The Use of Dental Care Facilities and Oral Health: A Multilevel Approach of Schoolchildren in the Brazilian Context

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Purpose: To appraise the association between dental care utilisation and gingival status in the Brazilian context, controlling for covariates on socio-demographic characteristics and dentofacial anomalies (12-year-old children).

Materials and Methods: A survey of oral health comprising 5780 schoolchildren in 35 towns of the state of São Paulo, Brazil, provided primary information regarding the assessment of the community periodontal index. The survey also provided information on socio-demographic characteristics and the dental aesthetic index of participants. The utilization of dental services was measured at the town-level, in terms of the dental care index (F/DMFT ratio). Multilevel models of logistic regression fitted the adjustment of covariates for gingival bleeding on probing and calculus.

Results: Almost 32% of the children examined presented unhealthy gingival conditions, with a significantly poorer profile for boys, black children and those enrolled in public schools than for their counterparts. Several dentofacial anomalies associated with unhealthy gingival status: crowding of the incisal segments, maxillary and mandibular irregularity, antero posterior molar relation, maxillary overjet and vertical anterior openbite. Towns with a higher dental care index presented a lower proportion of children with gingival bleeding and calculus.

Conclusion: This study confirmed previous observations of boys, blacks and children enrolled in public schools as presenting poorer oral health status than their counterparts in the Brazilian context. The utilization of dental services was significantly associated with improved profile of gingival status of participating towns, and this association is unlikely to be due to insufficient control of confounding on socio-demographic characteristics and dentofacial anomalies.

Key words: bleeding on probing, Brazil, community periodontal index, dental calculus, health promotion

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Toxins secreted by bacteria in plaque accumulated over time along the gum line can cause gingivitis, a dynamic condition widely prevalent in children, whose earliest clinical changes can be detected after 2–3 weeks of persistent plaque accumulation: redness, swelling, reduced resistance to probing and increased tendency to gingival bleeding on probing or when the teeth are brushed (Jenkins and Heasman, 1993). Clearly not all gingivitis progress to periodontitis, although chronic periodontitis must be preceded at some point by gingivitis (Brown and Loë, 1993). Calcium salt concretions formed on teeth (dental calculus) result from the mineralization of dental plaque. Dental calculus acts as a retentive factor for plaque, which can irritate the gum tissue and foster the progression of chronic gingivitis and periodontal disease. As brushing and flossing the teeth, and a regular use of dental services, can promote the removal of dental plaque and prevent both calculus and gingival bleeding, these conditions can be considered indicative of poor oral health and caries risk.

While assessing the DMFT for 12-year-old children in 18 European countries, Nadanovsky and Sheiham

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(1995) concluded that dental services were relatively unimportant in explaining differences in dental caries during the 1970s and early 1980s. On the other hand, recent approaches focusing dental health promotion indicated a contrasting perspective, and concluded that reductions in plaque and gingival bleeding were achieved in the short-term in the majority of studies reviewed (Watt and Marinho, 2005). These observations motivated the assessment of association between the prevalence of gingival unhealthy conditions and an index of dental care utilization, as a strategy to appraise the effectiveness of dental health promotion.

Recent studies in the Brazilian context indicated a poorer overall dental status for boys (Antunes et al, 2003a), for black children (Antunes et al, 2003b), and for children enrolled in public schools (Antunes et al, 2002) than for their respective counterparts. The appraisal of the association between the gingival status of schoolchildren and their utilization of dental services should thus consider the control for socio-demographic characteristics of examined individuals.

Geiger (2001) addressed the longstanding question of whether malocclusion plays an aetiological role in gingival inflammation and periodontal disease in a retrospective essay focusing evidences and arguments raised in the literature. During the 1950s and 1960s, a few studies tried to evaluate the anatomic and functional contribution of dentofacial anomalies for the maintenance of improved gingival status in children. However, these studies had their conclusions appraised as limited due to the reduced number of subjects, and the inability of researchers to account for the many variables involved in the assessment of periodontal and occlusal status. Subsequently, newly developed methodologies for assessing both conditions, namely the community periodontal index of treatment needs (Ainamo et al, 1982) and the dental aesthetic index (Cons et al, 1986) gave rise to further studies assessing hypotheses of association between periodontal and occlusal variables (Onyeaso et al, 2003).

