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Tooth loss and associated risk indicators in an adult urban population from south Brazil

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Abstract

The aim of the present study was to assess the prevalence, extent, and risk indicators of tooth loss in a representative adult, urban population in the Brazilian state of Rio Grande do Sul. A sample of 974 subjects (ages 30 to 103 years, mean 48.7, SD 13.4) representative of the metropolitan area of Porto Alegre, Brazil was selected by a multi-stage probability cluster sampling strategy. In all, 94% of the subjects had experienced tooth loss. The mean tooth loss was 11.2 teeth, and varied between 5.5 and 20.2 teeth in the 30–39 and 60+ years age groups, respectively. The multivariable analysis, adjusted for age, showed that subjects who had lost 7–13 or ≥14 teeth were more likely to be females (odds ratio (OR) = 1.4, 2.4), of low (OR = 2.8, 5.1) or middle socio-economic status (OR = 2.3, 3.4), and heavy smokers (OR = 2.0, 2.3) than those with 6 or fewer missing teeth. Furthermore, loss of ≥14 teeth was associated with presence of >50% teeth with attachment loss ≥5 mm (OR = 5.7), and loss of 7–13 teeth was associated with presence of >50% teeth with attachment loss ≥5 mm (OR = 2.4) and having 15–30% or >30% decayed-filled teeth (OR = 2.7 and 4.1). In conclusion, tooth loss is highly prevalent in this urban Brazilian population. Gender, socio-economic status, cigarette smoking, caries experience, and attachment loss are important risk indicators. A reduction in the population's tooth loss may be achieved by the implementation of community programs for the prevention and treatment of dental caries and periodontal diseases.

Key Words: *Dental caries, periodontal disease, smoking, socio-economic factors, tooth loss*

Introduction

Tooth loss is a reliable measure of a population's oral health status. The study of trends in tooth loss over time within populations, and comparisons of rates and trends between different populations, may provide important information about risk factors of tooth loss, potential changes in oral health status, and possible causes of these changes [1–7]. The prevalence and extent of tooth loss have decreased significantly in many countries during recent decades [1–3,5–8]. This decline may be attributed partly to the increased availability of, and accessibility to, oral diseases prevention and control programs [5,9,10] as well as an increase in the awareness of the importance of oral health in the population [11,12].

The relationship between oral health and tooth retention is complex. While dental caries and periodontal diseases are the main reasons for tooth loss [13–18], the contribution of other modifying factors such as cultural beliefs, socio-economic characteristics, and other demographic and behavioral variables seem to influence the tooth retention profile of a population [13,17–21]. This may explain why certain populations with limited access to dental care [16–18,22] may experience lower frequency of tooth loss than those in many developed countries where dental care is widely available [1–3,6,8]. In addition, it has been suggested that dental care philosophy may be another important factor influencing treatment planning, including decisions about extraction of teeth [2,23,24].

Information about the frequency of tooth loss and its risk factors in developing countries is sparse, particularly in Brazil and other Latin American countries. A study conducted in 1986 surveyed major metropolitan areas in Brazil and estimated a mean tooth loss of 12.2

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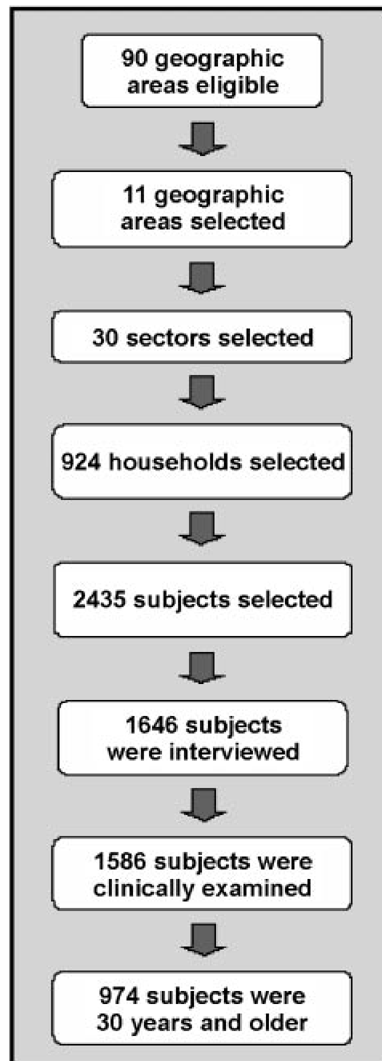

Figure 1. Sampling strategy and study sample.

and 22.5 teeth in the age groups 34–44 and 50–59 years, respectively [25]. There is no information on whether the rate of tooth loss in Brazil has changed during the past two decades.

This study was undertaken to assess the prevalence, extent, and risk indicators of tooth loss in a representative adult, urban population in the Brazilian state of Rio Grande do Sul.

