
Yes (Stage II/III/IV)	177	1262	1439				
Total	190	1266	1456				
	No	Yes	Total				
	No/Mild/Moderate	(Moderate/Severe)					
Severe				100	8.3	31.6	100
No (No/Stage I)	85	0	85				
Yes (Stage II/III/IV)	938	433	1371				
Total	1023	433	1456				

Abbreviations: SN, sensitivity; SP, specificity; PPV, positive predictive value; NPV, negative predictive value.

periodontitis (100%) but a low specificity for both categories (moderate = 6.8%; severe = 8.3%). The positive predictive value (PPV) was 88.7% for moderate periodontitis and 31.7% for severe periodontitis. The NPV amounted to 76.5% for moderate periodontitis and 100% for severe periodontitis. The AUC was 0.57 (95% CI = 0.53–0.62) and the optimal cut-off on the curve was Stage III (see Supplementary Figure S2 in online *Journal of Periodontology*).

3.6 | Predictors for the presence of periodontitis in adolescents and adults

In adolescents, the adjusted logistic regression model revealed that BOP ≥ 25% (OR = 2.49; 95% CI: 1.19 to 2.66) and city of origin (lower ORs for all cities compared to Santiago de Chile, Chile) were risk indicators for suffering periodontitis according to the AAP/EFP case definition (any stage; reference group: no periodontitis; see Supplementary Table S3 in online *Journal of Periodontology*). Conversely, age, school, smoking, diabetes, and plaque resulted as not associated to periodontitis in the final model.

In Chilean adults, the adjusted logistic regression demonstrated that age (OR = 10.35; 95% CI: 5.25 to 20.42) and < 13 years of education (OR = 1.95; 95% CI: 1.43 to 2.66) were risk indicators for suffering Stage IV periodontitis (reference: all the other participants; see Supplementary Table S3). In contrast, sex, smoking, diabetes, BOP and plaque were not associated with Stage IV periodontitis in adults.

4 | DISCUSSION

The present study predominantly revealed: (1) considerable differences in the prevalence of periodontitis depending on the case definition used, (2) a high accuracy of the AAP/EFP classification system relative to the CDC/AAP case definition in adolescents and (3) a relatively low accuracy of the AAP/EFP system relative to CDC/AAP in adults with high prevalence of periodontitis.

In the adult cohort the prevalence of periodontitis was only slightly influenced by the application of the two different case definitions (99.0% for AAP/EFP, 88.3% for AAP/CDC) whereas in the adolescent cohort the use of the AAP/EFP classification resulted in an almost three-fold increase of the reported prevalence (75.6% for AAP/EFP, 27.2% for AAP/CDC). Apart from the lower threshold of interproximal CAL employed in the AAP/EFP classification system ("detectable" versus ≥ 3 mm CAL), the AAP/EFP definition does not include PPD as a parameter to define a periodontitis case, as opposed to the AAP/CDC definition. These aspects may account for the observed discrepancy in the prevalence between the two case definitions. Indeed, whereas in the adult cohort most of the periodontitis cases were more severe (Stage III-IV)—thus exceeding the threshold limits of both case definitions—in the adolescent cohort a higher proportion of incipient forms (Stage I-II) was observed.

In addition, the CDC/AAP case definition only considers interproximal CAL for a diagnosis, whereas the AAP/EFP also considers buccal CAL for a diagnosis. This is not surprising given the different target of the two case definitions. The AAP/EFP case definition has been designed to identify periodontitis cases in clinical practice, where the identification of incipient cases is fundamental for early treatment. In contrast, the AAP/CDC case definitions have been conceived for population-based studies, where the capability to identify only true cases of the disease (i.e., specificity) is the main purpose, thereby hindering the early detection of periodontitis.[16]

Sensitivity and specificity are related to the accuracy of a diagnostic test (in this case the AAP/EFP definition) relative to a reference standard (the AAP/CDC definition). In adolescents, the present study revealed that the AAP/EFP definition had a high sensitivity (> 95%), moderate to high specificity (> 75%) and a high accuracy (> 0.90) indicating a good ability to correctly identify periodontitis cases relative to the CDC/AAP definition. These findings are in accordance with a previous report, which indicated a high accuracy (> 0.90%) of the AAP/EFP definition against the AAP/CDC classification.[20] In contrast, the application of the AAP/EFP definition in adults showed a moderate sensitivity and a low specificity (< 9%) along with a low accuracy (0.57). This indicates that AAP/EFP is less accurate to correctly identify periodontitis cases relative to the CDC/AAP definition. This is most likely explained by the high levels of periodontitis in Chilean adults as the diagnostic accuracy of a given test increases as the disease prevalence decreases.[21]

