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Tooth loss prevalence and risk indicators in an isolated population of Brazil

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Abstract

Objective. The aim of this study was to assess the prevalence, extent, and risk indicators of tooth loss in an isolated population of Brazil. ***Material and methods.*** Two-hundred-and-forty-two subjects, ranging in age from 14 to 82 years (mean 36.2 years), were identified by census in an isolated population of Brazil. All consenting subjects received a full-mouth clinical (DFT index and information about missing teeth) and periodontal examination of 6 sites per tooth. Furthermore, they were interviewed using a structured written questionnaire in order to gather information about demographic, environmental, and biological variables. ***Results.*** Of the 200 subjects (80% response rate), 19 (9.5%) were edentulous, 90% had lost at least one tooth, and 39% had lost more than 8 teeth. The mean number of teeth lost was 9.5 (95% CI = 8.2–10.8). First mandibular molars were the most commonly missing teeth. In a multiple logistic regression analysis based on a theoretical hierarchical model of tooth loss, having more than 8 teeth lost was strongly associated with adult age (OR = 18.3–17.3, 95% CIs = 4.8–69.7 and 4.0–75.1) and female gender (OR = 5.9, 95% CI = 1.9–18.2) in the final model. ***Conclusions.*** Tooth loss was highly prevalent and extensive in this isolated population. Demographic and behavioral factors played an important role in tooth loss prevalence in this population.

Key Words: *Dental caries, epidemiology, periodontal diseases, risk indicators, tooth loss*

Introduction

Tooth loss is the ultimate endpoint for both periodontal diseases [1] and dental caries, being a reliable measure of a population's oral health status [2,3]. It leads to: loss of masticatory function [4], restricting specific food intake such as vegetable and fibers [5]; significant phonetic changes; and loss of self-esteem due to appearance impacts. Fusion of all these aspects collapses into a significant reduction in the quality of life of these subjects, as previously reported [6–8].

Dental caries is still the main cause of tooth loss in most developing [9,10] and developed countries [11], followed by periodontal diseases. Other causes of tooth loss include orthodontic treatment, traumatic injury to the teeth, prosthetic treatment and symptomatic impacted 3rd molar. However, tooth loss as a proxy for life-time cumulative oral health experiences is a complex interaction with several other factors [3,12]. The most consistent findings addressing the issue suggest age [13,14], gender [12,14], socio-economic status [2,13], cultural values towards oral health [12], and other biological and behavioral factors as influencing tooth loss [2,13].

The prevalence and extent of tooth loss have decreased significantly in many countries during recent decades [15–18]. However, tooth loss data are in short supply in populations of Latin American countries, and this is especially true for Brazil [2].

In order to obtain convincing data on the relative role of dental diseases in causing mortality of the dentition, one must be able to identify a population that has had minimal interference from formal dental services [9], and that is representative of the general lifestyles and socio-economic conditions prevailing in the target population. A problem in

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performing studies in most populations is that there is always some form of treatment effect involved when risk assessment is studied. The effect of treatment influences the results of these studies to an extent that cannot be controlled for [19]. Therefore, the aim of the present study is to report on the patterns of tooth loss and its risk indicators in an isolated population in southeastern Brazil.

Material and methods

Study population. The study population lives in the micro-area Cajaíba, which comprises six beaches located along the southeastern coastline of Brazil between the states of Rio de Janeiro and São Paulo. People living in this micro-area make their living from subsistence inshore fishing and they are effectively isolated from the rest of the country by both an impassible mountain range and the impenetrable Juatinga ecological reserve, which is in the Cairuçu Environmental Protection Area. Owing to their isolation, consanguinity is frequent among the population. There is no piped water supply, no sewer system, no electricity, and no tradition for garbage collection in the area. Drinking water is obtained from wells or headsprings. Neither dental care nor preventive programs have ever been offered to this population, and access to dental services is limited. The tradition for oral hygiene procedures is extremely limited, that is, toothbrushes and toothpastes are rarely used.

Since no updated information was available for the population of Cajaíba, we carried out a census for the purpose of this study. A total of 358 subjects were identified by the 2006 census, 250 of whom were aged 14 years or above and therefore considered eligible for the present study. An age limit of 14 years was chosen to avoid confusing tooth loss with unerupted teeth.

The study protocol and the informed consent form were approved by the Ethics Committee of the University of São Paulo, São Paulo, Brazil. As a result of a high frequency of illiteracy, the informed consent form had to be read to all eligible individuals. All subjects who agreed to participate or, in the case of children, the adult guardian, were asked to sign the form to attest to their understanding of its contents and acceptance to participate in the study.

