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Tooth loss and associated factors in adolescents: a Brazilian population-based oral health survey

ABSTRACT

OBJECTIVE: To estimate tooth loss among adolescents and its factors associated.

METHODS: Data from 16,833 participants of the Brazilian Oral Health Survey 2002-2003 were analyzed. The outcome studied was tooth loss of at least one tooth. Independent variables included geographical localization, gender, skin color, per capita income, education gap, dental service utilization and fluoridated water supply at the local level. Crude and adjusted prevalence ratios were estimated using Poisson regression for each Brazilian macroregion and nationwide.

RESULTS: The prevalence of at least one tooth loss was 38.9% (95% CI 38.2%;39.7%). Adolescents living in localities with non-fluoridated water supply were 40% more likely to have tooth loss compared with those living in areas with fluoridated water supply. There was seen a strong association ($p<0.01$) between non-fluoridated water supply and tooth loss prevalence in the Northeast. In other Brazilian regions this association was confounded for distal variables, mainly socioeconomic variables, reinforcing regional inequalities.

CONCLUSIONS: High prevalence of tooth loss among Brazilian adolescents shows a need for targeted dental actions including prevention at earlier ages, treatment of affected teeth and universal access to fluoridated water.

DESCRIPTORS: Adolescent. Tooth Loss, epidemiology. Risk Factors. Socioeconomic Factors. Dental Health Surveys. Oral Health. Health Inequalities.

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INTRODUCTION

The Brazilian Ministry of Health published in 2004 the findings of the largest epidemiological oral health survey conducted in Brazil – the Brazilian Oral Health Survey.[a] This study showed that among adolescents aged 15–19, the prevalence of dental caries experience was 88.9% and mean DMFT index was 6.2. The DMFT index expresses the number of permanent decayed teeth by the sum of decayed (D component), missing due to caries (M component) and filled teeth (F component). In the adolescents studied, mean M component was 0.9 or 14.4% of the index. In a national epidemiological survey carried out by

[a] Brazilian Ministry of Health. Health Department. Office of Primary Care. Projeto SB Brasil 2003: condições de saúde bucal da população brasileira 2002-2003: resultados principais. Brasília; 2004.

the Ministry of Health in 1986, mean DMFT index was 12.7 and M component was 1.9 or 15.2%.[a] Despite nearly 50% reduction of mean dental caries index over a period of almost 20 years, the proportion of the M component has remained stable.

In addition to biological factors, socioeconomic conditions may affect tooth loss. In more industrialized countries, dental injuries are more prevalent among economically underprivileged people due to limited access to protective sports equipament.[18] Other factors causing tooth loss are orthodontic extractions.

A Medline search conducted for the period 1966–2006 using the key words "tooth loss" and "adolescent" found only two studies focusing exclusively on tooth loss among Brazilian adolescents and young adults.[8,17] Both studies focused on tooth loss but they did not include a representative population of all Brazilian regions. The first study investigated tooth loss in adolescents in Belo Horizonte, southeastern Brazil, in 1980s.[8] The second one, carried out in 2006, investigated tooth loss in adolescents and young adults in Porto Alegre, southern Brazil.[17] The scarcity of studies in adolescents supports further studies that will prioritize a focus on regional differences.

The objective of the present study was to estimate the prevalence of tooth loss among Brazilian adolescents aged 15 to 19 and to describe factors associated.

METHODS

Study based on secondary data obtained from the Brazilian Oral Health Survey 2003, which investigated 108,921 subjects aged 18 months to 74 full years between May 2002 and October 2003. For the present study, a database was created based on this survey data available at the Brazilian Ministry of Health website.[b]

Probability sampling was carried out through drawing a cluster sample in 250 cities of different population sizes in all Brazilian federation units.

Data collection involved experienced trainers in epidemiological oral health surveys who calibrated and trained nearly 900 dentists and 1,200 recorders following diagnostic criteria of the World Health Organization (WHO) *Oral health surveys: basic methods*,[19] 1997 – 4th edition.

In the age group 15 to 19, it was estimated a sample of 19,910 subjects to undergo an interview and examination.

A total of 16,833 male and female subjects aged 15 to 19 years were examined. Oral examinations were performed at the participants' households under natural light using the WHO community periodontal index **(**CPI**)** ballpoint probe, a flat mirror and wooden tongue spatulas. There were collected information on dental crown and periodontal conditions, occlusal disorders, dental fluorosis and need of dental prosthesis. Information about socioeconomic condition, utilization of dental services, self-perception and self-assessment of oral health were also collected during an interview using a pre-tested questionnaire.