These observations suggest the importance of also controlling for dentofacial anomalies of schoolchildren while assessing the association between their gingival status and dental health services utilization. The objectives of the current study were to describe the prevalence of gingival bleeding on probing and dental calculus in 12-year-old schoolchildren in the state of São Paulo, Brazil, and to assess its association with an index for the effectiveness of the local dental service, while controlling for socio-demographic characteristics and dentofacial anomalies of the schoolchildren examined.

MATERIALS AND METHODS

Data source

From May 2002 to October 2003, the Brazilian health authority sponsored a major survey of oral health (Brazil, 2004), comprising 108 921 dental examinations performed in accordance with international standards established by the World Health Organization (WHO, 1997). Nearly 2000 professionals participated as dental examiners, and as recorders and coordinators. All dentists were previously trained and calibrated for the examinations; the appraisal of data reproducibility indicated 0.7 as the lowest kappa statistic for the inter- and intra-observer agreement of examinations, referring to the examination of oral conditions assessed in the current study.

Although the survey comprised all Brazilian regions and all age groups indicated by the WHO, we focused on 12-year-old schoolchildren living in the State of São Paulo (35 towns). When sponsoring institutions made the survey data available for public consultation, we reviewed 5780 oral-examination records, which correspond to the entire data set for the selected age group and region.

Surveys on oral health that follows WHO directions use the DMF (decayed, missing and filled permanent teeth or tooth surfaces) index for assessing dental caries. Diagnostic criteria for the epidemiologic assessment of dental caries was supplied by the WHO's guidebook (WHO, 1997). As to the assessment of gingival conditions for this age, the Community Periodontal Index (CPI) classified each sextant of the mouth as healthy (CPI = 0); bleeding observed after probing (CPI = 1); or calculus detected during probing (CPI = 2). The oral examination record also informed dentofacial anomalies by the Dental Aesthetic Index (DAI), which comprises the following conditions: missing incisor, canine and premolar teeth, crowding and spacing in the incisal segments, diastema, anterior maxillary and mandibular irregularity, anterior maxillary and mandibular overjet, vertical anterior openbite, and antero posterior molar relation (WHO, 1997).

The oral-examination record also gathered information on socio-demographic characteristics of participating children: gender, ethnic group and type of school. Type of school refers to the differentiation of students enrolled in public and private schools. As public schools do not collect tuition fees, dental studies have assumed that children attending private schools in the Brazilian context would present higher socio-economic status than those enrolled in public schools (Antunes et al, 2002; Freire et al, 1996). The

classification of ethnic group discriminated 'blacks' (i.e. black children and children of mixed African descent), from 'non-blacks' (i.e. white children of European descent). As ethnic miscegenation is a prominent characteristic of the Brazilian population, children of mixed descent markedly prevail in the 'black' group.

DMFT information enabled the estimation of the dental care index, a measurement originally proposed by Walsh (1970) for comparative studies addressing dental programmes, which indicates the utilization of dental services by the group. Although the DMFT can be assessed either at individual or at contextual (town) level, the care index is solely calculated for aggregate data (on account of its absent definition for caries-free children), and refers to the ratio (F/DMFT) between the number of filled teeth and the overall index of caries for each participating town.

Data analysis

Statistical analyses used the SPSS 8.0 1997. The assessment of covariates for the prevalence of unhealthy gingival status in one or more sextants of the mouth used odds ratios (OR) and 95% confidence intervals as calculated by maximum likelihood estimation and unadjusted for the remaining variables of the study. The subsequent adjustment of covariates used multivariate models explaining the prevalence of any gingival unhealthy condition (CPI ≥ 1: bleeding after probing or calculus) and the prevalence of calculus (CPI = 2) in at least one sextant of the mouth.

