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Individual factors associated to malocclusion in adolescents

Adriana Gama Rebouças [1]
Luciane Zanin [1]
Gláucia Maria Bovi Ambrosano [2]
Flávia Martão Flório [1]

Abstract *The study aimed to identify the severity of malocclusions and associated factors among Brazilian adolescents. Data from 5,445 adolescents participating in the Brazilian Oral Health Survey (SBBrasil 2010) were evaluated, of which 4,276 were included in the study based on the inclusion criteria. The dependent variable was severe and very severe malocclusion, according to the Dental Aesthetic Index (DAI > 30). The independent variables were place of residence, macro-region, self-reported ethnicity, income, gender, schooling, access to dental care, untreated caries and front and back teeth loss due to caries. A hierarchical multiple logistical regression analysis was performed, considering the complex cluster sampling plan. Prevalence of severe/very severe malocclusions was 17.5%. After adjustments, black/brown ethnicity group (OR = 1.59, 95% CI: 1.09-2.34), lower household income (OR = 0.67, 95% CI: 0.55-0-82), front (OR = 2.32, 95% CI: 1.14-4.76) and back teeth (OR = 1.45, 95% CI: 1.14-1.84) loss due to caries were associated with the outcome. Therefore, we conclude that black/brown ethnicity, lower household income and greater number of front and back teeth loss due to caries increased the odds for severe/very severe malocclusion.*

Key words *Epidemiology, Orthodontics, Malocclusion*

[1] Faculdade de Odontologia e Centro de Pesquisas Odontológicas São Leopoldo Mandic. R. Dr. José Rocha Junqueira 13, Ponte Preta. 13045-755 Campinas SP Brasil. agreboucas@yahoo.com.br
[2] Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas. Piracicaba SP Brasil.

Introduction

Malocclusion results from changes in the growth and development of the craniofacial system, affecting jaw muscles and bones[1] and, due to its prevalence rate, the inclusion of orthodontics in the Brazilian public service was facilitated[2]. In Brazil, severe and very severe occlusopathies affect 6.6% and 10.3% of adolescents between the ages of 15 and 19[3] and cause functional and aesthetic disorders that impair social interaction and quality of life[1].

Although there is evidence that malocclusion is associated with poorer socioeconomic status[4-6], with the presence of dental problems such as caries[7], tooth loss[6,8] and periodontal disease[9], results have been diverse and the association between these aspects and malocclusion is unclear. Part of this divergence may be due to the use of different malocclusion evaluation indices[6].

Knowledge about the distribution of malocclusions in the population and the identification of factors and conditions associated with them allows the construction of models to understand their occurrence and to collaborate in the creation of public policies[4]. In this context, this study aimed to identify the severity of malocclusion in Brazilian adolescents aged 15 to 19 years and to analyze its association with clinical and demographic variables.

Materials and methods

This is a cross-sectional analytical quantitative study that used secondary data from the National Oral Health Survey – SBBrasil 2010[3], which was a survey conducted by the Ministry of Health, aiming to describe oral health conditions of the Brazilian population, besides collecting socioeconomic, demographic and quality of life characteristics of the population.

SBBrasil 2010 was conducted within the standards required by the Declaration of Helsinki and approved by the National Ethics and Research Council, under registration Nº 15.498 on January 7, 2010. It analyzed a representative sample of the Brazilian population, consisting of 37,519 individuals residing in 177 municipalities (including the 27 state capitals)[3].

The sample selection type of SBBrasil 2010 was probabilistic by cluster and structured in two stages for the capitals of the 26 states and the Federal District and in three stages for the rural municipalities of the five Brazilian regions. The primary sampling units were: (a) municipality, for the rural areas of the regions, and (b) census sector, for capitals[3]. The draw of individuals was made according to the number of permanent private urban dwellings of each census sector, data provided by the Brazilian Institute of Geography and Statistics (IBGE) in the 2007 census and by the quick count of households for SBBrasil 2010, sectors with data of 2000, as well as the proportion of people within each age group in the Brazilian age pyramid. This process generated a sample interval value and from this value, a number of individuals were drawn to be examined in each age group surveyed[3].

Previously trained and calibrated staff dentists of the Brazilian public health system evaluated individuals at their residence. Oral examinations were carried out to evaluate the prevalence and severity of major oral ailments and diseases and questionnaires were used to collect data on socioeconomic status, use of dental services and health perception[3].

The base population of this study consisted of 5,445 individuals of the 15-19 years age group. From the spreadsheet data, we excluded all individuals in which the clinical exams appeared to be not performed (n = 78). Next, those who lacked DAI values were excluded (n = 968). We then excluded individuals from the yellow/indigenous ethnic groups due to the low sample representativeness (1.8% and 0.8% respectively/n = 123)[10], reaching a final sample of 4,276 adolescents.