Since a considerable need for urgent treatment was expected, a partnership was established with the NGO "Sorriso Marinho" to provide such treatment during the study.

Data collection

Data were collected by means of an interview and a clinical examination. First, all participants were visited at home (October 2005 to November 2006) and interviewed by a trained dental assistant based on a structured written questionnaire. The interview questions were tested prior to the survey and reproducibility of the final questionnaire was assessed as described previously [20]. The data collected through the interview included information on age (years), gender, occupation, household size, presence of cash-income (yes/no) and, if applicable, its approximate monthly amount in Brazilian Reais, literacy (yes/no), length of formal education (years), experience of relief-of-pain treatment (yes/no), frequency of tooth cleaning, and smoking habits. The questions pertaining to smoking habits included duration of smoking habit for both current and former smokers (years); as well as the type and number of tobacco-containing items smoked on a daily basis for both current and former smokers. Subjects were considered smokers if they had smoked at least 100 cigarettes during their lifetime, and the tobacco-containing items used in the study population included commercial cigarettes or hand-rolled cigarettes (or corn straw hand-rolled cigarettes) and, in a few cases, Cannabis or pipes. A few of the elderly subjects were unaware of their exact age, which was therefore estimated.

Following the interview, the clinical examinations were carried out by a single trained and calibrated [20] periodontal specialist (PC) assisted by a recorder. All clinical examinations were done under field conditions in the households of the participants using natural daylight and a headlamp (Dark, Azteq, Brazil) as source of illumination. The status of each permanent tooth (3rd molars excluded) was recorded as present; missing/needing extraction; or unerupted. A tooth was considered in need of extraction when only the roots persisted following extensive decay or attempts to perform self-extraction of the affected tooth. The number of decayed and/or filled teeth was also recorded. A tooth with a visible cavity, undermined enamel, or a softened floor or wall detected by a probe (EXDSBR, Hu-Friedy, Chicago, Ill., USA) was scored as decayed [21]. Filled teeth in this study were defined as teeth with a temporary or permanent restoration.

A manual periodontal probe (PCPUNC–15, Hu-Friedy, Chicago, Ill., USA) and a mouth mirror (Mirror #5, Hu-Friedy, Chicago, Ill., USA) were used to assess the periodontal conditions at six sites per tooth of all fully erupted teeth. Measurements of pocket probing depths and gingival recession were made to the lowest whole millimeter, and periodontal attachment loss (PAL) was calculated as the sum of the probing depth and gingival recession measurements.The presence of diabetes was assessed by measurement of the casual plasma glucose concentrations (PGC) in mg/dl using the Accu-Check Active device (Roche, São Paulo, SP, Brazil). The criteria for diabetes were a casual PGC $\geq$200 mg/dl,

confirmed on the following day by the measurement of fasting PGC $\geq$126 mg/dl [22].

Detailed information about measurement reproducibility of the interview and periodontal variables has been described previously [20]. Intra-examiner reproducibility of missing teeth was assessed by double recordings in 15 subjects (7.5% of the study population), repeated 7 days after the first clinical examination. The intra-class correlation coefficient of the number of missing teeth per subject was 1.0.

Statistical analysis

Based on the clinical indications that a person can manage with 20 well distributed teeth [23], we chose to use "Having lost more than 8 teeth" (yes/no) as the outcome variable for a series of multivariable logistic regression analyses. This included both missing and needing-extraction teeth. These analyses were based on a theoretical hierarchical model of tooth loss [13] (Figure 1), according to which socio-demographic variables are entered first, followed by the behavioral and biological variables, and finally the oral disease variables, reflecting on the presumed causal path leading to tooth loss. Analyses were carried out using procedure logit in STATA (Stata v. 9.2, Stata Corporation, College Station, Tx., USA). The candidate predictor variables considered for inclusion in the logistic regression analyses included age (12–29/30–39/40+years), gender, cash-income (yes/no); illiteracy (yes/no); household size (<5/ $\geq$5 people); experience with relief-of-pain treatment in the form of extractions or temporary fillings (yes/no); diabetes (yes/no); being a current or former smoker (yes/no); presence of at least one tooth with PAL $\geq$7 mm; as well as the proportion of decayed or filled teeth (0–19%/ $\geq$20%).

