https://doi.org/10.54589/aol.35/3/178

Periodontitis prevalence and associated factors: a comparison of two examination protocols

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ABSTRACT

The fact that there are different epidemiological definitions of periodontitis and different evaluation protocols affects the estimate of periodontitis prevalence and of the influence of associated factors. The gold standard for periodontal examination is full-mouth record assessing CAL and PD. However, there are not always sufficient human and financial resources available to apply such assessment for epidemiological surveillance systems. ***Aim:*** *This study was conducted to compare different protocols and definitions of periodontitis for assessing prevalence and the impact of related factors in adult patients who requested care at the School of Dentistry, UdelaR.* ***Materials and Method:*** *This was a cross-sectional study of 410 subjects with a high burden of disease in terms of NCDs and periodontitis. Clinical examination evaluated PD in all teeth and CAL in the CPI sextants (WHO 2013). Four periodontitis criteria were defined based on two examination protocols (WHO 2013 and WHO 1997) and two definitions of epidemiological case. Comparisons were made taking the 2013 WHO protocol as a reference.* ***Results:*** *Comparison of the two examination protocols showed that prevalence was underestimated when the WHO 1997 protocol was used to define moderate-severe and severe periodontitis, by 20% and 60%, respectively.* ***Conclusions:*** *When the severity of periodontitis was not considered, the WHO 2013 protocol did not provide more information on what factors increase the chance of periodontitis. However, when severity was considered, the associated factors were different. Consequently, in a small population, it would be worth using the WHO 2013 protocol, which is the closest to the full-mouth gold standard criterion.*

Keywords: *cross-sectional studies - periodontal index - periodontitis - risk factors - non-communicable diseases*

To cite:
Lorenzo-Erro SM, Andrade E, Massa F, Colistro V, Asquino N, Moliterno P. Periodontitis prevalence and associated factors: a comparison of two examination protocols. Acta Odontol Latinoam. 2022 Dic 31;35(3):178-187. https://doi.org/10.54589/aol.35/3/178

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Received: May 2022.
Accepted: August 2022.

Prevalencia y factores asociados a periodontitis: comparación de dos protocolos de examen WHO

RESUMEN

La variabilidad en la definición epidemiológica de la periodontitis y los protocolos de evaluación afectan la medición de la prevalencia y su asociación con ciertos factores. Si bien, el patrón oro para el examen periodontal es el registro de boca completa, que evalúa la pérdida de inserción (CAL, por sus siglas en inglés) y profundidad de sondaje (PS, por sus siglas en inglés), los recursos no siempre están disponibles para los sistemas de vigilancia epidemiológica. ***Objetivo:*** *En este estudio se compararon diferentes protocolos y definiciones de periodontitis evaluando la prevalencia y la asociación de factores relacionados en pacientes adultos que solicitaron atención en la Facultad de Odontología de la UdelaR.* ***Materiales y Método:*** *Los datos provienen de un estudio transversal de 410 sujetos con una elevada carga de enfermedad en términos de ENT y periodontitis. Se utilizó un examen clínico registrando PD en todos los dientes y CAL en los sextantes CPI (WHO 2013). Se definieron cuatro criterios de periodontitis basados en dos protocolos de examen y dos definiciones epidemiológicas de caso. Las comparaciones se realizaron tomando como referencia el protocolo de la OMS de 2013.* ***Resultados:*** *Al comparar los dos protocolos de examen, se verificó la subestimación de la prevalencia cuando se utilizó el protocolo de la OMS de 1997 para la definición de caso moderado-grave y para la periodontitis grave, siendo en el primer caso del 20% y en el segundo caso tres veces mayor que.* ***Conclusiones:*** *Si no se considera la gravedad de la periodontitis, el uso del protocolo de la OMS 2013 no proporciona más información sobre qué factores aumentan la probabilidad de periodontitis. Sin embargo, al analizar la gravedad, los factores asociados fueron diferentes. En consecuencia, en una población pequeña estaría justificado el esfuerzo de utilizar el protocolo de la OMS de 2013, ya que el criterio de referencia es la boca completa.*

Palabras clave: *estudios transversales - índice periodontal - periodontitis - factores de riesgo - enfermedades no transmisibles*