The Dental Aesthetic Index (DAI) was used to evaluate the severity of malocclusion. It takes into account ten components to which different weights are attributed: Crowding in incisal segments, incisal segment spacing, front maxillary irregularity and back mandibular irregularity, with weight 1; front maxillary prominence, with weight 2; incisal diastema and anteroposterior molar ratio, with weight 3; front mandibular sparing and vertical anterior open bite, with weight 4; and incisor teeth, canines and premolars lost, with weight 6. The 10 measures obtained are added to a constant (13) and generate a score that ranks individuals into four categories: Normal occlusion or small occlusal problems (score ≤ 25); definite malocclusion for which treatment is elective (score 26-30); severe occlusion with highly desirable treatment (score 31-35); severe or incapacitating malocclusion with the highest priority for treatment (score ≥ 36)[11].

For this study, the outcome variable was severe/very severe malocclusion (DAI > 30)[4], which

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indicates a need for highly desirable and top priority treatment[11].

The independent variables selected were: place of residence (capital or rural area), macro-region of residence, gender, self-referred ethnic group, schooling, household income, access to dental services, caries in front/back teeth and front/back teeth loss due to caries are detailed in Chart 1 and the analysis was performed based on a theoretical model with a hierarchical approach[12], which considers that distal factors (background) influence intermediate factors and these, in turn, influence proximal factors, which act more directly on the outcome.

Chart 1. Description of the independent variables and distribution according to the proposed hierarchical model.

Variables	Description	Used in this study
Distal Level - Demographic Characteristics		
Location	Resident of the State Capital or State Rural Region	1-Capital 2-Rural region
Region	Macro-region of residence	1-North 2-Northeast 3-Southeast 4-South 5-Midwest
Gender	Male or Female	1-Male 2-Female
Ethnic group	Self-referred Yellow and indigenous were excluded due to low representativeness (1.8% and 0.8% respectively) and blacks and browns were grouped into one category (Peres et al., 2013)[10]	1-White 2-Black/Brown
Distal Level - predisposition or facilitation variables		
Schooling	Based on the average schooling of 9.2 years of study found in the studied age range	1- <9.2 years 2- >9.2 years
Household income	Based on the SBBrasil2010 family socioeconomic characterization questionnaire	1-below R$ 500 2- R$501,00 to R$ 1,500 3- 1,501 to R$ 4,500 4- Over R$ 4,501
Intermediate Level - Oral Health Condition		
Decayed front teeth	Teeth decayed and restored with caries in the frontal region, according to the DMFT	1-Without caries 2-With caries
Decayed back teeth	Teeth decayed and restored with caries in the back region, according to the DMFT	1-Without caries 2-With caries
Dental service	Based on the questions: Have you ever been to the dentist? When did you last see the dentist?	0-Never 1-Less than one year ago 2-One/two years ago 3- Three years ago 2and over
Proximal Level - Dental Loss		
Loss of front teeth due to caries	Amount of teeth lost in the frontal region, according to the DMFT	0-None 1- =1 2- ≥2
Loss of back teeth due to caries	Amount of teeth lost in the back region, according to the DMFT	0-None 1- =1 2- ≥2

In constructing the model's hierarchy, the distal level was composed of demographic and predisposing characteristics, which have already been shown to be associated with malocclusion in previous studies[4,6]. At the intermediate level, mediation characteristics (caries, use of the dental service) were included, on which distal determinants may exert effects[13] and have already been associated with the demonstrated malocclusion[6,14]. Dental loss due to caries identified by the DMFT index was included at the proximal level because of a close relationship with malocclusion[4], including among Brazilian adolescents[15].

The association between DAI and the independent variables was evaluated through a hierarchical multiple logistic regression model. Data analysis was performed by *proc procedurefreq* and *proc surveylogistic* considering the complex sampling plan of conglomerates. Each observation received a specific weight, depending on the location, which resulted in weighted frequencies adjusted for the design effect.

The variables with p≤0.20 of each block were tested in the multiple logistic regression model, and those that continued to be associated with the DAI with $p \leq 0.05$ after adjusting for the variables of the same block and the hierarchically superior ones remained in the model.

Results

Among the 4,276 adolescents included in the sample, the prevalence of severe and very severe malocclusion (DAI > 30) was 17.5%. Table 1 shows the crude analysis of distal level variables in relation to the DAI, and we verified that the prevalence of individuals with severe and very severe malocclusion is significantly higher among those with lower household income ($p = 0.001$) and belonging to the black/brown ethnic group ($p = 0.0021$).

Table 2 shows the crude analysis of intermediate-level variables in relation to DAI. The frequencies of variables of this level (use of the dental service, caries in the front/back dental units) were not associated with severe and very severe malocclusion ($p > 0.05$).

At the proximal level (Table 3), the frequency of front/back teeth loss due to caries was higher among individuals with DAI > 30 ($p = 0.0002$ and $p = 0.0023$, respectively).