Material and Methods

Study sample

A multistage probability sampling method was used to derive a sample representative of the adult urban population in the Brazilian state of Rio Grande do Sul in the southern part of Brazil. The sample consisted of 974 individuals between 30 and 103 years of age (mean 48.7, SD 13.4 years) derived from a larger sample of individuals 14 years and older living in the metropolitan area of Porto Alegre, which is the capital of Rio Grande do Sul. The group comprised 428 (43.9%) males and 546 (56.1%) females, and 802 (82.3%) whites and 172 (17.7%) non-whites. The present study covered 14 major municipalities from the Porto Alegre metropolitan area. A brief description of the study design is shown in Figure 1. A more detailed description is provided elsewhere [26]. Only consenting subjects were included in the study. Exclusion criteria were presence of diseases/conditions that might pose health risks to the participant or examiner, or that may interfere with the clinical examination. Hence, subjects were excluded if they had a history of psychiatric problems, or intoxicated with alcohol or drugs. Individuals requiring a prophylactic regimen of antibiotics were provided with the appropriate medicine before the clinical examination. The sampling unit was the household. All adults were invited to participate. The response rate in this study was 65.1%.

Examinations

Letters explaining the aims of the study with an invitation to participate in the study were sent in advance to households that had been selected. Later, one dentist visited the households and answered questions about the study and encouraged participation. Eligible subjects who consented to participation were examined clinically, and also interviewed to gather demographic, socio-economic, oral health, and other health-related data using a structured written questionnaire.

Four examiners conducted the clinical examinations in a mobile examination center. Two trained dental assistants recorded the data on prepared record sheets. Typically, the examinations were conducted between 0800 h and 2000 h from Monday through Saturday. Alternative schedules were also used in certain cases. A full-mouth clinical examination, excluding 3rd molars, was performed in 2001. For all subjects the status of each permanent tooth and the number of missing teeth were determined clinically. The number of decayed and/or filled teeth was recorded. A tooth with an unmistakable cavity, undermined enamel, a detectably softened floor or wall, or a temporary filling was scored as decayed. Filled teeth were defined as those having a permanent restoration [27].

Clinical attachment loss (CAL) was defined as the distance from the cemento-enamel junction (CEJ) to the bottom of the pocket/sulcus, and was calculated as the sum of the probing depth and gingival recession measurements. A manual periodontal probe (PCP10-SE; Hu-Friedy Mfg. Co. Inc., Chicago, Ill., USA) color-coded at 1, 2, 3, 5, 7, 8, 9, 10 mm was used. Six sites per tooth were assessed in the mesiobuccal, midbuccal, distobuccal, distolingual, midlingual, and mesiolingual sites. Measurements were made in millimeters and rounded to the lower whole millimeter.

Ethical considerations

The study protocol was approved by the Research Ethics Committee, Federal University of Rio Grande

do Sul, Porto Alegre, Brazil; the National Commission on Ethics in Research, Ministry of Health, Brasilia, Brazil; Ethics in Medical Research Committee, University of Bergen, Bergen, Norway.

Subjects who agreed to participate signed a written informed consent form. The participants were provided with a written report detailing their oral status and a recommendation about suggested treatment alternatives. Patients diagnosed with oral mucosal lesions were informed about the finding and advised to seek specialist consultation and treatment.

Non-response analysis

Subsequent to completion of the examinations, a random sample of 339 (39.9%) subjects was selected out of 849 eligible subjects who either refused to participate or were not available during the normal survey schedule. Attempts were made to contact the selected subjects by telephone in order to collect data for the non-response analysis. Of the 339 selected for interview, 50 (14.7%) subjects and their household were not available on 2 telephone call attempts, and an additional 18 (5.3%) subjects refused to be interviewed.

Non-response data were obtained for 271 (79.9%) subjects. Of these, 127 subjects were present and agreed to the telephone interview. The other 144 subjects were not available on 2 telephone call attempts, and the non-response data were therefore obtained through a 1st-degree relative living in the same household. The information collected included the subject's gender, age, education, dental care visits, and income level. In addition, information about the number of teeth present was collected for the 127 subjects who were present during the telephone interview.

In the non-respondents group, the mean age was 35.2 years; 51.3% were males and 90.8% were whites. In contrast, the mean age of the study group was 38 years; 45.3% were males and 82.5% whites. Of the non-respondent and respondent groups, respectively, 7.4% and 22.3% subjects had 4 or fewer years of education, 22.5% and 40.0% subjects had 5 to 8 years, and 70.1% and 37.8% had more than 8 years. This suggests that the non-respondents were similar to the study group in their mean age, but included somewhat higher percentages of males and whites, and had a higher number of years of education. Given the discrepancy in some of the demographic features and the level of education between the study participants and subjects that did not wish to participate, a weight variable was introduced to minimize the bias in the population parameter estimation [28], and the calculation of this variable was based on Census information provided by IBGE (Brazilian Institute of Geography and Statistics) [29].

The weight variable and data from the study sample were used in the assessment of the population's tooth loss (weighted estimate). A second estimate of the population's tooth loss was calculated using the double sampling method [30] by using tooth loss data obtained from the study sample as well as data from the non-respondents who were interviewed by telephone. The mean tooth loss was 7.6 and 6.9 teeth, and the percentages subjects with tooth loss was 76.5% and 71% using the two methods, respectively. The difference between the tooth loss estimates using the two estimation schemes was small. In this study, the reported findings are based on the weighted estimate method.