Multivariate analysis fitted four models for each of these conditions, using a stepwise forward procedure of logistic regression analysis (Holford, 2002): the empty model (without covariates); model 1 (controlling for socio-demographic characteristics of subjects); model 2 (controlling for socio-demographic characteristics and dentofacial anomalies of subjects); and the full model, comprising a multilevel assessment of socio-demographic characteristics and dentofacial anomalies of subjects (first level), and the dental care index of participating towns (second level). The appraisal of goodness-of-fit indicators for these models used the –2 log-likelihood test as a measure of deviance.

Multilevel modelling

Multilevel analysis used the scheme of fixed effects / random intercept (Snijders and Bosker, 2003), considering two levels of data organisation: examined schoolchildren (first level) and towns (second level). At the first level, a conventional multivariate logistic regression analysis comprising all schoolchildren allowed assessing the effect of covariates on socio-demographic characteristics and dentofacial anomalies. If p_i is the predicted probability of the i^{th} individual being positive for each outcome (CPI ≥ 1 and CPI = 2), $p_i/(1-p_i)$ will be the corresponding odds. The logit function can thus be defined as: $\text{logit}(p_i) = \log[p_i/(1-p_i)]$, and the conventional logistic regression equation is: $\text{logit}(p_i) = b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_k X_k$ (Holford, 2002), in which b_0 is the intercept, and $b_1, b_2, \ldots, b_k$ are the slopes referring to the effect of covariates for the first level.

At the second level, a conventional multivariate logistic regression analysis was run for each town, thus totalling 35 new regression equations. The slopes of these equations were fixed to coincide with the slopes predetermined by the overall equation comprising the whole data set, as this model does not allow for second-level variations on the effect of first-level covariates. Therefore, all second-level variation was attributed to the intercept, and an ordinary least squares (OLS) regression analysis assessed the variation of the intercept: $b_0 = B_0 + B_1 Y_1$, in which B_0 is the fixed part of the intercept, Y_1 is the dental care index (the second-level covariate), and B_1 is the slope accounting for the effect of the second-level covariate on the intercept.

RESULTS

Nearly one third (31.99%) of the schoolchildren examined presented unhealthy gingival conditions, with bleeding after probing or calculus in one or more sextants of the mouth (Table 1).

The assessment of covariates, as unadjusted for the remaining conditions being appraised, identified socio-demographic conditions associated with a poorer gingival status of schoolchildren (Table 2). Males, blacks and children enrolled in public schools presented a higher prevalence of unhealthy gingival status, both in the assessment of CPI ≥ 1 and CPI = 2. Several dentofacial anomalies also associated with unhealthy gingival status: crowding of the incisal segments, maxillary and mandibular irregularity, maxillary overjet, vertical anterior openbite and antero posterior molar relation. Children presenting gingival bleeding after probing or calculus had poorer use of dental services (as indicated by their significantly lower figures of the dental care index) than those ranking CPI = 0 for all sextants of the mouth ($p < 0.001$).

The adjustment of covariates in the multivariate assessment confirmed socio-demographic status, dento-

Table 1 Community periodontal index assessment of 5780 12-year-old schoolchildren, state of São Paulo, Brazil, 2002

Gingival status		n	%
Healthy (all sextants)		3931	68.01
Bleeding on probing	in one sextant	440	7.61
	in two or more sextants	597	10.33
Calculus	in one sextant	277	4.79
	in two or more sextants	191	3.31
Mixed conditions of unhealthy gingival status: at least one sextant affected by gingival bleeding on probing and one sextant presenting calculus		344	5.95

facial anomalies and utilization of dental services as conditions effectively associated with the risk of unhealthy gingival status, i.e. CPI ≥ 1. As the full model presented a significantly lower deviance than the remaining prior models, the multilevel model comprising the whole set of covariates was considered the most effective for explaining the outcome variable (Table 3).