The dependent variable was tooth loss, obtained by adding up codes 4 (tooth loss due to dental caries experience) and 5 (tooth loss due to other causes) for crown diagnosis of every 32 dental spaces examined per subject. The resulting variable was then dichotomized into presence or absence of tooth loss.

The following variables were categorized in accordance to the Brazilian Oral Health Survey: geographical localization; gender; skin color; age; and local fluoridated water supply for at least a five-year period.

Family income, originally a continuous numerical variable, was converted into *per capita* income by dividing it by the number of persons living in the household. It was then categorized into quintiles as follows: more than R$ 200.00; R$ 100.00 to R$ 199.99; R$ 66.68 to R$ 99.99; R$ 34.30 to R$ 66.67; and less than R$ 34.29. During the study period (2002–2003), the American dollar rate to the Brazilian real ranged between R$ 2.37 (lowest) to R$ 3.87 (highest).

Education gap (years of schooling by age) is a variable incorporated by the United Nations Development Program based on the estimated human development index in Brazil.[c] For comparison analysis, education gap was used to identify adolescents with at least one-year gap compared to that expected for the age (11 years of schooling for adolescents aged 18 and 19; 10 years for those aged 17; 9 years for those aged 16; and 8 years for those aged 15). This contingent included adolescents that, for any reason, dropped out before completing middle school.

The variable type of dental service was categorized into private, contracted, and public. Other categories such as other types of services and charitable care accounted for less than 2.4% of the all types and thus were excluded from the analysis.

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[a] Brazilian Ministry of Health. National Department of Special Health Care Programs. National Office of Oral Health. Levantamento epidemiológico em saúde bucal: Brasil, zona urbana, 1986. Brasília; 1988.
[b] Brazilian Ministry of Health. Health Department. Office of Primary Care. Projeto SB Brasil 2003: Condições de saúde bucal da população brasileira 2002-2003: database [internet]. [cited 2006 Mar 3]. Available from: http://dtr2004.saude.gov.br/dab/saudebucal/banco_dados.php
[c] United Nations Development Program. Institute of Applied Economic Research. Report of human development in Brazil. Brasília: Fundação João Pinheiro; 2003.

The study variables were grouped into blocks constructing a theoretical hierarchical model for determination of tooth loss (Figure 1). In this model, the geographical localization of subjects' residence was located at the distal position to the outcome because it was regarded as a determinant of the other groupings. It is assumed that those living in rural areas would probably have lower schooling and income compared to those living in urban areas. Similarly, health services are less available and of more difficult access in rural areas. It should be noted that fluoridated water supply is largely available only in urban centers, which may indicate that water fluoridation is a benefit out of reach of those living in rural areas. Univariate analyses were first performed for each independent variable showing tooth loss by the number and proportion of subjects. Then to estimate unadjusted and adjusted prevalence ratios and their related 95% confidence intervals and p-value (Wald test), Poisson regression was used. To identify regional differences, in addition to the analysis of the entire sample, stratified analyses were conducted for each Brazilian macroregion.

Statistical analysis followed the theoretical hierarchical model for determination of tooth loss. Prevalence ratios for geographical localization (block 1) were first estimated. Then socioeconomic and demographic variables (block 2) were adjusted for themselves and for geographical localization (block 1). Variables related to the utilization of dental services and fluoridated water supply (block 3) were then adjusted for themselves and for upper level variables (blocks 1 and 2). Those variables with $p>0.25$ in the unadjusted analysis were excluded from the multivariable model. Likewise, those variables with $p>0.25$ in the adjusted model were excluded from the analysis of the next blocks.

All analyses were performed using Stata 9.0 (College Station, United States) and *svy* commands for the analysis of data from complex samples.

The Brazilian Oral Health Survey 2003 was approved by the National Research Ethics Committee (CONEP) on July 21, 2000.

RESULTS

The response rate achieved 84.5%, corresponding to 16,833 adolescents. A total of 16,178 teeth were lost, a mean of 0.961 (95% CI: 0.957; 0.963) teeth lost per subject. Of all teeth lost, 14,999 (92.71%) were due to dental caries experience.

It was found 38.9% prevalence of tooth loss (95% CI 38.2%; 39.7%). Considering tooth loss due to code 5 (causes other than dental caries experience), the highest rates were seen in the South and Southeast region, accounting for 63.6% of all these losses nationwide. In regard to demographic and socioeconomic variables, tooth loss due to other causes was more prevalent in adolescents of white skin color (60% of all) with higher per capita monthly income (35.1%) and no education gap (58.6%). As for utilization of dental services, this loss occurred mostly in private service users (45.1%) and those living in cities with fluoridated water supply (67.7%). Given the proportion of teeth lost due to caries experience (code 4) was nearly 93%, all the remaining results are presented considering the sum of codes 4 and 5.