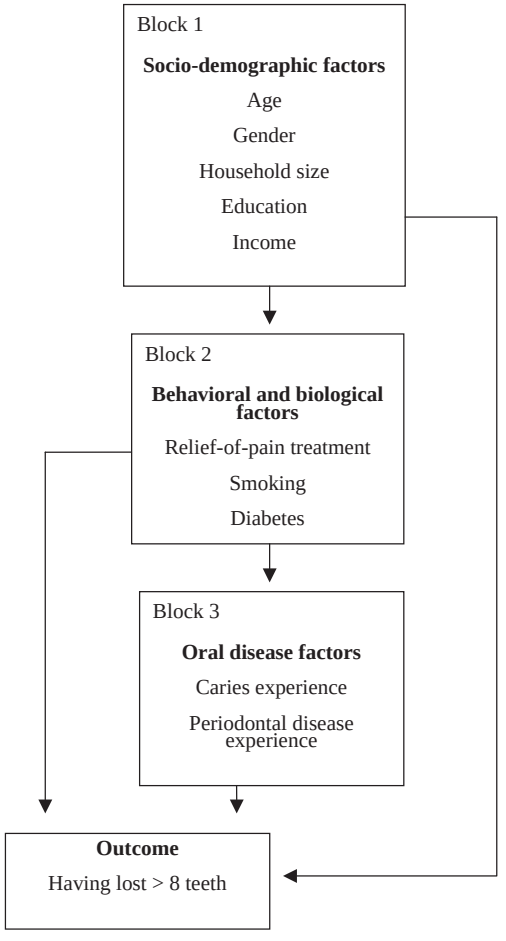

Figure 1. The hierarchical model used for the data analysis. Socio-demographic variables are entered first, followed by the behavioral and biological variables, and finally the oral disease variables.

All candidate predictor variables that were associated with the outcome at $p < 0.25$, as evidenced in a univariable logistic regression analysis [24], were included in the full models. Predictor variables were removed from the logistic model one at a time, until the log-likelihood ratio test [24] indicated that no more variables could be removed. Subsequently, all candidate predictor variables pertaining to the same block, and that were not included in the full models, were added to the resulting model and the log-likelihood ratio test was used to determine whether they would improve the model. A variable was considered a confounder if its removal from the model resulted in changes in the β estimates by more than 15%. We attempted to investigate biologically plausible interactions by adding interaction terms to the model and using the log-likelihood ratio test to determine their effect on the model. However, attempts to do so led to collinearity problems, and it was therefore not possible to check for interactions. Model fit was evaluated using the Hosmer & Lemeshow goodness-of-fit test [24] and by calculation of the area under the ROC curve, which describes the ability of the logistic model to correctly predict outcome variable status.

Results

A total of 250 subjects were eligible for examination in this survey. Of those, 200 (80%) received a clinical examination as well as an interview. Twelve subjects were interviewed but refused to be clinically examined, 10 refused both interview and clinical examination, and 28 were not present at the time of the examinations. Most non-respondents were males aged 14–29 years (Table I), and the probable reason was being at sea fishing. The final study population according to age and gender is given in Table I.

The overall prevalence of tooth loss was 90% (Table II), and 39% had lost more than 8 teeth. The mean number of teeth lost was 9.5 (95% CI = 8.2–10.8). Complete edentulism was found in 19 subjects (15 F and 4 M), all aged 40+ years. The age-dependent prevalence of tooth loss was 64.0%, 87.1%, and 95.0% for those aged 14–19, 20–29, and 30–39 years, respectively.

Table I. Distribution of the study population according to age and gender.

	Men	Women	Total	
Age (years)	*n*	*n*	*n*	% of target pop.
14–19	13	12	25	69
20–29	31	31	62	74
30–39	22	18	40	89
40–49	14	13	27	82
50+	21	25	46	88
Total	101	99	200	80

The percentage of teeth extracted or in need of extraction was markedly increased with increased age (Figure 2), especially in the 50+ age group. First mandibular molars were the teeth most frequently missing, followed by the 2nd mandibular molars, maxillary molars, and upper incisors (Figure 3).

Table III gives the frequency distribution of the candidate predictors of the outcome "Having >8 teeth missing" and the results of the univariable regression analyses of their association. The univariable logistic regression analyses suggested that age, gender, illiteracy, household size, smoking, % DFT, and having at least one tooth with PAL ≥7 mm should be included in the multiple logistic regression analysis.