Data analysis

Prevalence of tooth loss was defined as the percentage of individuals with one or more missing teeth, and extent as the number of missing teeth per person. The prevalence and extent of tooth loss was calculated with and without inclusion of edentulous subjects [31].

Race was scored as "White" or "non-White". Family economy was assessed using a standard Brazilian economic classification (CCEB). The income variable and the level of education of the individual were strongly correlated. Hence, these two variables were combined into one variable. High socio-economic status was defined as having ≥ 9 years of education and being in the upper two tertiles of the CCEB economic classification, or having 5–8 years of education and being in the highest tertile of the CCEB classification. Low socio-economic status was defined as having 1–4 years of education, and being in the lowest two tertiles of the CCEB classification, or having 5–8 years of education and being in the lowest tertile of the CCEB classification. Individuals who had higher economic level and education than the low socio-economic group, but less than the high group were classified as having a middle socio-economic status.

Individuals who had visited a dentist on a regular basis for maintenance care were classified as receiving regular dental care. Subjects who had visited a dentist only for emergency dental treatment, or had not visited a dentist during the previous 5 years were classified as not receiving regular dental care. Most participants claimed using a toothbrush regularly at least once a day, and therefore this variable was not included in the analysis.

The exposure to cigarette smoking was calculated to reflect the total exposure of current and former smokers combined. The total number of packs of cigarettes consumed in a lifetime was calculated as the number of cigarettes consumed per day, multiplied by the number of years of habit, divided by 20 cigarettes/pack. Participants were classified into 4 groups: non-smokers, light (1–2734 packs), moderate (2735–7300 packs), and heavy smokers (>7300 packs).

The subjects were categorized according to presence and extent of clinical attachment loss (CAL) ≥ 5 mm. Moderate and severe attachment loss were defined as

subjects with CAL $\geqslant 5$ mm in 15–50% and >50% of the teeth, respectively. The reference group was subjects with CAL $\geqslant 5$ mm in <15% of the teeth. The subjects also were classified by dental status into 3 subgroups, having either >30%, 15–30%, or <15% of their teeth with dental caries and/or restorations.

Data analysis was performed using STATA software (Stata 7.0 for Windows; Stata Corporation, College Station, Tx., USA) and survey commands that take into account the survey design, including stratification, clustering, and weighting and robust variance estimation. The clusters were geographic areas and they were stratified into low or high-income according to IBGE criteria. A weight variable was used to adjust for the probability of selection and deviations in the sample distributions from the target population distribution by age, gender, and education [28,29]. Pairwise comparisons of crude estimates were carried out using the Wald test [28]. The chosen level of statistical significance was $p < 0.05$.

A multinomial logistic regression for complex survey data (procedure mlogit) [28,32] was used and the outcome variable was the extents of tooth loss. Accordingly, the subjects were grouped as having $\geqslant 14$, 7–13, or $\leqslant 6$ missing teeth, with the latter being the reference group. The threshold and grouping by outcome variable was based on the distribution of tooth loss in the population. The probability of occurrence of tooth loss was expressed as a relative risk ratio, which is equivalent to the odds ratio of the binary or dichotomous logistic regression analysis. This probability will be referred to hereafter in the text as odds ratio (OR). In each analysis, all independent variables were entered, and variables that did not contribute significantly to the model were then excluded. A total of 848 subjects contributed to the final model.

Measurement reproducibility

The examiners were calibrated at two time-points: before and 3 months following the start of the study. In addition, the examiners' reproducibility in assessing tooth loss, DMFT, and periodontal attachment loss was recorded during fieldwork. One examiner with the most clinical experience served as the "gold standard" examiner. A total of 57 subjects, divided into 4 groups ranging from 8 to 20 subjects, were used for the reproducibility assessment. In one of the groups, the replicate measurements consisted of repeated measurements by the reference examiner. In each of the remaining three groups, the replicate measurements were made by one examiner and the reference examiner. The reproducibility of measurements was assessed by the intraclass correlation coefficient [33], weighted and unweighted kappa [34]. For the gold standard examiner, the intraclass correlation coefficient of the number of missing teeth per subject was 1.0, the unweighted kappa coefficient of DMFT was 0.98, the intraclass correlation coefficient of extent of CAL $\geqslant 5$ mm was 0.97, and the weighted kappa (within ± 1 mm) at the site level was 0.87. For the other three examiners, the intraclass correlation coefficient of the number of missing teeth per subject ranged between 0.99 and 1.0, while the unweighted kappa coefficient of DMFT ranged from 0.89 to 0.98. The intraclass correlation coefficient of extent CAL $\geqslant 5$ mm ranged between 0.82 and 0.94, and the weighted kappa coefficient (within ± 1 mm) at the site level ranged between 0.65 and 0.71.

Ninety-seven subjects of the study sample were interviewed a second time by the gold standard examiner 1–4 days following the first interview. The kappa coefficient for self-reported smoking was 0.92 and for socio-economic status 0.93.