INTRODUCTION

Periodontal disease is a public health problem that affects numerous global populations. It is the leading cause of tooth loss, particularly in older adults, significantly affecting their quality of life[1]. It is a multifactorial, inflammatory-based, socio-culturally modeled disease[2], like other chronic noncommunicable diseases (NCDs). Its prevalence ranges from 15 to 47%[1,2] worldwide, and 10.8% of the population is affected by severe periodontitis. Brazil's 2010 population survey showed that the prevalence of "moderate to severe" periodontal disease in adults aged 35-44 years was 15.3%[3]. In Uruguay, Lorenzo et al. reported that 22% of the population over 35 years of age presented moderate-severe forms of periodontitis, and that 9% presented the severe form[4]. Several factors associated to periodontitis have been described: age, sex and socioeconomic status; tobacco consumption[5], and with a lower level of evidence, the consumption of acohol[6], the intake of fruits and vegetables[7,8], and as associated pathologies, diabetes[9] and obesity[10]. Different definitions and examination protocols have been used to study prevalence, severity and the associations mentioned, to the point that the epidemiological definition of "periodontitis case" has become extremely controversial[11–14].

The use of different definitions has decisive influence on the epidemiological surveillance of periodontitis by comparing results of prevalence and severity[12-15], as well as on the direction and magnitude of the associations with the risk factors and systemic diseases analyzed[16]. The gold standard of periodontal examination is the full-mouth periodontal examination (FMPE) protocol based on the clinical examination of 6 sites per tooth, including the study of clinical attachment loss (CAL) and probing depth (PD) as continuous variables[17]. However, the time, logistics and costs involved in applying FMPE sometimes render it impractical for epidemiological surveillance systems[18,19]. To compensate for these difficulties, different partial mouth periodontal examination (PMPE) protocols have been developed, which examine certain teeth [Community Periodontal index (CPI), Ramfjord], randomly selected quadrants, among others[20]. These protocols have demonstrated varying degrees of accuracy compared to FMPE. They underestimate the prevalence, and sometimes overestimate the severity of the pathology, the dental sector, and the population age[3,21,22].

One of the partial protocols widely used in public health, especially in populational oral health surveys, is the Community Periodontal Index (CPI)[23] proposed by the WHO in the 1990s. The CPI divides the mouth into sextants and uses index teeth to evaluate periodontitis. This indicator has been modified and improved over time. For example, national oral health studies in Brazil have adopted a recording system in which the prevalence of each condition can be counted per sextant, not recording only the worst condition[24]. In 2013, the WHO developed a new manual for basic national surveys, in which it introduced the full mouth examination to assess probing depth (PD), while maintaining the use of six sextants for the clinical attachment loss (CAL) examination[25]. The CPI, with several of the aforementioned strengths and weaknesses, is still used for population surveys, creating the need to evaluate its new version.

In order to evaluate the weaknesses and strengths of each method, the aim of this article was to compare different protocols and definitions of periodontitis by assessing the prevalence and the magnitude of association of related factors in adult patients who requested care at the Screening and Admission Service of the School of Dentistry, UdelaR (Uruguay).

MATERIALS AND METHOD

Study design and sample

This was a cross-sectional, observational study conducted at the School of Dentistry (F.O)/ UdelaR. Participants were patients who requested care at the institution's Screening and Admission Service. The study was conducted from August 2015 to December 2016.

A representative sample was used. Over a 6-month period, the Screening and Admissions Service receives 4000 people requesting dental care. The sample was planned to obtain prevalence of up to 30% in two estimation domains with a 95% confidence level and a 5% margin of error. Sample size was estimated as 620 patients. The eligibility criteria were being older than 18 years, and having requested dental care at the Screening and Admission Service from August to December 2015 or March to May 2016. For the present study, considering epidemiological characteristics of periodontitis affecting adults and elderly adults, patients younger than 35 years (n=210) were excluded.