The multiple logistic regression analysis showed that, with the exception of household size, all the predictors included were markedly associated with the outcome, although smoking,%DFT, and PAL ≥ 7 mm, strictly speaking, were not statistically significantly associated with "Having lost >8 teeth" among this population (Table IV).

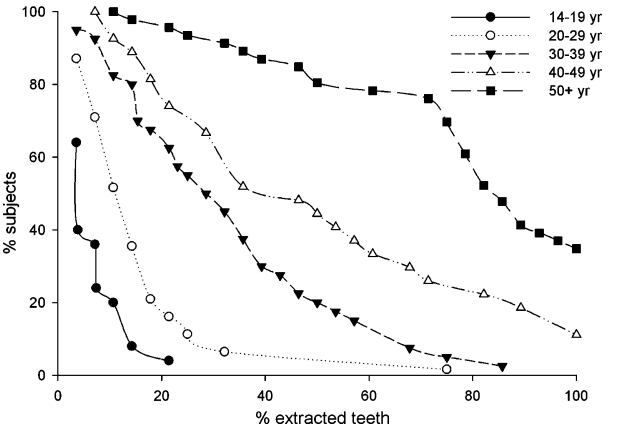

Figure 2. Cumulative frequency distribution of the proportion of teeth extracted per subject or in need of extraction, related to age. Note that the denominator used for calculating this proportion was 28 minus the number of unerupted teeth, i.e. the risk set for tooth loss.

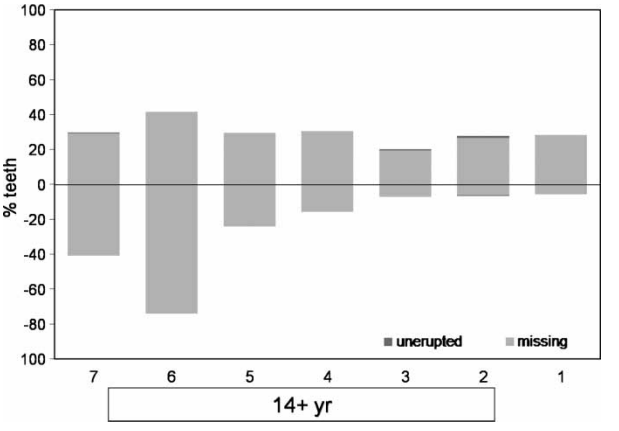

Figure 3. Percentage of missing teeth, or of teeth in need of extraction, and unerupted teeth according to tooth type. Central incisor = 1, lateral incisor = 2, canine = 3, 1st premolar = 4, 2nd premolar = 5, 1st molar = 6, 2nd molar = 7. Negative values on the *y*-axis correspond to percentages in the mandibular teeth.

Discussion

The results of this study show that the prevalence and the extent of tooth loss were quite substantial in this isolated population. Even among those aged 14–19 years, about 65% had experienced tooth loss or had teeth in need of extraction. However, a major

Table II. Prevalence and extent of tooth loss, according to age for all and dentate subjects. Extent was expressed as the mean number of teeth lost per subject. Tooth loss was defined as both missing and needing-extraction teeth. The denominator for calculating the proportion of teeth lost per subject was 28 minus the number of unerupted teeth.

	Age					
All subjects	14–19 yr	20–29 yr	30–39 yr	40–49 yr	50+ yr	All
Prevalence (%) of tooth loss	64.0	87.1	95.0	100	100	90
Mean number of teeth lost	1.4	3.3	8.4	13.0	21.4	9.5
95% CI	[0.8;2.0]	[2.4;4.1]	[6.6;10.2]	[9.6;16.3]	[19.2;23.5]	[8.2;10.8]
Total number of subjects	25	62	40	27	46	200
Dentate subjects only	14–19 yr	20–29 yr	30–39 yr	40–49 yr	50+ yr	All
Prevalence (%) of tooth loss	64.0	87.1	95.0	100	100	86.7
Mean nunber of teeth lost	1.4	3.3	8.4	11.1	17.8	7.6
95% CI	[0.8;2.0]	[2.4;4.1]	[6.6;10.2]	[8.1;14.1]	[15.3;20.3]	[6.5;8.7]
Total number of subjects	25	62	40	24	30	195

Table III. Univariate logistic regression analyses of the candidate predictors for the outcome variable "having lost >8 teeth".