Results

In this adult population, 94.4% of the subjects had lost 1 or more teeth, and the mean tooth loss was 11.2 teeth (Table I). Tooth loss was high in all age groups (Figure 1). Subjects 30–39, 40–49, and 60+ years old had lost, on average, 5.5, 10.6, and 20.2 teeth, respectively. First molars were the teeth most frequently missing (Figure 2). Mandibular and maxillary 1st molars were missing in 80% and 46% of 30–49 years olds, and in 89% and 69% of 50+ years olds, respectively. Mandibular anterior teeth were the least frequently missing teeth.

Extent of tooth loss was significantly higher in females than in males ($p < 0.002$), in whites than non-whites ($p < 0.02$), in the low socio-economic group than the middle ($p < 0.001$) or high socio-economic groups ($p < 0.001$), and in heavy smokers than non-smokers ($p < 0.003$) (Table II).

The multivariable analysis, adjusted for age, showed that subjects who had lost 7–13 or $\geqslant 14$ teeth were more likely to be females (OR = 1.4, 2.4), of low (OR = 2.8, 5.1) or middle socio-economic status (OR = 2.3, 3.4), and heavy smokers (OR = 2.0, 2.3) than those with 6 or fewer missing teeth (Table III). Furthermore, loss of $\geqslant 14$ teeth was associated with presence of >50% teeth with attachment loss $\geqslant 5$ mm (OR = 5.7), and loss of 7–13 teeth was associated with presence of >50% teeth with attachment loss $\geqslant 5$ mm (OR = 2.4) and having 15–30% or >30% decayed-filled teeth (OR = 2.7 and 4.1) (Table IV).

Discussion

In the present survey, a relatively high frequency of tooth loss was found in this urban adult Brazilian population. Almost all subjects aged 30 years or older had lost one or more permanent teeth, and the average number of teeth lost was 11.2. The prevalence and extent of tooth loss increased sharply with increasing age. Gender, socio-economic status, and cigarette smoking were significantly associated with tooth loss

Table I. Percentage of subjects and mean tooth loss in adults, by age group

	Age (years)	Dentulous and edentulous			Dentulous subjects only		
		n	Estimate	SE*	*n*	Estimate	SE
% subjects with tooth loss	30–39	297	88.8	1.4	295	88.7	1.3
	40–49	260	95.3	1.4	254	95.2	1.4
	50–59	200	98.5	0.5	175	98.2	0.6
	60+	217	100.0	0.0	129	100.0	0.0
Total		974	94.4	0.9	853	93.7	0.9
Mean number of missing teeth	30–39	297	5.5	0.5	295	5.4	0.5
	40–49	260	10.6	0.8	254	10.2	0.8
	50–59	200	14.2	0.8	175	12.1	0.7
	60+	217	20.2	0.6	129	15.0	0.4
Total		974	11.2	0.7	853	9.2	0.5

* SE = Standard error.

irrespective of age. High caries experience was associated with more localized tooth loss (7–13 missing teeth), whereas extensive attachment loss ⩾5 mm was associated with generalized (⩾14 missing teeth), and to a lesser extent with localized tooth loss.

A survey conducted in 1986 in urban populations in 3 states in south Brazil with somewhat comparable demographics to the present study population estimated that the mean tooth loss was 12.2 and 22.5 teeth in the age groups 34–44 and 50–59 years, respectively [25]. The corresponding figures in the present study were 7.4 and 14.2 teeth. The lower mean tooth loss in the present study compared to the 1986 survey may partly be attributed to differences in study design and population characteristics between the two studies [25]. In addition, it has been shown that the urban population in southern Brazil has had a significant decline in caries experience during the past two decades [35], and this may have contributed to a decline in mean tooth loss between 1986 and 2001.

A recent national survey of the United States population estimated the mean tooth loss in subjects aged 30–34 and 60–64 years was 2.6 and 13.2 teeth, respectively [8]. A national survey of the United Kingdom population found 6.6 and 9.5 missing teeth among 35–44 and 45–54 year olds, respectively [6]. In comparison, the mean tooth loss in the present study was 4.7 and 18.1 teeth in the age groups 30–34 and 60–64 years, and 7.4 and 13.0 teeth in the age groups 35–44 and 45–54 years, respectively, which is higher than that of the US and UK populations. Comparisons with other studies show that the tooth