Data collection

Dental examination was performed in a dental chair, with mirror, clamp and CPI probe, recording PD in all teeth present[25] and CAL per sextant. Each tooth was probed at six sites (mesio-buccal, mid-buccal, disto-buccal, disto-lingual, mid-lingual and mesio-lingual). PD was measured as the distance from the free gingival margin to the base of the gingival crevice, and subjects were classified using the following categorization: "absent", when pocket depth was 0 to 3 mm, and "present" when pocket depth was ≥ 4mm. Edentulous subjects were not considered. The Brazilian national oral health survey modification for CPI was used. It consisted of measuring periodontal conditions (PD and CAL) on each tooth and reporting the value for each condition, not only the worst situation as the original CPI index does.

Participating examiners were calibrated by means of the examination of 30 volunteers covering all the age ranges to be included in the study. The kappa coefficient was calculated for the CPI indicator, and PD and CAL were calibrated, obtaining values of 0.71 and 0.79, respectively.

The participants answered a questionnaire on socio-demographics (sex, age, studies completed, monthly income and medical and dental healthcare coverage), behavior (quality of diet, alcohol and tobacco consumption, physical activity) and metabolic risk factors (history of hypertension, diabetes, high cholesterol and altered glycemia).

The question about education recorded participants' maximum educational level; the question about income recorded average monthly household income (in Uruguayan pesos), and the question about health and dental coverage recorded participants' healthcare providers.

The questions about diet included the amount and frequency of weekly consumption of fruits and vegetables; sugary drinks and products; ready-to-eat, high-salt products; use of salt when cooking and eating, and type and frequency of alcohol consumption. The questions about smoking enquired about whether the participant smoked and if so, how much. The questions about physical activity considered frequency and duration of moderate and intense physical activity, using a chart with examples[26].

Glycemia was measured by capillary puncture using disposable lancets and test strips for measurement on a digital glucometer (Bayer® Contour TS), following the manufacturer's recommendations. Blood pressure (BP) was measured with an aneroid sphygmomanometer (RIESTER® verified by LATU No. 333075. 06/2015), after the patient had sat at rest for 15 minutes, with his/her arm relaxed on a firm surface, using an appropriately sized cuff for arm perimeter, and recording a single measurement

Anthropometric data were height, weight and waist circumference. Body height (Seca®) was measured to the nearest 0.5 cm. Weight (Seca®) was recorded to the nearest 100 grams with patients wearing light indoor clothing without shoes. Waist circumference was measured with an inelastic measuring tape (Seca®), following the WHO protocol[25].

Variables and indicators

Dental variables

Four periodontitis criteria were defined based on two examination protocols and two epidemiological definitions of periodontitis, combined as follows (Fig. 1).

- *Partial protocol, moderate-severe*: examination of CPI sextants with their index teeth, considering

	PROTOCOLS					
	WHO 1997		WHO 2013		CASE DEFINITION OF PD	
	PP	CAL	PP	CAL	moderate-severe	severe
Partial protocol, moderate-severe	CPI sextants	CPI sextants			X	
Partial protocol, severe	CPI sextants	CPI sextants				X
Full mouth, moderate-severe			All teeth	CPI sextants	X	
Full mouth, severe			All teeth	CPI sextants		X

Fig. 1: *Case Definition of Periodontitis*

"moderate and severe" disease: moderate to severe when CPI > 2 (periodontal pocket ≥ 4mm and CAL ≥ 4mm).

- *Partial protocol, severe*: examination of sextants with their index teeth, considering severe periodontitis when CPI > 2 (periodontal pocket ≥ 4mm and CAL ≥ 6mm).
- *Full mouth, moderate-severe:* complete mouth examination for PD and by sextant for CAL, considering "moderate to severe" periodontitis as in item 1.
- *Full mouth, severe:* complete mouth examination for PD and by sextant for CAL, considering "severe" periodontitis as in item 2.

Socio-demographic variables

Educational level was classified as primary education or lower; secondary education or a lower; and tertiary education or higher. Health coverage was classified as either public or private coverage. Income level was classified as up to 700 USD, from 700 to 1000 USD, from 1000 to 1200 USD, or higher than 1200 (according to the local dollar exchange rate in 2015).