Variable	Levels	*n* (%)	OR	95% CI	*p*-value
Missing teeth	0–8	122 (61.0)	–	–	–
	9–28	78 (39.0)	–	–	–
Age (years)	14–29	87 (47.2)	*1*	–	–
	30–39	40 (18.7)	17.0	[5.2;55.3]	<0.01
	40+	73 (34.1)	68.4	[21.8;213.9]	<0.01
Gender	Male	101 (51.0)	*1*	–	–
	Female	99 (49.0)	2.4	[1.4;4.4]	<0.01
Illiterate?	No	130 (66.8)	*1*	–	–
	Yes	70 (33.2)	8.1	[4.2;15.7]	<0.01
Household size	<5 people	121 (58.4)	*1*	–	–
	≥5 people	79 (41.6)	1.6	[0.9;2.8]	0.13
Do you have cash income?	No	11 (6.1)	*1*	–	–
	Yes	189 (93.9)	1.3	[0.4;4.5]	0.65
Ever received relief-of-pain dental treatment?	No	74 (39.3)	*1*	–	–
	Yes	126 (60.7)	1.1	[0.6;1.9]	0.80
Former or current smoker?	No	114 (59.8)	*1*	–	–
	Yes	86 (40.2)	3.9	[2.1;7.1]	<0.01
Casual PGC ≥200 mg/dl?	No	197 (98.6)	*1*	–	–
	Yes	3 (1.4)	3.2	[0.3;35.7]	0.35
% DFT	<20%	92 (53.3)	*1*	–	–
	≥20%	89 (46.7)	2.3	[1.2;4.3]	0.01
PAL ≥7 mm	No	125 (71.3)	*1*	–	–
	Yes	56 (28.7)	7.9	[3.9;16.2]	<0.01

*'Missing' does not include unerupted teeth.

proportion of the total tooth lost was accounted for mainly by women aged 50+years. Compared with the results observed in other isolated populations with limited access to dental care, our results suggest more extensive tooth loss among the present population. In Indonesians aged between 15 and 25 years [25], as well as in adult subjects living in remote communities of Guatemala [26], the mean number of teeth retained was approximately 27 (of 32), while in the present study group an average of 26.6 (among 14–19 year olds) and 24.7 (among 20–29 year olds) teeth were retained among the 28 teeth possible. In a representative sample of a rural area in Kenya, Manji et al. [9] found that over than 85% of those aged under 35 years had not experienced tooth loss. This was the case for only 20% of the similarly aged subjects in Cajaiba.

Even though little information is available for Brazil, the results for the 65–74 years [14] cohort examined in the 2002–2003 National Survey indicated considerable tooth loss among this old-age group, that is, almost 90% of the subjects had more than 8 missing teeth. Similarly, the data from an adult urban population of South Brazil [2] indicated a tooth loss prevalence of 94% among subjects aged 30 years or over living in Porto Alegre, and a mean number of lost teeth of 11.2. The corresponding estimates for the present isolated population would be 98% prevalence with a mean number of teeth lost of 14.8, that is, somewhat higher. In fact, Brazil still has a long way to go to achieve the year 2000 FDI global goals [27], according to which at least 75% and 50% of subjects aged 35–44 years or 65+years, respectively, should retain at least 20 teeth. It may

Table IV. Multivariate regression models for the outcome having lost more than 8 teeth (excluding unerupted teeth).

Predictors	Levels	Model 1 OR [95% CI]	Model 2 OR [95% CI]	Model 3 OR [95% CI]	Model 4 OR [95% CI]
Age (14–29 ref) (years)	30–39	21.7† [6.1;77.1]	26.1† [6.9;98.7]	18.4† [4.8;70.2]	18.3† [4.8;69.7]
	40+	56.7† [15.5;208.0]	43.7† [11.5;165.4]	17.3† [4.0;75.4]	17.3† [4.0;75.1]
Gender (Male ref)	Female	5.2† [2.2;12.5]	8.5† [3.0;23.7]	5.9† [1.9;18.2]	5.9† [1.9;18.2]
Illiterate? (No ref)	Yes	2.9* [1.1;7.3]	2.8* [1.1;7.3]	2.6 [0.9;7.4]	2.7 [1.0;7.4]
Household size (<5 ref)	≥5 people	1.3 [0.6;3.0]	1.2 [0.5;2.8]	1.0 [0.4;2.6]	–
Smoker? (No ref)	Yes		3.6* [1.3;10.0]	2.8 [0.9;8.5]	2.8 [0.9;8.4]
% DFT (<20% ref)	≥20%			2.3 [0.9;6.1]	2.3 [0.9;6.1]
PAL ≥7 mm (no ref)	Yes			2.9 [0.9;9.6]	2.9 [0.9;9.6]
Hosmer-Lemeshow Goodness-of-fit test statistic		Chi^2 =12.78 d.f. =8/p =0.12	Chi^2 =8.17 d.f. =8/p =0.42	Chi^2 =7.36 d.f. =8/p =0.50	Chi^2 =7.94 d.f. =8/p = 0.44
ROC–Area Under the Curve		0.91	0.92	0.92	0.92