The fitting of multivariate models for the risk of dental calculus (CPI = 2) also presented significant estimates for the whole set of covariates appraised in the study (Table 4), and the full multilevel model also presented a significantly lower deviance. This observation indicates that the same determinants of socio-demographic status, dentofacial anomalies and utilization of dental services affect the risk of a further outcome of gingival unhealthy status.

DISCUSSION

Studies reviewed by Jenkins and Papapanou (2001) support the current observation of boys presenting a poorer gingival status than girls. The literature also reports gender differences in behaviour and knowledge concerning oral health, with indications of girls having advantages in most issues such as flossing and brushing their teeth, diet, self-esteem, and regular use of dental care (Clarkson and Worthington, 1993; Haugejorden, 1996; Chen and Andersen, 1997; Ostberg et al, 1999; Antunes et al, 2003a). While reviewing studies appraising discrepant oral health status among ethnic groups in the USA, Hunt (1990) stated that black children received less dental services than their white counterparts. Within the Brazilian context, Antunes et al (2002, 2003b) observed higher dental treatment needs in black than in white children. These indications are consistent with the current report of poorer gingival status for black than for white schoolchildren in the state of São Paulo.

The present study observed the prevalence of gingival bleeding on probing and dental calculus as associated with a socio-economic indicator of examined children; an observation also met by the dental literature. Gesser et al (2001) appraised the gingival status of youngsters in a Brazilian city, and reported both bleeding and calculus as significantly associated with family income, instructional levels of examined subjects and of their parents. Kallio and Murtomaa (1997) observed a significant association of gingival bleeding on probing with toothbrushing frequency and socio-economic status of Finnish adolescents. Taani (2002) appraised the gingival status of Jordanian children using the same proxy for socio-economic status (enrolment in public or in private schools), and observed worse oral health for the poor than for their better-off counterparts. However, as the difference was not statistically significant, the author concluded that dental health education was recommended for both socio-economic groups.

Also, the occlusal status of children has been studied as related to children's gingival conditions. In a longitudinal appraisal of children receiving orthodontic treatment, Glans et al (2003) indicated the orthodontic correction for crowding in the incisal segments as a condition associated with improved tooth cleaning. Davies et al (1988) observed higher plaque scores in 12-year-old children presenting anterior overjet, suggesting that tooth cleaning is more difficult in these cases. Ashley et al (1998) reported evidence of a direct relationship between irregularities of the incisor teeth and gingival redness, bleeding, and profuse bleeding on probing, for children aged 11–14 years.

Table 2 Unadjusted assessment of covariates for gingival unhealthy status (CPI ≥ 1) and dental calculus (CPI=2) in 12-year-old schoolchildren, state of São Paulo, Brazil, 2002

Conditions		Gingival unhealthy status			Dental calculus		
		CPI ≥ 1	CPI = 0	Unadjusted OR (95% CI)	CPI = 2	CPI ≤ 1	Unadjusted OR (95% CI)
Socio-demographic							
Gender	females	839	2139		354	2624	
	males	1010	1792	1.44 (1.28, 1.61)	458	2344	1.45 (1.24, 1.69)
Ethnic group	non-blacks	1113	2781		479	3415	
	blacks	736	1150	1.60 (1.42, 1.80)	333	1553	1.53 (1.31, 1.79)
Type of school	private	71	287		26	332	
	public	1778	3644	1.97 (1.50, 2.60)	786	4636	2.17 (1.42, 3.33)
Dentofacial anomalies							
Crowding (incisal segments)	Absent	977	2534		401	3110	
	Crowded	872	1397	1.62 (1.44, 1.81)	411	1858	1.72 (1.47, 2.00)
Anterior maxillary irregularity	Absent	1020	2520		451	3089	
	≥ 1 mm	829	1411	1.45 (1.30, 1.63)	361	1879	1.32 (1.13, 1.53)
Anterior mandibular irregularity	Absent	1007	2540		406	3141	
	≥ 1 mm	842	1391	1.53 (1.36, 1.71)	406	1827	1.72 (1.48, 2.00)
Anterior maxillary overjet	≤ 3 mm	1198	2728		492	3434	
	≥ 4 mm	651	1203	1.23 (1.09, 1.39)	320	1534	1.46 (1.25, 1.70)
Vertical anterior openbite	Absent	1710	3749		741	4718	
	≥ 1 mm	139	182	1.67 (1.32, 2.12)	71	250	1.81 (1.36, 2.40)
Antero posterior molar relation:	Normal	949	2389		406	2932	
	Half or full cusp	900	1542	1.47 (1.31, 1.65)	406	2036	1.44 (1.24, 1.68)
Dental treatment				Significance			Significance
Dental care index		52.97%	72.79%	p < 0.001	49.66%	68.51%	p < 0.001