The high prevalence of periodontitis in Chilean adults compares relatively well with two recent studies.[20,22] In the first study[20] the prevalence of Stage III/IV periodontitis amounted to 71.8% and based on AAP/CDC the prevalence of moderate and severe periodontitis amounted to 47.6% and 29.7%, respectively. The slight differences with the present figures are likely explained by the wider age range of the participants in that study (e.g., 15–93 years).[20] In the second study the prevalence of periodontitis amounted to 100% using AAP/EFP definition and to 61.9% with the CDC/AAP definition.[22] Those rates are largely in line with the present findings. It should be noted, however, that the present rates are still higher than in most epidemiological surveys studying population samples of similar ages. A recent epidemiological study on an indigenous population in Northern Norway described the prevalence of periodontitis using the new AAP/EFP classification.[23] That study reported an overall prevalence of 34% in young adults (35–49) and 81% in senior adults (65–75).[23] In both cohorts the most common form of periodontitis was Stage II, whereas in the present study the most common one was Stage IV. Using the CDC classification on the other hand, the National Health and Nutrition Examination Survey 2009-2014 reported an overall prevalence of periodontitis of about 30% in young adults (35–44) and 60% in senior adults (65 or older).[24] Similarly, other studies in different parts of the World have also reported lower rates of periodontitis.[22,25–29]

The high prevalence of periodontitis in the present study could be explained by a series of adjustable risk factors associated with aspects of lifestyle. Multivariable logistic regression revealed that in the adolescent cohort, BOP≥ 25% and city of origin were found to be risk indicators for periodontitis. Although BOP≥ 25% may simply represent a manifestation of the disease, the city of origin may be an indicator of different socio-economic conditions. In the adult cohort, after adjusting confounding variables, age and < 13 years of education were found to be risk indicators for having Stage IV periodontitis. With respect to age, there is ample evidence indicating a higher prevalence with increasing age.[2,24] In relation to education, the present findings are consistent with the principles of Social Determinants of Health. These principles identify education as an indicator that shapes health.[30] About 80% of Chilean adults had less than 13 years of education. Given that education can influence health behaviors, such as healthcare access[30] this aspect may account for the disparities in periodontitis across the Chilean population. In addition, Chile ranks the highest in income inequality among the Organization for Economic Co-operation and Development (OECD) member countries showing the largest social inequality gradient in terms of tooth loss.[31] Therefore, it is reasonable to state that these upstream social determinants of health partly explain the high prevalence of periodontitis in the Chilean population. Conversely, smoking and diabetes were not significantly associated with periodontitis (in the adolescent cohort) and with Stage IV periodontitis (in the adult cohort). This contrasts with most epidemiological studies[32–34] employing the CDC/AAP case definitions. This discrepancy might be explained by the possible lack of power to detect an association because of the high prevalence and the case definition used (AAP/EFP).

Although the social determinants of health are well known, the implementation of policies to address these determinants has been slow.[30] Previous studies have already highlighted the importance of integrated upstream and community-based approaches,[35] nevertheless, oral health care still operates in a non-integrated manner. This is because policy makers tend rely on downstream clinical interventions rather than upstream interventions because of the challenge of tackling oral health inequalities at the structural level.[36] The downstream clinical interventions do not tackle the underlying causes of the disease.[35] In fact, the evidence suggests that these downstream approaches are only effective in the short term having a lower impact compared to upstream approaches[37]. In general, downstream interventions will achieve little[29] and are unaffordable in most low-income and middle-income countries.[35]

The major strength of the present study is the inclusion of a representative sample of Chilean adults with a full-mouth periodontal examination resulting in a valid representation of the prevalence of periodontitis in the population. The adolescent cohort on the other hand was a non-representative sample selected according to the population of each city, thus limiting the generalization of the present findings. Furthermore, a possible misclassification bias for staging (e.g., lack of information regarding the reasons of tooth loss) and grading (lack of Hb1Ac and lack of radiographs) might have been present resulting in a higher prevalence of Stage IV and a lower prevalence of Grade C. This may have had an impact on the results of the risk indicators in the adult cohort. Finally, the chosen reference standard (CDC/AAP) may have influenced the diagnostic accuracy of the AAP/EFP definition.