The frequency distribution of tooth loss is skewed: few subjects had a large number of losses; while 61.1% of the sample did not have any loss, nearly 35% had up to four teeth lost.

Figure 2 shows the proportions of tooth loss by tooth group. Proportional values are given to each tooth group based on the usual notation. The first molars were the most commonly missing teeth accounting for more than 55% (95% CI: 54.0%; 56.0%) of all teeth lost; and of these, lower molars (36 and 46) accounted for nearly 41% (95% CI: 39.8%; 42.2%).

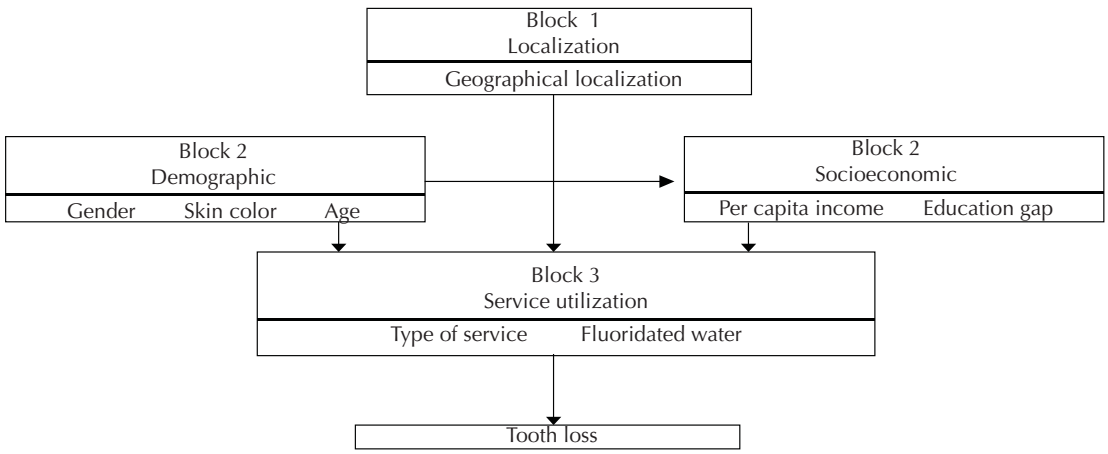
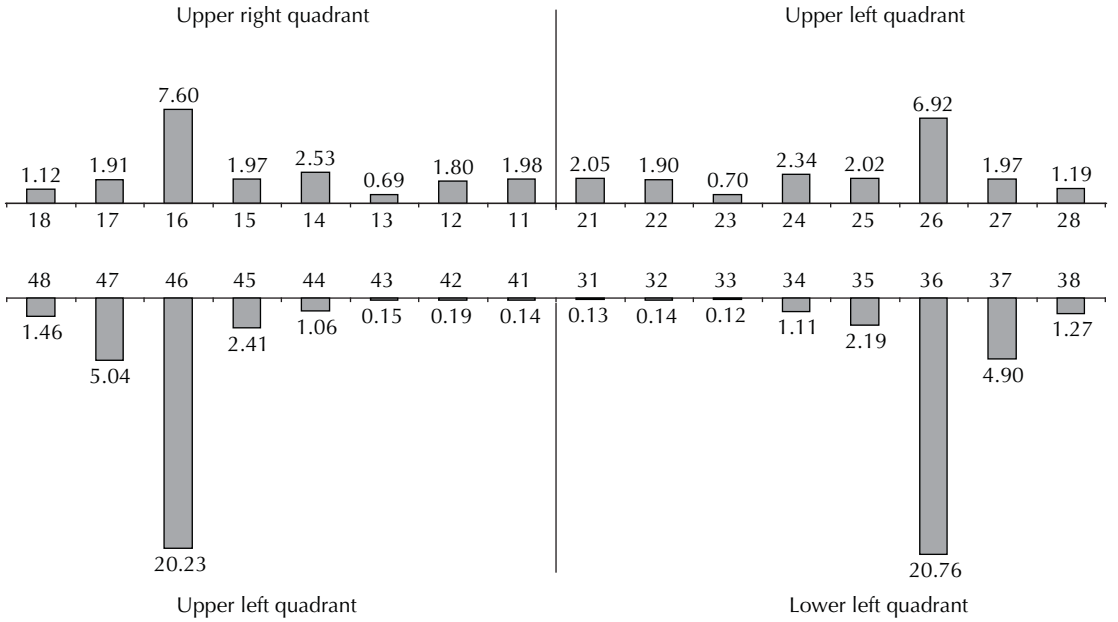


Figure 1. Hierarchical model for data analysis.