Table 3 Multivariate models of logistic regression and multilevel assessment for the risk of gingival unhealthy status (CPI?1) in 12-year-old schoolchildren, state of São Paulo, Brazil, 2002

	Empty model		Model 1					Model 2				
First level: subjects	Estimate	SE	Estimate	SE	OR	95% CI	Significance	Estimate	SE	OR	95% CI	Significance
Constant	-0.75	0.03	-1.69	0.14			p < 0.001	-2.09	0.14			p < 0.001
Socio-demographics												
blacks			0.45	0.06	1.57	1.39 to 1.76	p < 0.001	0.46	0.06	1.58	1.41 to 1.78	p < 0.001
males			0.37	0.06	1.45	1.29 to 1.62	p < 0.001	0.37	0.06	1.45	1.29 to 1.62	p < 0.001
public schools			0.63	0.14	1.88	1.44 to 2.45	p < 0.001	0.64	0.14	1.89	1.44 to 2.48	p < 0.001
Dentofacial anomalies												
crowding								0.33	0.07	1.39	1.20 to 1.60	p < 0.001
mandibular irregularity								0.21	0.07	1.24	1.07 to 1.43	p = 0.003
molar relation								0.32	0.06	1.37	1.23 to 1.54	p < 0.001
openbite								0.50	0.12	1.65	1.30 to 2.08	p < 0.001
Deviance	7245.71		7118.56					6988.93				
Second level: towns								Estimate	SE		95% CI	Significance
Constant (fixed part)								-0.25	0.09		-0.43 to -0.07	p = 0.012
Dental care index								-0.39	0.14		-0.67 to -0.11	p = 0.009
Deviance (full model)								6821.14				

Table 4 Multivariate models of logistic regression and multilevel assessment for the risk of dental calculus (CPI=2) in 12-year-old schoolchildren, state of São Paulo, Brazil, 2002

	Empty model		Model 1					Model 2				
First level: subjects	Estimate	SE	Estimate	SE	OR	95% CI	Significance	Estimate	SE	OR	95% CI	Significance
Constant	-1.81	0.04	-2.84	0.21			p < 0.001	-3.38	0.22			p < 0.001
Socio-demographics												
blacks			0.40	0.08	1.49	1.28 to 1.74	p < 0.001	0.42	0.08	1.52	1.30 to 1.78	p < 0.001
males			0.37	0.08	1.45	1.25 to 1.69	p < 0.001	0.35	0.08	1.42	1.22 to 1.65	p < 0.001
public schools			0.72	0.21	2.06	1.37 to 3.10	p < 0.001	0.75	0.21	2.12	1.41 to 3.20	p < 0.001
Dentofacial anomalies												
crowding								0.29	0.10	1.33	1.10 to 1.61	p = 0.003
mandibular irregularity								0.33	0.10	1.40	1.16 to 1.69	p < 0.001
maxillary overjet								0.28	0.08	1.32	1.12 to 1.54	p < 0.001
molar relation								0.25	0.08	1.29	1.11 to 1.50	p = 0.001
openbite								0.59	0.14	1.81	1.37 to 2.40	p < 0.001
Deviance	4691.53		4624.08					4519.31				
Second level: towns								Estimate	SE	95% CI		Significance
Constant (fixed part)								-3.26	0.05	-3.36 to -3.16		p < 0.001
Dental care index								-0.19	0.08	-0.03 to -0.35		p = 0.018
Deviance (full model)								4458.94				