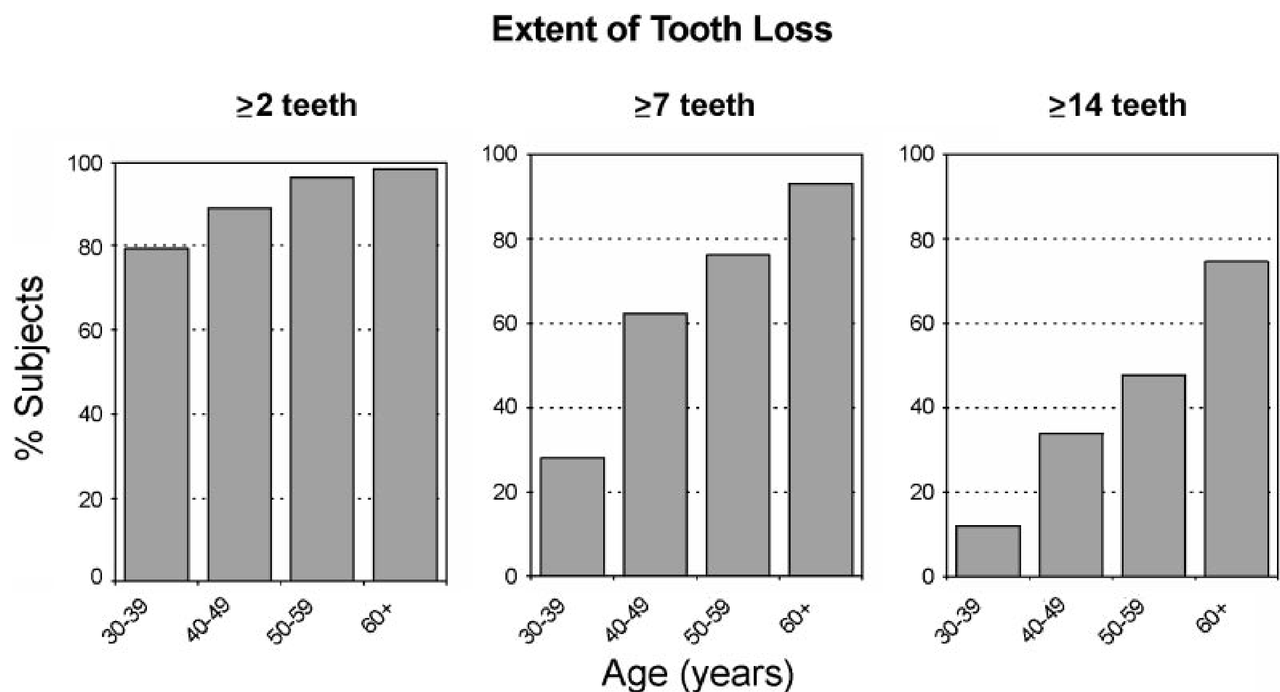

Figure 2. Percentage of subjects, by extent of tooth loss and age.

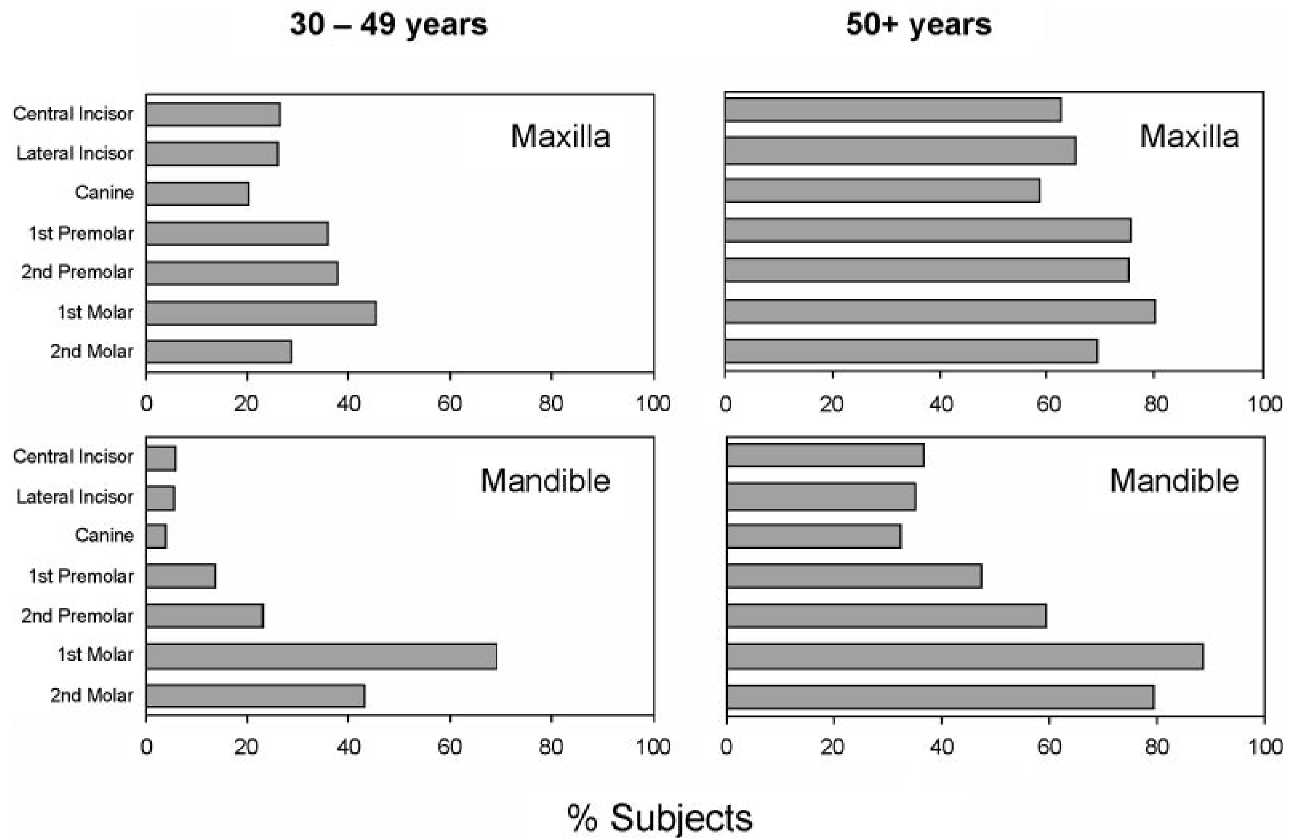

Figure 3. Prevalence of tooth loss by tooth type and jaw.

loss in the present study also is significantly higher than that reported for the populations of Sweden [5], China [16,36], and Kenya [18].