Source: Brazilian Ministry of Health, Oral Health Survey 2003

Figure 2. Proportion of each tooth lost to the total loss in Brazilian adolescents. Brazil, 2003 (n= 16,178)

Table 1 shows the number and proportion of subjects with tooth loss and the corresponding total for each variable studied. Based on the values defined for each category of independent variables, the poorest results were seen among those living in rural areas; female adolescents; mixed skin color; 19 years of age; per capita income between R$ 34.30 and R$ 66.67; adolescents with education gap; utilization of public dental service; and living in cities with no fluoridated water supply.

Of the variables studied, only the category 19 years old (for the variable age) had a median of one for tooth loss. All others had a median of zero (data not shown).

Table 2 illustrates unadjusted and adjusted prevalence ratios of tooth loss for the variables studied based on the hierarchical model (Figure 1) considering the entire sample. After adjusting for variables of the same block and of higher blocks, they all remained statistically significant. In regard to fluoridated water supply, after controlling for potential confounders, tooth loss was 40% higher in adolescents living in areas with no water fluoridation compared to those living in areas with fluoridated water supply.

The results of the analyses in Brazilian macroregions are displayed in Tables 3 and 4. Gender and age were associated to tooth loss in all regions. Geographical localization was not associated to tooth loss in the Central-West and Northeast regions. A similar effect was seen in the South and North regions for skin color, which lost its effect after adjusting for in the Southeast region. Per capita income was associated to tooth loss in all regions but the Central-West. After adjusting, education gap remained associated to tooth loss, except in the South and North regions. Type of dental service was only associated to the outcome in the Central-West region, where the categories public and contracted service apparently had a protective effect.

In contrast with the results found nationwide, availability of fluoridated water supply only remained associated to tooth loss in the South (borderline statistical significance) and Northeast regions. After adjusting, Northeast adolescents living in cities with no fluoridated water supply available had a prevalence of tooth loss 63% greater than that seen in those living in cities with water fluoridation.

DISCUSSION

The prevalence of tooth loss among Brazilian adolescents (38.9%) is high compared to that found in the 1986 survey (after almost a 20-year period) and in international studies.

Data available from WHO[a] show that, in 1999, in Japanese adolescents aged 15 to 19, the M component accounted for 0.6% of total DMFT index (7.1). In Australia, during 1987–1988, tooth loss due to dental caries experience accounted for nearly 7% of the DMFT index (4.3) in this same age group. Tooth loss among Brazilians is still very high (14.4%).

[a] World Health Organization. WHO Oral Health Country. Area Profile Program. Caries for 12-year-olds by country/area [internet]. [cited 2008 Nov 8]. Available from: http://www.whocollab.od.mah.se/countriesalphab.html

Table 1. Univariate analysis of the association between tooth loss and geographical, socioeconomic, and demographic variables, fluoridated water supply and type of dental services in Brazilian adolescents. Brazil, 2003 (n= 16,833)

Variable	Subjects L≥1*		Total n
	n	%	
Geographical localization			
Urban	5533	38.0	14569
Rural	1014	45.2	2244
Sex			
Male	2492	35.5	7015
Female	4061	41.4	9818
Skin color			
Asian	209	41.7	501
White	2376	33.6	7071
Lighter-skinned black	3250	44.1	7369
Dark-skinned black	630	37.4	1686
Indigenous	72	42.6	169
Age (years)			
15	1393	29.1	4795
16	1138	34.3	3320
17	1179	39.7	2969
18	1209	44.9	2692
19	1634	53.5	3057
Per capita income			
≥R$ 200.00	1044	31.0	3373
R$ 100.00 to R$ 199.99	1530	36.5	4195
R$ 66.68 to R$ 99.99	869	41.3	2102
R$ 34.30 to R$ 66.67	1674	44.3	3783
≤ R$ 34.29	1436	42.5	3380
Education gap			
No	2329	33.2	7024
Yes	4149	43.6	9522
Type of service			
Private	1499	41.5	3611
Contracted	356	31.5	1129
Public	4095	44.3	9242
Fluoridated water supply			
Yes	2272	30.2	7529
No	4281	46.0	9304

* Subjects with one or more teeth lost.
Source: Brazilian Ministry of Health, Oral Health Survey 2003

The Federation Dentaire Internacionale[7] has established for those aged 18 the goal of having 85% of all natural teeth by the year 2000. However, the present study showed that Brazil has not achieved this goal; around 61% of the subjects studied had all their teeth.