Behavioral variables

Dietary risk factors were considered to be present when the consumption of fruits and vegetables was < 5 servings per day; the consumption of sugary drinks, sugary products and ready-to-eat foods was > 2 times a week; the addition of salt to ready-to-eat preparations (considering the answers "always/almost always"). The alcohol consumption variable considered the frequency and number of drinks, with the categories: "does not consume", "consumes" and "harmful consumption". Consumption was considered harmful when respondents reported having at least 5 drinks (on one of those days) or drinking alcohol more than twice a week. For tobacco, 3 categories were considered: never, currently or formerly consumed. Insufficient physical activity was considered to be less than 75 minutes per week of vigorous physical activity or less than 150 minutes per week of moderate physical activity.

Metabolic variables

Hypertension was considered as systolic BP greater than or equal to 140 mmHg and/or diastolic BP greater than or equal to 90 mmHg[27], or self-reported hypertension. Diabetes was defined as capillary glycemia ≥ 200 mg/dl with or without fasting, or a self-reported history of diabetes diagnosed by respondent's physician[26]. Obesity and overweight were analyzed through body mass index [BMI = weight (kg)/square of height (m^2)] and considered as BMI values of 25.0 to 29.9 kg/m^2 and 30 kg/m^2 or more, respectively. Altered values of waist circumference corresponded to > 88 cm in women and > 102 cm in men.

Ethical aspects

This study was approved by an Institutional Review Board (Uruguayan Research Ethics Committee) of the School of Dentistry (F.O; file number 091900-000121-14) and was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2013. Participation was voluntary, and participants signed a written informed consent. The participants were informed of the results of the measurements (weight, height, waist circumference, capillary glycemia and blood pressure) and advised on the need for medical consultation when appropriate.

Statistical analysis

After performing the descriptive analysis, 4 logistic regression models were adjusted, one for each periodontitis criterion. These models included explanatory variables in hierarchical blocks. First, sociodemographic factors were included, then metabolic variables and lastly, factors referring to behavioral variables. The association was described using odds ratios (OR), assessing its uncertainty using 95% confidence intervals. All statistical procedures were performed in the R[28] software.

RESULTS

A total 410 subjects were analyzed. Table 1 provides the data recorded. The population was predominantly female (58.8%); with 79.0% in the 35- to 64-year age range, and 16% having university studies. Regarding income, 58.2% earned less than 700 USD, and only 9% more than 1200 USD. Considering oral health, 70% used the private subsector, and 9.8% used the public subsector of the National Integrated Health System. Table 1 reports prevalence of NCDs and their risk factors.

The prevalence of periodontitis according to the 4 criteria used to assess it in the study population was: "Partial protocol, moderate-severe": 43.9%

Table 1. Characteristics of the study population

Sociodemograhic	n	%	
Sex			
Female	241	58,8%	(54% - 63,5%)
Male	169	41,2%	(36,5% - 46%)
Age			
35 - 44	114	27,8%	(23,5% - 32,1%)
45 - 64	210	51,2%	(46,4% - 56,1%)
65 - 74	59	14,4%	(11% - 17,8%)
≥ 74	27	6,6%	(4,2% - 9%)
Healthcare system			
ASSE	264	64,4%	(59,8% - 69%)
Mutualist	131	32,0%	(27,4% - 36,5%)
Other	15	3,7%	(1,8% - 5,5%)
Dental care			
ASSE	287	70,0%	(65,6% - 74,4%)
Mutualist	40	9,8%	(6,9% - 12,6%)
Others	83	20,2%	(16,4% - 24,1%)
Income (thousands)			
≤ 17	228	58,2%	(53,4% - 62,9%)
17 - 24	76	19,4%	(15,6% - 23,2%)
24 - 32	51	13,0%	(9,8% - 16,3%)
≥ 32	37	9,4%	(6,6% - 12,3%)
Education			
primary (≤6 years)	134	32,7%	(28,1% - 37,2%)
secondary (6 - 12 years)	210	51,2%	(46,4% - 56,1%)
tertiary (≥12 years)	66	16,1%	(12,5% - 19,7%)
NCD			
Hypertension			
sick	216	52,7%	(47,9% - 57,5%)
heathy	194	47,3%	(42,5% - 52,1%)
Obesity			
sick	270	65,9%	(61,3% - 70,4%)
healthy	140	34,1%	(29,6% - 38,7%)
Diabetes			
sick	77	18,8%	(15% - 22,6%)
healthy	333	81,2%	(77,4% - 85%)
Habits and consumption			
Harmful alcohol consumption			
does not drink	171	41,7%	(36,9% - 46,5%)
no	209	51,0%	(46,1% - 55,8%)
yes	30	7,3%	(4,8% - 9,8%)
Physical activity			
insufficient	196	47,8%	(43% - 52,6%)
sufficient	214	52,2%	(47,4% - 57%)
Always or almost always adds salt			
yes	60	14,6%	(11,2% - 18,1%)
no	350	85,4%	(81,9% - 88,8%)
Servings of fruits and vegetables			
5 or more	39	9,5%	(6,7% - 12,4%)
fewer than 5	371	90,5%	(87,6% - 93,3%)
Consumption of sugary drinks			
2 or more days a week	193	48,9%	(44% - 53,7%)
less than 2 days a week	202	51,1%	(46,3% - 56%)
Consumption of tobacco			
currently	122	29,8%	(25,4% - 34,3%)
former	107	26,2%	(21,9% - 30,4%)
never	180	44,0%	(39,2% - 48,8%)