In 1982 the FDI recommended global goals for the year 2000 for the desirable number of remaining teeth in populations [37]. According to these goals, 75% or more of individuals aged 35–44 years, and more than 50% of individuals 65 years and older should have $\geqslant$20 teeth present. In the present population, 69.5% of 35–44 year olds, and 8.5% of 65+ year olds had $\geqslant$20 remaining teeth. This suggests that, for this Brazilian population, the FDI goals have not been reached. Notably, the difference between the number of teeth present in this population and the FDI goals is much

Table II. Percentage of subjects with tooth loss and mean tooth loss (dentulous and edentulous), by demographic, socio-economic, and behavioral characteristics

		Subjects			Mean tooth loss		
	n	%	SE*	*p*	Mean	SE	*p*
Gender							
Male	428	93.5	1.5		9.7	0.5	
Female	546	95.1	0.7	0.33	12.4	0.9	0.002
Race							
White	802	94.5	0.8		11.7	0.8	
Non-white	172	93.7	1.9	0.67	8.8	0.7	0.02
Socio-economic status							
Low	441	96.1	1.1		13.9	0.8	
Middle	252	95.9	1.0	0.86	10.4	1.1	0.001
High	281	90.1	0.9	0.002	7.3	0.7	0.0001
Smoking							
Non-smokers	472	91.2	1.9		10.5	1.0	
Light	170	96.2	1.5	0.04	10.9	1.2	0.68
Moderate	159	97.4	1.4	0.07	10.7	0.9	0.86
Heavy	173	98.5	0.6	0.0006	13.8	0.9	0.003

* SE = Standard error.

Table III. Multivariable analysis (multinomial logistic regression) of the association of tooth loss with demographic, socio-economic, and behavioral variables in dentate subjects. Estimates are adjusted for age

		No. of missing teeth†					
		7–13			⩾14		
Risk indicators	Group	OR	95%	CI	OR	95%	CI
Gender	Male	1.0			1.0		
	Female	1.4†	1.1	1.6	2.4†	1.4	4.3
Socio-economic level	High	1.0			1.0		
	Middle	2.3†	1.4	3.7	3.4†	1.4	8.1
	Low	2.8†	1.9	4.1	5.1†	2.5	10.5
Smoking status	Non-smokers	1.0			1.0		
	Light	1.5	1.0	2.3	1.3	0.5	3.3
	Moderate	0.9	0.5	1.8	1.1	0.5	2.4
	Heavy	2.0*	1.1	3.6	2.3†	1.3	4.1

Reference group: subjects with ⩽6 missing teeth.
* $p<0.05$; † $p<0.01$.

smaller for the 35–44 years than the 65+ years groups. It remains to be seen whether in the future the gap from the FDI goals for the older age groups will diminish.

In this study, females had a significantly higher mean number of missing teeth than males, and higher likelihood of having ⩾15 missing teeth than males after adjusting for other covariates. This is consistent with the findings of several other studies showing higher tooth loss in females than in males [2,3,6,16,18,22, 36,38]. In contrast, in the US population tooth loss was similar in the 2 gender groups [8]. Warren et al. [15] also did not find a significant difference in the incidence of tooth loss between males and females after 15 years of follow-up in a group of elderly Iowans. Furthermore, a few recent studies have shown a higher mean tooth loss and a tendency towards a higher prevalence of edentulism in males than in females in Finland [2] and Sweden [5].

The race variable is an important confounder of caries experience and periodontal diseases and has a strong association with socio-economic status and pattern of dental visits [39]. A survey of the US population found that tooth loss was significantly higher in African-Americans than in whites [8]. In our population, whites showed higher tooth loss than non-whites in univariable analysis, but did not have a significant effect in the multivariable analysis. This suggests that the multivariable model adequately adjusted for the effect of race in the analysis.

Socio-economic status was significantly associated with tooth loss after adjusting for age, gender, and smoking status (Table III). Significant association between tooth loss and economic status has been reported in other studies [3,20]. A telephone survey in north Florida showed that individuals with low economic status were more likely to be edentulous [23]. However, higher risk was not confirmed in a 24 months' follow-up in a selected subsample [13]. An association between tooth loss and poor economy was also shown in a Chinese population [36]. Moreover, education has been associated with tooth loss [2,3,14,36,40], and it has been shown that educational level is significantly associated with the type of decision regarding tooth extraction [41]. Subjects with higher level of education and better economy are more likely to afford check-ups and conservative dental treatment and to retain their teeth.