* $p<0.05$, † $p<0.01$.

thus be calculated that only 56% of the 35–44 year olds and none of the 65+ year olds in the present study group fulfilled these criteria.

In isolated populations where access to dental services is limited, teeth are not extracted by dentists or dentally trained persons. Instead, dental diseases are allowed to progress to the extent that the affected teeth may be pulled using fingers only, typically as a result of periodontitis, or, to the extent that dental caries has resulted in toothache, in which case the tooth or root remnants are extracted by "craftsmen" in the local community [28]. In a few cases in the present population, teeth were also removed due to relief-of-pain treatment by the NGO dentist associated with this study. This may have occurred before a clinical examination was undertaken, which could have contributed to the actual tooth loss observed. However, these NGO extractions cannot have influenced the tooth loss observed when teeth in need of extraction are counted as if they were lost teeth. One limitation from this study was the absence of distinct evaluation and classification of the missing teeth. Hence, teeth could have been extracted by a dentist, or by local tooth-pulling craftsmen. Teeth remaining as residual roots only were included in the needing-extraction category and therefore effectively considered missing. It is possible, however, that some root remnants/root complexes may have been overlooked, since these can become completely overgrown by the alveolar mucosa. To assess this, however, we would have needed a radiographic examination, which was not possible under the present field conditions. We therefore had to rely on the accuracy of our clinical observations combined with the information provided by each subject, which could of course be biased. The strengths of this study included a high response rate and reproducibility of the interviews and a control of confounding by multivariate logistic regression analyses.

The multivariate analysis showed that higher age reflected a significant association with having lost more than 8 teeth. As expected owing to the cumulative nature of tooth loss, and in line with the results of other analytical studies [13,16,28], age was the most important risk indicator for extensive tooth loss among the candidate predictors included. Female gender was also a strong predictor of extensive tooth loss in this study. Women were approximately 6 times more likely than men to have lost more than 8 teeth, regardless of their similarities on the prevalence and extent of PAL [20], smoking habits, and on the%DFT. These results are in agreement with observations made in other Brazilian [2,14] and Latin American [12] studies, although one of the Brazilian studies [14] did not evaluate important confounders such as smoking and diabetic status. The women in this isolated population spend their day caring for children, cooking, and carrying out other domestic chores, and thereby have better access to food and hence a different dietary pattern than the men, who are away fishing offshore. Moreover, during interviews, some women reported that when rarely attending for dental treatment during pregnancy, all or most of their teeth were extracted at once in Paraty City. This may reflect that tooth loss was more a social, cultural, and behavioral-related issue than a disease-related issue in this isolated population.

However, the few subjects living in this isolated population, leading to a few subjects with the outcome included in a multivariable logistic regression model, may have not allowed identification of other important risk indicators for tooth loss in this study.

Information on the extent and patterns of tooth loss within a population is important for the planning of dental health services. Moreover, in order to have a rational basis for developing such interventions, it is important that the reasons for the loss of teeth are identified [9]. However, the causes of tooth loss were not explicitly investigated in the present study. Even so, the results of the multivariate analysis clearly indicate that both caries and periodontal disease may be significant in extensive tooth loss, defined here as the loss of more than 8 teeth. The role played by periodontitis can be underestimated, because it is plausible that some of the effect of periodontitis on tooth loss is expressed in the association between smoking and tooth loss. Similarly, it may be proposed that the increased risk of having lost more than 8 teeth associated with dental caries (%DFT) is underestimated, particularly for women, who were much more likely to have lost more than 8 teeth than were men.

As microbial deposits on the teeth are a common cause of dental caries and periodontitis, our results indicate an urgent need for dental preventive programs to be established for this isolated population, programs focusing on enhancing or developing sustainable means for daily oral hygiene procedures. In so doing, however, it is important to recognize that this should be part of programs based on a common risk factor approach to the prevention and control of the health afflictions of this population.

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