(95% CI: 34.8-53.9), "Partial protocol, severe": 6.5% (95% CI: 3.2-12.9), "Full mouth, moderate-severe" 53.9% (95% CI: 44.5-63.1) and "Full mouth, severe": 16.1% (95% CI: 10.3-24.2). Thus, considering as a reference the WHO 2013 protocol[25] in its two versions of periodontitis ("Full mouth, moderate-severe", and "Full mouth, severe") and comparing it to the WHO protocol 1997[23] ("Partial protocol, moderate-severe", "Partial protocol, severe"), the differential relative gap resulted in an underestimation of the disease by approximately 20% and 60% for moderate to severe and severe disease, respectively.

The result of the multivariate analysis using four models (*Model 1: Moderate and severe PD (teeth index); Model 2: Severe PD (teeth index); Model 3: Moderate and severe PD (teeth index + WHO); Model 4: Severe PD (teeth index + WHO);* each model corresponds to a criterion, is presented in Table 2. According to model 1, those most likely to have periodontitis were men [OR 1.47 (95% CI: 1.16-1.86)], people aged 45-64 years [OR 1.48 (95% CI: 1.1-2.02)], people aged 65-74 years [OR 1.99 (95% CI: 1.36-2.92)], and ex-smokers [OR 1.43 (95% CI: 1.06-1.93)]. A linear trend was observed in age, where the older the subject, the greater the chance of periodontitis (p=0.039).

In model 2, age 45-64 and 65-74 years, and a monthly income level of less than 700 USD increased the chance of presenting periodontitis, with OR 4.03 (95% CI: 1.38–17.1), 6.69 (95% CI: 1.96–30.6) and 4.21 (95% CI:1.22–26.5), respectively. Considering behavioral variables, alcohol intake and the addition

Table 2. Adjusted OR (95%) of Periodontitis in Multivariate Logistic Regression Model for different protocols and case definitions