Similar findings were reported by Susin et al[17] (2006). They demonstrated that the first lower molar is the most frequently tooth lost (31%), followed by the first upper molar (15%). These findings are also corroborated by Gjermo et al[8] (1983) who investigated a group of adolescents aged 13 to 16 in Belo Horizonte, Brazil. The first molars are the most affected teeth contributing to the prevalence of tooth loss. Some factors may play a role: first molars are the first permanent teeth to erupt; people are generally not aware that this toothwill be permanent; lack of a preventive approach by health providers; and greater occurrence of caries experience due to longer exposure to local contributing factors – all leading to early tooth loss.

While studying a sample of Chilean students aged 12 to 21, López & Baelum[11] found prevalences of tooth loss of 11.5% and 21.1% in those aged 15 to 17 and 18 to 21, respectively. In our study, we found a similar association with age, showing that, despite a one-year interval between age groups, it is possible to evidence increase of tooth loss over lifetime, even in very young people.

Higher prevalence of tooth loss in female adolescents found in the present study was also corroborated in other studies[1,8,11,17] despite age group differences. This finding could be explained by the fact that women use more dental services because they have either more health or esthetic concerns, which may lead to overtreatment. Peres et al[15] conducted a cohort study investigating a group of adolescents in the city of Pelotas, southern Brazil. They found higher rates of care – reflecting greater utilization of dental services – among female adolescents, regardless of their family socioeconomic trajectories during childhood and adolescence. Caldas Jr. et al,[6] in a study conducted in Recife, northeastern Brazil, reported a strong association between number of extracted teeth due to dental caries experience and frequency of dental restoration.

Gender differences concerning the utilization of dental services indicate a need for further studies. In the present study, the findings regarding the association between type of dental service and tooth loss were inconsistent with those reported in the Brazilian Oral Health Survey 2002–2003[3] that included a sample of adults (aged 33–44). In the latter, after adjusting for confounders, users of public services had 9% higher prevalence of tooth loss.

The association of tooth loss with poorer socioeconomic indicators was described in other studies, regardless of the age groups studied.[1,3,11] Dental caries experience, a major cause of tooth loss, is more prevalent and affects to greater extent and severity more deprived groups, evidencing an unequal distribution of dental caries burden.[12] These people usually have less access to prevention and care services,[4] consume more sucrose, have poorer oral hygiene habits,[16] and less access and use of fluoride resulting in more damage and loss.

Table 2. Multivariable analysis of the association between tooth loss and demographic and socioeconomic variables, type of dental service and fluoridated water supply in Brazilian adolescents. Brazil, 2003 (n= 16,833)

Variable	Unadjusted			Adjusted		
	PR	95% CI*	p-value**	PR	95% CI*	p-value**
Block 1						
Geographical localization			<0.01			<0.01
Urban	1.00			1.00		
Rural	1.19	1.13;1.25		1.19	1.13;1.25	
Block 2						
Sex			<0.01			<0.01
Male	1.00			1.00		
Female	1.16	1.12;1.21		1.15	1.10;1.19	
Skin color			<0.01			<0.01
Asian	1.00			1.00		
White	0.81	0.72;0.90		0.82	0.74;0.91	
Lighter-skinned black	1.06	0.95;1.18		1.00	0.9;1.11	
Dark-skinned black	0.90	0.79;1.01		0.85	0.76;0.96	
Indigenous	1.02	0.83;1.25		0.98	0.80;1.19	
Age (years)			<0.01			<0.01
15	1.00			1.00		
16	1.18	1.10;1.25		1.17	1.10;1.25	
17	1.37	1.28;1.46		1.35	1.27;1.44	
18	1.55	1.45;1.64		1.52	1.47;1.62	
19	1.84	1.74;1.94		1.83	1.73;1.93	
Per capita income			<0.01			<0.01
≥ R$ 200.00	1.00			1.00		
R$ 100.00 to R$ 199.99	1.18	1.10;1.26		1.14	1.07;1.21	
R$ 66.68 to R$ 99.99	1.34	1.24;1.43		1.27	1.18;1.36	
R$ 34.30 to R$ 66.67	1.43	1.34;1.52		1.33	1.25;1.42	
≤ R$ 34.29	1.37	1.29;1.46		1.30	1.21;1.39	
Education gap			<0.01			<0.01
No	1.00			1.00		
Yes	1.31	1.26;1.37		1.14	1.10;1.19	
Block 3						
Type of service			<0.01			0.021
Private	1.00			1.00		
Contracted	0.76	0.69;0.83		0.82	0.74;0.89	
Public	1.07	1.02;1.12		0.94	0.90;0.98	
Fluoridated water supply			<0.01			<0.01
Yes	1.00			1.00		
No	1.52	1.46;1.59		1.40	1.34;1.46	

Source: Brazilian Mnistry of Health, Oral Health Survey 2003
Block 2: variables adjusted for themselves and for block 1
Block 3: variables adjusted for themselves and for blocks 1 and 2
* 95% confidence interval adjusted for sampling design
** p-value = Wald test

In the present study, tooth loss due to causes other than caries experience (less than 10%) was associated to higher income, white skin color and living in cities with better indicators such as fluoridated water supply, which is determined by local social and economic development.[13,14] This finding reinforce the unequal distribution of dental caries experience and consequently of tooth loss.