5 | CONCLUSION

This study revealed a clear discrepancy in the prevalence of periodontitis between the AAP/EFP and the CDC/AAP classification when using epidemiological data. The 2017 AAP/EFP classification system performs well compared to the CDC/AAP case definition in identifying adolescents with periodontitis. The AAP/EFP system seems less accurate in an adult population with high prevalence of periodontitis.

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AUTHOR CONTRIBUTIONS

All authors have made substantial contributions to conception and design of the study. AM, MB, FC, JG, and FJS have been involved in data collection and data analysis. FJS, MR, CHF, and MS interpreted the data and drafted the manuscript. All authors critically revised the draft and approved the final version.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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APPENDIX

Adult cohort examination protocol

Complete dental examinations were performed in each individual by calibrated examiners. All examiners received theoretical classes, clinical training, and calibration by a senior member of the Periodontal Department of the Faculty of Dentistry, University of Chile (JG). Calibration training was performed on successive days during which groups of 20 subjects were examined. All examinations were repeated until acceptable consistency was achieved (0.80 – 0.90) determined by intraclass and interclass correlation coefficients. Validity and reliability examinations were performed before, during, and at the end of the study. Clinical evaluations were carried out in dental clinics from the public primary care system. The study protocol was explained to all patients, and informed consent forms were signed prior to entry in the study. Periodontal clinical parameters were evaluated at six sites in all teeth, excluding third molars. These parameters included probing depth (PD), clinical AL, dichotomous mid-buccal, mid-buccal, disto-buccal, disto-lingual, mid-lingual, and mesio-lingual measurements of supragingival plaque accumulation (plaque index [PI]), and bleeding on probing (BOP) at the base of the crevice. Clinical AL was determined using the distance from the cemento-enamel junction (CEJ) to the free gingival margin (FGM) and the distance from the FGM to the bottom of the pocket/sulcus. From these two measurements, the clinical AL (distance from the CEJ to the bottom of pocket/sulcus) was calculated. The assessment of the periodontal supporting tissue status was made with a periodontal probe. If necessary, at the time of recording depths, measurements were rounded down to the nearest whole millimeter. The number of teeth present in the mouth was counted, excluding wisdom teeth. To determine the impact of social, economic and environmental factors on periodontitis, information about the behavioural and socio-demographic characteristics were gathered through a personal interview. Individuals were classified by their educational level, which was categorised by the amount of education years in <12 or ≥ 12 years. Household income was categorized according the national minimal monthly salary of < \$286,000 or ≥ \$286,000 Chilean Pesos (CLP). Individuals were classified as current smokers or non-smokers/former smokers. Diabetes mellitus was recorded as self-reported.

Adolescent cohort examination protocol

Clinical evaluation was carried out in schools, under room light. The examiner was properly sitting down and the subject was lying down on a clinical stretcher. Periodontal clinical parameters were evaluated at six sites in all teeth, excluding third molars. These parameters included probing pocket depth (PPD), dichotomous mesio-buccal, mid-buccal, disto-buccal, disto-lingual, mid-lingual and mesio-lingual measurements of supragingival plaque accumulation (plaque index [PI]), and bleeding on probing (BOP) at the base of the crevice. Clinical attachment loss was determined using the distance from the cement- enamel junction (CEJ) to the free gingival margin (FGM) and the distance from the FGM to the bottom of the pocket/sulcus. From these two measurements, the clinical attachment level (distance from the CEJ to the bottom of pocket/sulcus) was calculated. The assessment of the periodontal supporting tissue status was made with a first-generation manual periodontal probe (UNC-15; Hu Friedy, Chicago, IL USA). If necessary, at the time of recording depths, measurements were approximated to the nearest whole millimetre. The interdentally measures were probed parallel in relation to the tooth axis. Finally, the subjects were asked to fill out a short questionnaire giving details about their demographic information (name, sex, age) and smoking habits.

All examiners received theoretical classes, clinical training and calibration in CAL, administered by a senior member of the Periodontal Department of the Faculty of Dentistry, University of Chile (JG). Nine dentists performed the clinical evaluations. Calibration training was performed within successive days. All examinations were repeated until acceptable consistency was achieved. A > 93% of intra-examiner agreement was obtained for CAL ≥1 mm, with an average maximum difference for each subject of 0.3 mm, corresponding to a kappa value of 0.88. A > 91% of inter-examiner agreement was obtained for the site with CAL ≥1 mm, with an average maximum difference for each subject of 0.8 mm, corresponding to a kappa value of 0.95. The reliability of the examiners was in a range considered good to excellent. Validity and reliability examinations were performed at the beginning of the study and after reaching 50% of the examinations.