	Moderate and severe PD (teeth index)		Severe PD (teeth index)		Moderate and severe PD (teeth index + WHO)		Severe PD (teeth index + WHO)	
	OR	IC95%	OR	IC95%	OR	IC95%	OR	IC95%
Sociodemographics								
Sex (Male)	1,474	(1,167 - 1,860)	1,661	(0,899 - 3,083)	1,878	(1,539 - 2,293)	2,548	(1,710 - 3,838)
Age (45 - 64)	1,483	(1,102 - 2,016)	4,032	(1,381 - 17,15)	1,837	(1,422 - 2,39)	3,697	(1,947 - 7,783)
Age (65 - 74)	1,999	(1,364 - 2,926)	6,695	(1,965 - 30,64)	2,504	(1,801 - 3,485)	4,858	(2,291 - 11,02)
Age (≥ 74)	1,568	(0,931 - 2,577)	3,980	(0,820 - 21,37)	1,983	(1,277 - 3,044)	3,426	(1,296 - 8,933)
Healthcare service (Mutualist)	1,098	(0,615 - 2,059)	1,055	(0,308 - 4,907)	0,787	(0,476 - 1,329)	0,683	(0,297 - 1,732)
Healthcare service (ASSE)	0,776	(0,449 - 1,418)	0,547	(0,179 - 2,387)	0,733	(0,457 - 1,202)	0,596	(0,283 - 1,417)
Dental care (Mutualist)	1,250	(0,806 - 1,968)	1,474	(0,411 - 6,897)	1,152	(0,785 - 1,704)	1,230	(0,543 - 3,055)
Dental care (ASSE)	1,202	(0,782 - 1,884)	2,225	(0,683 - 10,09)	1,005	(0,69 - 1,48)	1,412	(0,651 - 3,432)
Education (primary)	0,799	(0,558 - 1,151)	0,386	(0,160 - 0,918)	0,803	(0,592 - 1,091)	0,523	(0,302 - 0,907)
Education (secondary)	1,029	(0,747 - 1,433)	0,572	(0,276 - 1,236)	0,955	(0,725 - 1,265)	0,620	(0,381 - 1,027)
Income (less than 17)	1,147	(0,772 - 1,745)	4,207	(1,219 - 26,532)	1,238	(0,876 - 1,774)	1,955	(0,985 - 4,349)
Income (17 - 24)	1,153	(0,739 - 1,827)	3,293	(0,832 - 21,926)	1,055	(0,714 - 1,571)	1,468	(0,669 - 3,483)
Income (24 - 32)	1,090	(0,671 - 1,785)	0,458	(0,021 - 4,905)	1,229	(0,807 - 1,882)	0,893	(0,322 - 2,440)
NCD								
HTN (sick)	1,091	(0,845 - 1,409)	1,191	(0,608 - 2,395)	0,990	(0,797 - 1,23)	0,962	(0,627 - 1,483)
BMI (overweight/obesity)	1,012	(0,777 - 1,324)	0,588	(0,302 - 1,166)	0,925	(0,74 - 1,159)	0,817	(0,532 - 1,270)
Diabetes (sick)	1,073	(0,793 - 1,438)	0,982	(0,427 - 2,049)	1,127	(0,871 - 1,451)	0,914	(0,536 - 1,496)
Habits and consumption								
Harmful consumption of alcohol (no)	1,160	(0,894 - 1,509)	0,923	(0,450 - 1,916)	1,155	(0,923 - 1,447)	0,919	(0,584 - 1,451)
Harmful consumption of alcohol (yes)	1,001	(0,604 - 1,615)	3,258	(1,133 - 8,914)	1,216	(0,808 - 1,812)	1,571	(0,774 - 3,080)
Physical activity (insufficient)	1,025	(0,798 - 1,316)	1,547	(0,799 - 3,052)	1,043	(0,841 - 1,293)	1,297	(0,847 - 1,995)
Added salt SCS (yes)	1,029	(0,721 - 1,444)	2,179	(1,030 - 4,604)	1,008	(0,746 - 1,349)	1,467	(0,842 - 2,461)
Consumption of fruits and vegetables (less than 5)	1,207	(0,804 - 1,781)	2,294	(0,892 - 5,426)	1,301	(0,918 - 1,826)	2,027	(1,137 - 3,504)
Sugar consumption (more than 2 days a week)	0,985	(0,76 - 1,276)	0,815	(0,397 - 1,623)	1,003	(0,803 - 1,252)	0,661	(0,421 - 1,024)
Tobacco consumption (current)	1,253	(0,916 - 1,709)	0,447	(0,173 - 1,058)	1,593	(1,224 - 2,074)	0,920	(0,536 - 1,556)
Tobacco consumption (former)	1,433	(1,062 - 1,933)	0,929	(0,427 - 1,957)	1,349	(1,038 - 1,752)	0,877	(0,526 - 1,448)

of salt in ready-to-eat foods constituted risk factors with OR 3.26 (95% CI: 1.13–8.91) and 2.18 (95% CI: 1.03 – 4.60), respectively. Having only primary studies decreased the chance of presenting periodontitis [OR 0.39 (95% CI: 0.16 – 0.92)]. The presence of a linear trend in the educational level was observed, where the higher the subject's level of study, the more likely they were to report periodontitis (p=0.031). It was also observed that the lower the income, the more chances of periodontitis (p=0.012).