Table 3. Multivariable analysis of the association between tooth loss and demographic and socioeconomic variables, type of dental service and fluoridated water supply in Brazilian adolescents by macroregion of residence. South and Southeast Brazil, 2003 (n= 16,833)

Variable	South						Southeast					
	Unadjusted			Adjusted			Unadjusted			Adjusted		
	RP	95% CI *	p**	RP	95% CI *	p**	RP	95% CI *	p**	RP	95% CI *	p**
Block 1												
Geographical localization			0.007			0.007			<0.01			<0.01
Urban	1.00			1.00			1.00			1.00		
Rural	1.20	1.05;1.37		1.20	1.05;1.37		1.72	1.52;1.93		1.72	1.52;1.93	
Block 2												
Sex			0.001			0.004			0.053			0.070
Male	1.00			1.00			1.00			1.00		
Female	1.19	1.08;1.32		1.15	1.04;1.27		1.12	1.00;1.26		1.10	0.99;1.23	
Skin color			0.393						0.049			0.320
Asian	1.00						1.00			1.00		
White	0.77	0.62;0.95			NI		0.65	0.50;0.85		0.65	0.50;0.85	
Lighter-skinned black	0.83	0.65;1.06					0.73	0.56;0.95		0.69	0.53;0.90	
Dark-skinned black	0.73	0.53;1.00					0.83	0.63;1.09		0.77	0.59;1.02	
Indigenous	0.62	0.28;1.37					0.80	0.41;1.54		0.76	0.39;1.47	
Age (years)			<0.01			<0.01			<0.01			<0.01
15	1.00			1.00			1.00			1.00		
16	1.26	1.08;1.47		1.29	1.11;1.52		1.21	0.99;1.49		1.18	0.97;1.45	
17	1.37	1.17;1.61		1.43	1.21;1.67		1.65	1.37;2.00		1.57	1.30;1.89	
18	1.55	1.32;1.82		1.64	1.39;1.93		1.77	1.47;2.13		1.66	1.37;2.00	
19	1.92	1.66;2.24		2.03	1.75;2.35		2.39	2.01;2.83		2.26	1.90;2.68	
Per capita income			<0.01			<0.01			0.006			0.016
≥ R$ 200.00	1.00			1.00			1.00			1.00		
R$ 100.00 to R$ 199.99	1.20	1.05;1.37		1.23	1.08;1.40		1.08	0.91;1.29		1.04	0.88;1.24	
R$ 66.68 to R$ 99.99	1.37	1.16;1.62		1.46	1.23;1.73		1.27	1.04;1.55		1.22	1.00;1.48	
R$ 34.30 to R$ 66.67	1.52	1.31;1.76		1.56	1.34;1.81		1.26	1.05;1.52		1.17	0.97;1.41	
≤ R$ 34.29	1.23	1.02;1.48		1.31	1.08;1.58		1.22	1.00;1.48		1.16	0.96;1.40	
Education gap			0.028			0.574			<0.01			<0.01
No	1.00			1.00			1.00			1.00		
Yes	1.12	1.01;1.23		0.96	0.86;1.06		1.52	1.35;1.71		1.31	1.16;1.47	
Block 3												
Type of service			0.830						0.323			
Private	1.00						1.00					
Contracted	0.69	0.56;0.85			NI		0.73	0.56;0.96			NI	
Public	0.98	0.88;1.10					1.05	0.92;1.19				
Fluoridated water supply			0.003			0.049			0.211			0.598
Yes	1.00			1.00			1.00			1.00		
No	1.23	1.07;1.41		1.15	1.00;1.06		1.08	0.96;1.21		0.97	0.86;1.09	

Source: Brazilian Oral Health Survey 2003
Block 2: variables adjusted for themselves and for block 1
Block 3: variables adjusted for themselves and for blocks 1 and 2
* 95% confidence interval adjusted for sampling design
** p-value = Wald test
NI – variables not included in the multilvariable analysis due to p >0.25 in the bivariate analysis.