The identification of socio-demographic characteristics and dentofacial anomalies as modifying factors of gingival status demands that these conditions be considered as control variables for an effective appraisal of the impact of dental services utilization on outcomes of child oral health. Multilevel models estimated in the current study indicated that towns with a higher dental care index tended to present a reduced prevalence of gingival unhealthy status, referring to both bleeding and calculus. As these multilevel models comprised adjustment for covariates on socio-demographic characteristics and dentofacial anomalies, we suggest that this observation could not be explained by insufficient control of confounding on these variables.

The care index was used as indicative of dental care utilization for the appraisal of association with the town-level gingival health profile. For this assessment, the 'attendance' and 'consumption of dental care' are also important parameters, and the availability of oral hygiene products, the educational level of caregivers, other oral health campaigns, plaque index, oral hygiene and dietary habits can be considered as most important confounding factors regarding gingival health. However, none of these factors are usually assessed in surveys following WHO guidelines, and data on these dimensions were not available for the current assessment. This absent information can thus be considered a major shortcoming for this study.

The dental health service in Brazil underwent an extensive reform during the 1990s, with the implementation of restorative dental treatment, dental public health initiatives (epidemiologic surveys, education in dental health, fluoride mouth rinse, dental plaque disclosure, supervised toothbrushing and distribution of dentifrice and toothbrushes) and preventive dental treatment (fluoride varnish and fissure sealant) addressed to children. During this period, the implementation of state funding for dental assistance allowed an increased attendance of children, and the public sector of dental services was evaluated as effective for reducing inequalities in dental health in the Brazilian context (Antunes et al, 2003a; 2003b). Notwithstanding, the association between oral health status and dental care utilization has not yet been assessed, and the lack of information on this association during the 1990s is another shortcoming of the study.

Therefore, we observe that the conclusions of the current study should be interpreted cautiously, being solely considered as a prospective indication of effectiveness for the Brazilian dental health service; an appraisal that must be confirmed by further studies comprising longitudinal assessments and alternative analytical schemes.