Table IV. Multivariable analysis (multinomial logistic regression) of the association of caries experience and periodontal attachment loss with the occurrence of tooth loss in dentate adults. Estimates are adjusted for age, gender, socio-economic status, and cigarette smoking behavior

		No. of missing teeth†					
		7–13			⩾14		
Risk indicators	Group	OR	95%	CI	OR	95%	CI
% decayed-filled teeth	<15%	1.0			1.0		
	15% – 30%	2.7*	1.1	7.0	0.8	0.3	2.6
	>30%	4.1†	1.7	10.0	1.3	0.7	2.3
% teeth with attachment loss ⩾5 mm	0–15%	1.0			1.0		
	>15% – 50%	1.4	0.9	2.1	1.3	0.7	2.6
	>50%	2.4†	1.4	4.1	5.7†	2.8	11.6

Reference group: subjects with ⩽6 missing teeth.
* $p<0.05$; † $p<0.01$.

In the present multivariable model, presence of decayed-filled teeth and periodontal attachment loss were significantly associated with higher likelihood of tooth loss. Periodontal attachment loss was significantly associated with a generalized tooth loss (⩾14 missing teeth), whereas presence of decayed-filled teeth was significantly associated only with a more localized tooth loss (7–13 missing teeth). It merits noting here that using cross-sectional data to study the relationship of tooth loss with dental caries and attachment loss is challenging because a high number of teeth lost previously due to these two diseases may weaken the association. Hence, one may expect a higher association between tooth loss and the two diseases in younger subjects and in those with limited tooth loss.

Consistent with findings of other studies [2,3,20,36,42] we found a strong association between tooth loss and smoking. However, this association decreased considerably when attachment loss was included as a covariate in the multivariable model. This may be attributed to the high correlation between attachment loss and smoking [43].

The validity and the accuracy of results of surveys are influenced by the accuracy of the sampling frame, magnitude of bias due to non-response, and the precision of measurements. The sampling strategy adopted for the present study did not include sampling the homeless or the institutionalized. It is unlikely that these exclusions have seriously biased the estimates of tooth loss since these subjects constitute a relatively small proportion of the target population. The measurement precision was demonstrated by high measurement reproducibility.

Although this population had a high level of tooth loss, it is likely that the younger age groups may reach the FDI goals for the year 2000 in the near future, particularly if more emphasis is placed on oral diseases prevention. In this adult urban population, females, low socio-economic status groups, and smokers are high-risk groups for tooth loss. Subjects with several decayed-filled teeth were associated with localized tooth loss, and those with extensive attachment loss were associated with generalized tooth loss. Community-based oral diseases prevention programs should be implemented to reduce the risk for tooth loss in this and similar populations.

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References

[1] Brown LJ. Trends in tooth loss among U.S. employed adults from 1971 to 1985. J Am Dent Assoc 1994;125:533–40.

[2] Suominen-Taipale AL, Alanen P, Helenius H, Nordblad A, Uutela A. Edentulism among Finnish adults of working age, 1978–1997. Community Dent Oral Epidemiol 1999;27: 353–65.

[3] Osterberg T, Carlsson GE, Sundh W, Fyhrlund A. Prognosis of and factors associated with dental status in the adult Swedish population, 1975–1989. Community Dent Oral Epidemiol 1995;23:232–6.

[4] Ainamo J. Changes in the frequency of edentulousness and use of removable dentures in the adult population of Finland, 1970–80. Community Dent Oral Epidemiol 1983;11:122–6.

[5] Hugoson A, Koch G, Bergendal T, Hallonsten AL, Slotte C, Thorstensson B, et al. Oral health of individuals aged 3–80 years in Jonkoping, Sweden in 1973, 1983, and 1993. II. Review of clinical and radiographic findings. Swed Dent J 1995;19:243–60.

[6] Downer MC. The improving dental health of United Kingdom adults and prospects for the future. Br Dent J 1991;170:154–8.

[7] Hiidenkari T, Parvinen T, Helenius H. Edentulousness and its rehabilitation over a 10-year period in a Finnish urban area. Community Dent Oral Epidemiol 1997;25:367–70.

[8] Marcus SE, Drury TF, Brown LJ, Zion GR. Tooth retention and tooth loss in the permanent dentition of adults: United States, 1988–1991. J Dent Res 1996;75:684–95.

[9] Ahlqwist M, Bengtsson C, Grondahl HG, Halling A. Tooth mortality in women in a 12-year follow-up of a population sample in Gothenburg, Sweden. Community Dent Oral Epidemiol 1986;14:358–61.

[10] Clarkson JJ, McLoughlin J. Role of fluoride in oral health promotion. Int Dent J 2000;50:119–28.

[11] Haugejorden O, Klock KS. Expectation of retaining natural teeth for a lifetime and its predictors among Norwegian adults. Community Dent Health 2002;19:73–8.

[12] Loe H. Oral hygiene in the prevention of caries and periodontal disease. Int Dent J 2000;50:129–39.

[13] Gilbert GH, Miller MK, Duncan RP, Ringelberg ML, Dolan TA, Foerster U. Tooth-specific and person-level predictors of 24-month tooth loss among older adults. Community Dent Oral Epidemiol 1999;27:372–85.