Table 4. Multivariable analysis of the association between tooth loss and demographic and socioeconomic variables, type of dental service and fluoridated water supply in Brazilian adolescents by macroregion of residence. Central-West, North and Northeast Brazil, 2003 (n= 16,833)

Variable	Central-West						North						Northeast					
	Unadjusted			Adjusted			Unadjusted			Adjusted			Unadjusted			Adjusted		
	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**
Block 1																		
Geographical localization			0.485			0.485			<0.01			<0.01			0.322			0.322
Urban	1.00			1.00			1.00			1.00			1.00			1.00		
Rural	0.92	0.74;1.15		0.92	0.74;1.15		1.33	1.22;1.46		1.33	1.22;1.46		1.04	0.96;1.13		1.04	0.96;1.13	
Block 2																		
Gender			0.002			0.003			0.003			0.014			<0.01			<0.01
Male	1.00			1.00			1.00			1.00			1.00			1.00		
Female	1.22	1.08;1.38		1.21	1.07;1.38		1.10	1.03;1.18		1.08	1.02;1.15		1.15	1.07;1.23		1.14	1.06;1.22	
Skin color			0.157			0.132			0.465						0.122			0.111
Asian	1.00			1.00			1.00						1.00			1.00		
White	0.97	0.72;1.30		1.04	0.77;1.39		0.98	0.79;1.21			NI		0.82	0.66;1.03		0.85	0.69;1.05	
Lighter-skinned black	1.11	0.83;1.50		1.17	0.88;1.56		1.03	0.84;1.27					0.82	0.66;1.03		0.84	0.69;1.04	
Dark-skinned black	0.96	0.68;1.37		1.09	0.77;1.53		0.91	0.73;1.15					0.72	0.56;0.93		0.74	0.59;0.94	
Native	1.52	0.84;2.75		1.41	0.80;2.49		0.89	0.65;1.22					0.96	0.65;1.42		1.00	0.69;1.45	
Age (years)			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
15	1.00			1.00			1.00			1.00			1.00			1.00		
16	1.20	0.96;1.50		1.17	0.93;1.48		1.08	0.97;1.20		1.08	0.97;1.20		1.29	1.15;1.44		1.25	1.11;1.40	
17	1.37	1.11;1.69		1.40	1.12;1.74		1.24	1.12;1.38		1.25	1.13;1.39		1.45	1.30;1.62		1.38	1.23;1.54	
18	1.44	1.16;1.77		1.42	1.14;1.77		1.48	1.35;1.63		1.50	1.37;1.65		1.60	1.44;1.79		1.52	1.37;1.70	
19	2.13	1.79;2.55		2.08	1.73;2.50		1.61	1.48;1.76		1.63	1.50;1.78		1.71	1.54;1.89		1.67	1.51;1.45	

Continuation

Table 4 continuation

Variable	Central-West						North						Northeast					
	Unadjusted			Adjusted			Unadjusted			Adjusted			Unadjusted			Adjusted		
	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**	PR	95% CI*	p**
Block 2																		
Per capita income			0.672						0.123			0.061	1.00		0.038			<0.01
≥ R$ 200.00	1.00						1.00			1.00						1.00		
R$ 100.00 to R$ 199.99	1.18	1.01;1.38			NI		1.02	0.91;1.15		1.00	0.90;1.13		1.23	1.07;1.42		1.15	1.00;1.32	
R$ 66.68 to R$ 99.99	1.07	0.87;1.32					1.06	0.93;1.21		1.08	0.95;1.23		1.30	1.13;1.50		1.22	1.06;1.41	
R$ 34.30 to R$ 66.67	1.16	0.97;1.39					1.04	0.93;1.16		1.06	0.94;1.18		1.33	1.17;1.51		1.24	1.09;1.41	
≤ R$ 34.29	1.01	0.82;1.25					1.09	0.97;1.21		1.09	0.97;1.22		1.18	1.04;1.34		1.13	1.00;1.29	
Education gap			0.002			0.031			0.147			0.768			<0.01			0.001
No	1.00			1.00			1.00			1.00			1.00			1.00		
yes	1.22	1.08;1.38		1.15	1.02;1.30		1.05	0.98;1.13		0.99	0.92;1.06		1.19	1.10;1.28		1.14	1.06;1.23	
Block 3																		
Type of service			0.018			0.007			0.289						0.009			0.474
Private	1.00			1.00			1.00						1.00			1.00		
Contracted	0.70	0.54;0.90		0.71	0.55;0.91		0.88	0.75;1.05			NI		0.86	0.73;1.02		0.99	0.85;1.16	
Public	0.85	0.75;0.97		0.83	0.73;0.95		0.95	0.88;1.03					1.10	1.00;1.19		1.03	0.95;1.11	
Fluoridated water supply			0.081			0.304			0.134			0.202			<0.01			<0.01
Yes	1.00			1.00			1.00			1.00			1.00			1.00		
No	1.11	0.99;1.25		1.06	0.93;1.19		0.92	0.83;1.03		0.93	0.83;1.04		1.66	1.48;1.86		1.63	1.45;1.84	

Source: Brazilian Ministry of Health, Oral Health Survey 2003
Block 2: variables adjusted for themselves and for block 1
Block 3: variables adjusted for themselves and for blocks 1 and 2.
* 95% confidence interval adjusted for sampling design
** p-value = Wald test
NI – variables not included in the multilvariable analysis due to p >0.25 in the bivariate analysis.