In model 3, the factors that increased the chance of periodontitis were: male sex [OR 1.88 (95% CI:1.54-2.29)], age 45-64 years or 65 -74 years [OR 1.84 (95% CI:1.42 -2.4)] and OR 2.50 (95% CI:1.80-3.49)], respectively, and current consumption [OR 1.59 (95% CI:1.22-2.07)] or past consumption [OR 1.35 (95% CI:1.04-1.75)] of tobacco. The presence

of a linear trend in age was observed, where the older the subject, the greater the chance of periodontitis ($p<0.001$).

Finally, in model 4, the factors that increased the chance of periodontitis were: male sex [OR 2.55 (95% CI: 1.71–3.84)], age 45-64 years or 65-74 years [OR 3.70 (95% CI: 1.95-7.78)] and [OR 4.86 (95% CI:2.29-11.02)], respectively, and consuming < 5 servings of fruits and vegetables daily [OR 2.03 (95% CI: 1.14-3.50)]. Having only primary education was a protective factor [OR 0.53 (95% CI: 0.30-0.90)]. The presence of a linear trend in age was observed, where the older the age, the greater the chances of periodontitis ($p=0.007$). It was also observed that the higher the educational level, the more chances of periodontitis ($p=0.021$), and the lower the income level, the more chances of periodontitis ($p=0.039$).

Analysis of the models as a whole showed that age was associated in all models, and male sex in three of them. In models that refer to moderate to severe periodontitis ("Partial protocol, moderate-severe" and "Full mouth, moderate-severe"), smoking was also as a risk factor. It was observed that the effect of age as a risk factor was more pronounced in the full mouth model than in the partial mouth model (Table 2). In the "Partial protocol, severe" and "Full mouth, severe" models corresponding to severe disease, having university studies increased the chance of periodontitis.

DISCUSSION

The primary objective of the study was to compare two protocols for recording periodontitis[23,25] in relation to two case definitions of periodontitis (moderate-severe and severe). The four criteria used were "Full mouth, moderate-severe", "Full mouth, severe", "Partial protocol, moderate-severe" and "Partial protocol, severe". The comparisons were made in a population with a high burden of disease in terms of NCDs and periodontitis, and taking as a reference the WHO 2013 protocol. Comparison of the two examination protocols considered showed that prevalence was underestimated when the WHO 1997 protocol was used to define moderate-severe periodontitis and severe periodontitis, by 20% and 60%, respectively. The impact of the definition of a case of periodontitis and the way it is recorded have long been debated in the literature, generating diverse estimates of the prevalence of periodontitis[12–14]. This is one of the limitations of CPI[20,21], which is characterized by underestimation[18,29]. However, when Vettore et al.[3] studied two adult populations, they found that underestimation occurs when there are sites with incipient pockets, while in the case of moderate to severe pockets, the frequency of diseased sites was overestimated for both pockets and attachment loss. The current study found no other paper comparing different case definitions and different screening protocols at the same time.

All the criteria used showed that age was an associated factor. Sex was associated in all models except full mouth, moderate-severe. Other factors that showed association in some of the models were those related to behavior: current consumption of tobacco, harmful consumption of alcohol, addition of salt to ready-to-eat food, consumption of fruits and vegetables below the daily recommendation, and the socio-demographic variables education and income.

In the models that had moderate to severe periodontitis as a case definition, the present study showed that smoking was associated with periodontitis in both the WHO 2013 and 1997 protocols ("Partial protocol, moderate-severe" and "Full mouth, moderate-severe"). There is considerable evidence that tobacco use increases the likelihood of developing periodontitis[2,5,30–32]. It is important to note that in the study population, the proportion of smokers was 26.7%[33], which was similar to the figure reported at national level[26].

Considering severe periodontitis ("Full mouth, severe" and "Partial protocol, severe"), subjects with primary education only were less likely to have periodontitis. This differs substantially from previous studies in which the association occurs in the opposite direction (the higher the educational level, the lower the chance of periodontitis), both internationally[34,35] and nationally. This might be explained by the fact that in both models of severe disease, the population with only primary studies was older and had lost more teeth due to periodontitis. However, this would not be captured by the criterion used to measure periodontitis (PD and CAL) because it did not take into account the number of teeth lost and therefore of sextants excluded. This finding would confirm the difficulty of the CPI indicator in accounting for periodontitis in populations with a large proportion of older adults who are more likely to have lost teeth.