REFERENCES

1. Ainamo J, Barmes D, Beagrie G, Cutress T, Martin J, Sardo-Infirri J. Development of the World Health Organization (WHO) community periodontal index of treatment needs (CPITN). Int Dent J 1982;32:281-291.
2. Antunes JLF, Frazão P, Narvai PC, Bispo CM, Pegoretti T. Spatial analysis to identify differentials in dental needs by area-based measures. Community Dent Oral Epidemiol 2002; 30:133-142.
3. Antunes JLF, Junqueira SR, Frazão P, Bispo CM, Pegoretti T, Narvai PC. City-level gender differentials in the prevalence of dental caries and restorative dental treatment. Health Place 2003a;9:231-239.
3. Antunes JLF, Pegoretti T, Andrade FP, Junqueira SR, Frazão P, Narvai PC. Ethnic disparities in the prevalence of dental caries and restorative dental treatment in Brazilian children. Int Dent J 2003b;53:7-12.
4. Ashley FP, Usiskin LA, Wilson RF, Wagaiyu E. The relationship between irregularity of the incisor teeth, plaque, and gingivitis: a study in a group of schoolchildren aged 11–14 years. Eur J Orthod 1998;20:65-72.
5. Brazil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Coordenação Nacional de Saúde Bucal. Projeto SB Brasil 2003 – Condições de saúde bucal da população brasileira 2002–2003: Resultados principais. Brasília, Distrito Federal, 2004.
6. Brown LJ, Loë H. Prevalence, extent, severity and progression of periodontal disease. Periodontol 2000 1993;2:57-71.
7. Chen M, Andersen RM. Oral health behaviour by social group. In: Chen M, Andersen RM, Barmes DE, Leclercq MH, Lyttle CS (eds). Comparing oral health care systems. A second international collaborative study. Geneva: World Health Organization, Center for Health Administration Studies 1997:75-89.
8. Clarkson JE, Worthington HV. Association between untreated caries and age, gender and dental attendance in adults. Community Dent Oral Epidemiol 1993;21:126-128.
9. Cons NC, Jenny J, Kohout FJ. DAI: the dental aesthetic index. Iowa City: College of Dentistry, University of Iowa 1986.
10. Davies TM, Shaw WC, Addy M, Dummer PM. The relationship of anterior overjet to plaque and gingivitis in children. Am J Orthod Dentofacial Orthop 1988;93:303-309.
11. Freire MC, Melo RB, Almeida e Silva S. Dental caries prevalence in relation to socioeconomic status of nursery school children in Goiânia, GO, Brazil. Community Dent Oral Epidemiol 1996;24:357-361.
12. Geiger AM. Malocclusion as an etiologic factor in periodontal disease: a retrospective essay. Am J Orthod Dentofacial Orthop 2001;120:112-115.
13. Gesser HC, Peres MA, Marcenes W. Condições gengivais e periodontais associadas a fatores socioeconômicos. Rev Saúde Pública 2001;35:289-293.
14. Glans R, Larsson E, Øgaard B. Longitudinal changes in gingival condition in crowded and noncrowded dentitions subjected to fixed orthodontic treatment. Am J Orthod Dentofacial Orthop 2003;124:679-682.
15. Haugejorden O. Using the DMF gender difference to assess the 'major' role of fluoride toothpastes in the caries decline in industrialized countries: a meta-analysis. Community Dent Oral Epidemiol 1996;24:369-375, Correction 25:192.
16. Holford TR. Multivariate methods in epidemiology. Oxford: Oxford University Press 2002.
17. Hunt RJ. Behavioural and socio-demographic risk for caries. In Bader JD (ed). Risk assessment in dentistry. Chapel Hill: University of North Carolina Dental Ecology 1990:29-34.

18. Jenkins B, Heasman P. The prevention and control of periodontal disease. In: Murray JJ, Nunn JH, Steele JG. Prevention of Oral Disease, 4th ed. Oxford: Oxford University Press; 2003:125-144.
19. Jenkins WMM, Papapanou PN. Epidemiology of periodontal disease in children and adolescents. Periodontol 2000 2001;26:16-32.
20. Kallio P, Murtomaa H. Determinants of self-assessed gingival health among adolescents. Acta Odontol Scand 1997; 55:106-110.
21. Nadanovsky P, Sheiham A. Relative contribution of dental services to the changes in caries levels of 12-year-old children in 18 industrialized countries in the 1970s and early 1980s. Community Dent Oral Epidemiol 1995;23:331-339.
22. Onyeaso CO, Arowojolu MO, Taiwo JO. Periodontal status of orthodontic patients and the relationship between dental aesthetic index and community periodontal index of treatment need. Am J Orthod Dentofacial Orthop 2003;124:714-720.
23. Ostberg AL, Halling A, Lindblad U. Gender differences in knowledge, attitude, behavior and perceived oral health among adolescents. Acta Odontol Scand 1999;57:231-236.
24. Snijders TAB, Bosker RJ. Multilevel analysis: an introduction to basic and advanced multilevel modeling. London: Sage Publications 2003.
25. Taani DQ. Relationship of socioeconomic background to oral hygiene, gingival status, and dental caries in children. Quintessence Int 2002;33:195-198.
26. Walsh J. International patterns of oral health care: the example of New Zealand. N Zeal Dent J 1970;66:143-152.
27. Watt RG, Marinho VC. Does oral health promotion improve oral hygiene and gingival health? Periodontol 2000 2005; 37:35-47.
28. World Health Organization. Oral health surveys: basic methods, 4th ed. Geneva: WHO 1997.