Because of our study design, it was not possible to establish a causal relationship between fluoridated water supply and tooth loss as well as to determine exposed and non-exposed subjects to fluoridated water. In addition, information on other fluoride-related sources, such as use of fluoride-containing toothpaste,was not collected. However, the results of the present study showed a strong association between unavailability of fluoridated water supply and tooth loss in the analysis nationwide as well as in particular case of the Northeast, a region with the poorest socioeconomic indicators in Brazil. In other Brazilian regions, the association between tooth loss and fluoridated water was confounded by more distal variables, notably socioeconomic determinants. This finding stresses the social importance of providing fluoridated water in the public supply system. Hopcraft & Morgan[9] demonstrated in a group of Australian military recruiters that those exposed to fluoridated water throughout their lifetime had 23% less caries experience than non-exposed ones. These authors[9] reported that partial exposure to fluoridated water led to caries reduction by 17%.

A potential limitation of the present study was the sample gender composition. Female adolescents comprised 58.3% of all subjects studied, while during the period 2002–2003 the Brazilian population aged 15 to 19 had 49.8%[a] of females, which may have overestimated the prevalence of tooth loss.

Another potential limitation of the study is concerning the inclusion of an ecological variable, i.e., fluoridated water supply, while income was used as an individual variable but without taking into consideration socioeconomic information on the place of residence. This is a weakness of studies based on secondary data where the construction of the theoretical model for analysis relies on information available. Nevertheless, the association between income and the outcome studied would likely have remained in the same direction if a contextual variable were used for income as described by Antunes et al.[2] In the same way, the use of secondary data may have led to misinterpretation of results, for instance, regarding data on type of dental service. A total of 2,241 subjects (13.3%) reported they have "never seen a dentist;" and of them, 356 (15.9%) reported tooth loss as well. Since they were never seen at a dental service, they could not report tooth loss. In theory they might have made use of tooth self-extraction. Other possible explanations could be tooth loss due to trauma and/or advanced periodontal disease, which are quite unlikely given the negligible prevalence of these conditions at this age.[b] It is more likely to assume that there were inconsistencies in the study database and therefore it was opted for excluding these subjects. It evidences flawed quality control during data collection.

On the other hand, the present study has some strengths. The large sample size ensured high power to the study. Adolescents from 250 different size cities were examined in all Brazilian macroregions and states. Easy identification of the outcome investigated makes it less prone to misdiagnoses and classification bias. Blinding was another strength of the study because examiners were not aware of the associations tested. All analyses were adjusted for the design effect which was required because subjects in the same cluster potentially have more common characteristics among themselves than those in other clusters.[10] Finally, analyses including prevalence ratios as an alternative to odds ratios and Poisson regression as an alternative to logistic regression impart greater accuracy to estimates of effect measures and confidence intervals while studying a common outcome.[5]

High prevalence of tooth loss in adolescents – for the most part preventable – evidences a need for prioritizing dental care to the most affected groups of people to repair existing damage. Providing functional and esthetic maintenance care during adolescence can prevent major conditions during adult life. Prevention should be provided at earlier ages, before adolescence, to reduce the main risk factors for tooth loss with access to other fluoride sources to public service users. Medical actions should be also encouraged to protect early erupting teeth as they are still the most frequently extracted.

Established by federal law in Brazil since 1974, universal access to fluoridated water is an effective action that needs to be guaranteed to all Brazilian people, calling for stronger support from government administrators at all levels, as tooth loss is a clear expression of social inequality.

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[a] Brazilian Ministry of Health. DATASUS. Health information: demographic and socioeconomic [internet]. [cited 2008 Nov 8]. Available from: http://w3.datasus.gov.br/datasus/datasus.php?area=359A1B379C6D0E0F359G23HIJd6L26M0N&VInclude=../site/infsaude.php&VObj=http://tabnet.datasus.gov.br/cgi/deftohtm.exe?ibge/cnv/pop

[b] Brazilian Ministry of Health. Health Department. Office of Primary Care.. Projeto SB Brasil 2003: condições de saúde bucal da população brasileira 2002-2003: resultados principais. Brasília; 2004.

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