[14] Burt BA, Ismail AI, Morrison EC, Beltran ED. Risk factors for tooth loss over a 28-year period. J Dent Res 1990;69:1126–30.

[15] Warren JJ, Watkins CA, Cowen HJ, Hand JS, Levy SM, Kuthy RA. Tooth loss in the very old: 13–15-year incidence among elderly Iowans. Community Dent Oral Epidemiol 2002;30: 29–37.

[16] Luan WM, Baelum V, Chen X, Fejerskov O. Tooth mortality and prosthetic treatment patterns in urban and rural Chinese aged 20–80 years. Community Dent Oral Epidemiol 1989; 17:221–6.

[17] Baelum V, Fejerskov O. Tooth loss as related to dental caries and periodontal breakdown in adult Tanzanians. Community Dent Oral Epidemiol 1986;14:353–7.

[18] Manji F, Baelum V, Fejerskov O. Tooth mortality in an adult rural population in Kenya. J Dent Res 1988;67:496–500.

[19] Ahlqwist M, Bengtsson C, Grondahl HG, Lapidus L. Social factors and tooth loss in a 12-year follow-up study of women in Gothenburg, Sweden. Community Dent Oral Epidemiol 1991;19:141–6.

[20] Gilbert GH, Duncan RP, Crandall LA, Heft MW, Ringelberg ML. Attitudinal and behavioral characteristics of older Floridians with tooth loss. Community Dent Oral Epidemiol 1993;21:384–9.

[21] Klock KS, Haugejorden O. An analysis of primary and contributing reasons for extraction of permanent teeth given by the dentist. Acta Odontol Scand 1993;51:371–8.

[22] Ekanayaka A. Tooth mortality in plantation workers and residents in Sri Lanka. Community Dent Oral Epidemiol 1984; 12:128–35.

[23] Dolan TA, Gilbert GH, Duncan RP, Foerster U. Risk indicators of edentulism, partial tooth loss and prosthetic status

among black and white middle-aged and older adults. Community Dent Oral Epidemiol 2001;29:329–40.
[24] Nuttall NM, Nugent ZJ. Indicators of dental extractions and full mouth clearances: a longitudinal analysis. Community Dent Oral Epidemiol 1997;25:181–3.
[25] Ministério da Saúde. Levantamento epidemiológico em saúde bucal: Brasil, zona urbana, 1986: Ministério da Saúde; 1988.
[26] Susin C, Dalla Vecchia CF, Oppermann RV, Haugejorden O, Albandar JM. Periodontal attachment loss in an urban population of Brazilian adults, and the effect of demographic, behavioral and environmental risk indicators. J Periodontol 2004;75:1033–41.
[27] WHO. Oral health surveys – basic methods, 4th edn. Geneva: World Health Organization; 1997.
[28] Korn E, Graubard B. Analysis of health surveys. New York: John Wiley & Sons, Inc; 1999.
[29] Brazilian Institute of Geography and Statistics. Population Census (in Portuguese). Rio de Janeiro: Brazilian Institute of Geography and Statistics; 1996.
[30] Levy P, Lemeshow S. Sampling of populations. Methods and applications, 3rd edn. New York: John Wiley & Sons, Inc; 1999. p. 70–9.
[31] Owall B. Prosthetic epidemiology. Int Dent J 1986;36:230–4.
[32] Hosmer D, Lemeshow S. Applied logistic regression, 2nd edn. New York: John Wiley & Sons; 2000: 260–87.
[33] Shrout P, Fleiss J. Intraclass correlations: uses in assessing rater reliability. Psychol Bull 1979;86:420–8.
[34] Hubert L. Kappa revisited. Psychol Bull 1977;84:289–97.
[35] Maltz M, Schoenardie AB, Carvalho JC. Dental caries and gingivitis in schoolchildren from the municipality of Porto Alegre, Brazil in 1975 and 1996. Clin Oral Invest 2001;5:199–204.
[36] Lin HC, Corbet EF, Lo ECM, Zhang HG. Tooth loss, occluding pairs, and prosthetic status of Chinese adults. J Dent Res 2001;80:1491–5.
[37] Fédération Dentaire Internationale. Global goals for oral health in the year 2000. Int Dent J 1982;32:74–7.
[38] Central Bureau of Statistics. Statistical Yearbook 1998. Oslo: Central Bureau of Statistics; 1998.
[39] Albandar JM. Global risk factors and risk indicators for periodontal diseases. Periodontol 2000. 2002;29:177–206.
[40] Haugejorden O, Klock KS, Trovik TA. Incidence and predictors of self-reported tooth loss in a representative sample of Norwegian adults. Community Dent Oral Epidemiol 2003; 31:261–8.
[41] Klock KS. Patients' perceptions of the decision-making process leading to extraction of permanent teeth in Norway. Community Dent Oral Epidemiol 1995;23:165–9.
[42] Xie Q, Ainamo A. Association of edentulousness with systemic factors in elderly people living at home. Community Dent Oral Epidemiol 1999;27:202–9.
[43] Gelskey SC. Cigarette smoking and periodontitis: methodology to assess the strength of evidence in support of a causal association. Community Dent Oral Epidemiol 1999;27:16–24.