Another finding regarding the case definition of severe disease was that harmful consumption of alcohol tripled the chance of periodontitis in the "Full mouth, severe" model; a finding that is consistent with the international literature[36,37].

In the protocols that refer to severe disease, there are associations with less studied and diet-related risk factors, such as the consumption of salt ("Partial protocol, severe") and consumption of fruits and vegetables ("Full mouth, severe"). High salt intake has been linked to high blood pressure, an indicator of periodontitis risk. In the current study, high BP was not associated with increased chances of periodontitis, however, the addition of salt at the table was. A recent study on mice described how, compared to a high-salt diet, mice experienced increased low-impact inflammation related to hyperglycocorticoidism induced by high sodium intake. In turn, healthy volunteers who followed a salt-rich diet for a week experienced similar results[38]. These results could explain the associations found. On the other hand, adequate consumption of vegetables and fruits rich in bioactive compounds with antioxidant function has been associated with better periodontal health[39] and lower risk of periodontitis[8]. Fiber, another component of vegetables and fruits, has been associated with improvements in periodontitis markers when consumed in large quantities[40].

The current study sought to explore the association of periodontitis with various NCDs and their risk factors. The results show that there was no statistically significant association with obesity, diabetes or hypertension in the study population. These findings may be explained by the fact that this was a cross-sectional study. In addition to the diagnostic criterion, not having measured CAL in all teeth, and having applied the CPI criterion, which is less sensitive because it uses a probe that does not allow measurement in millimeters, could explain this result. Moreover, age is a factor that may interfere in the associations between the aforementioned NCDs, which are more prevalent in elderly people. Old age is also related to progressive tooth loss, leading to the exclusion of a greater number of sextants when the CPI criterion is applied.

One of the limitations of this study is the difficulty of not having the CAL record for all teeth, which would have allowed the objective of this study to be addressed more fully. The prevalence of periodontitis in Uruguay is 22%[4] (considering moderate to severe disease, WHO protocol 1997), whereas the value found in the study population is double. Working with a population with a high burden of pathology may have resulted in biases difficult to control that could affect the possibility of finding significant associations with the different factors.

Given that the CPI is recommended for epidemiological surveillance and easy to use[41], it is of interest to compare the cost-effectiveness of the 2013 and 1997 WHO protocols. According to the fieldwork conducted in the national survey of Uruguay and compared to the present work, an examination using the CPI 1997 indicator performed by a dentist who does not specialize in periodontics would take about 10 minutes, while an examination using the WHO 2013 would take about 15 minutes, i.e., one third longer. Further research should compare protocols with full-mouth CPI criteria to partial mouth, recording PD and CAL in all teeth for comprehensive evaluation of the new protocol's cost effectiveness and ability to show the effect of associated factors.

The WHO 1997 partial mouth protocol underestimated the prevalence of periodontitis when compared to that of WHO 2013 by 20% and 60% for the case definition of "moderate to severe" and "severe" periodontitis, respectively. This should be taken into account when studying populations with a high burden of disease.

To study periodontitis as a whole and its relationship with risk factors (considering both definitions of "moderate-severe" case), the complete mouth examination for periodontal pocket but not for CAL (WHO, 2013) does not provide more information on which factors increase the chance of periodontitis or on its magnitude. However, if the focus is on the definition that only includes severe cases, the associated factors expressed in the full mouth protocol (WHO 2013) and in the partial protocol (WHO 1997) are different. This would justify the effort to use the 2013 protocol, which is the closest to the full-mouth golden rule.

ACKNOWLEDGMENTS
This study was supported by the Sectoral Commission for Scientific Research of the University of the Republic. Professor Marcos Britto's contribution to the revision of this manuscript is appreciated.

DATA AVAILABILITY
The data that support the findings of this study are available upon request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

DECLARATION OF CONFLICTING INTERESTS
The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

FUNDING
This study was supported by the Sectoral Commission for Scientific Research of the University of the Republic.

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