Table 1. Gross analysis of distal level variables in relation to DAI.

Variable	Category	DAI				p-value
		Without/elective		Desirable/severe		
		Frequency	%	Frequency	%	
Location	Capital	2,727	82.7	571	17.3	0,7252
	Rural area	802	82.0	176	18.0	
Region	North	988	82.1	216	17.9	0.4657
	Northeast	947	81.6	214	18.4	
	Southeast	623	82.0	137	18.0	
	South	458	83.3	92	16.7	
	Midwest	513	85.4	88	14.6	
Ethnic group	White	1,457	83.6	285	16.4	0.0021
	Black/Brown	2,072	81.8	462	18.2	
Household Income	Up to 500	566	81.7	127	18.3	< 0.001
	501 to 1,500	1,726	81.6	389	18.4	
	1,501 to 4,500	912	85.0	161	15.0	
	> 4,500	155	87.6	22	12.4	
Schooling	Up to 9 years	1,885	80.7	451	19.3	0.5290
	Over 9 years	1,635	84.8	293	15.2	
Gender	Male	1,589	82.1	346	17.9	0.4438
	Female	1,935	83.0	396	17.0	

In the hierarchical multiple logistic regression analysis, we verified that, among distal level variables, ethnic group and household income variables showed influence on DAI. Intermediate level variables were not significant in relation to DAI. At the proximal level, front/back teeth loss due to caries was directly associated with severe and very severe malocclusion (DAI > 30) (Table 4).

Table 2. Gross analysis of intermediate-level variables in relation to DAI.

Variable	Category	DAI				p-value
		Without/elective		Desirable/severe		
		Frequency	%	Frequency	%	
Dental service	Never	519	86.1	84	13.9	0.4776
	Less than one year	1,710	82.2	372	17.9	
	One to two years	813	81.4	185	18.5	
	Three years and over	438	82.6	93	17.5	
Caries in the back units	Without	1,764	84.9	317	15.2	0.4652
	With	1,765	80.4	430	19.6	
Caries in the front units	Without	3,087	83.9	591	16.1	0.1484
	With	442	73.9	156	26.1	

Table 3. Gross analysis of variables of the proximal level in relation to DAI.

Variable	Category	DAI				p-value
		Without/elective		Desirable/severe		
		Frequency	%	Frequency	%	
Loss of back units due to caries	0	2,896	84.9	514	15.1	0.0023
	= 1	317	73.4	115	26.6	
	≥ 2	316	72.8	118	27.2	
Loss of front units due to caries	0	3,514	82.9	727	17.1	0.0002
	= 1	12	52.2	11	47.8	
	≥ 2	3	25.0	9	75.0	

Table 4. Results of hierarchical multiple logistic regression analysis adjusted to describe the influence of the variables studied on DAI.

Variable	Estimated	[$]SE	[#]Adjusted OR	[&]CI95%	p-value
Intercept	0.9475	0.2336			<0.0001
Block I (Distal)					
Ethnic group					
White					
Black/Brown	0.2332	0.0978	1.59	1.09-2.34	0.0171
Household income	-0.3945	0.1002	0.67	0.55-0.82	< 0.0001
Block II (Intermediate)					
Not significant					
Block III (Proximal)					
Loss of front units due to caries	0.8446	0.3645	2.32	1.14-4.76	0.0205
Loss of back units due to caries	0.3743	0.1218	1.45	1.14-1.84	0.0021

[$] Weighted standard error of estimate; [#]Adjusted odds ratio; [&] Confidence interval of adjusted odds ratio.

Discussion

The SBBrasil 2010 sampling plan allowed for inferences at both the national and regional/municipal levels, both in the capital and rural areas realms[3]. In general, surveys based on large samples have relatively higher accuracy and can protect the study of random error[4], although the cross-sectional character of the design does not allow the inference of causality to the associations found[10]. In this study, we opted for the use of multivariate analysis due to the importance of investigating interactions between variables at different individual levels, which brings greater statistical efficiency[16].

Of the 4,276 individuals studied, the prevalence of adolescents aged 15-19 years with severe and very severe malocclusion was 17.5%, which represented a 15.3% reduction in the prevalence found seven years earlier in SBBrasil 2003[17]. The prevalence found in this study was higher than that found in Turkey (6.7%)[9] and in India (4.6%)[14], and lower than that found in other studies conducted in Peru (32.6%)[5] and Nigeria (43.9%)[18]. In Brazil, similar prevalence of malocclusion have been reported, of 16.5% (São Paulo)[4], and higher, of 24.7% (Seaside Camboriú)[19]. A very severe malocclusion (DAI > 35) reported a prevalence of 6.5% and 9.1% among Brazilian adolescents aged 12 and 15-19 years, respectively[6].

The divergence found in the comparison between different studies may be related to the use of different evaluation indices of malocclusion[9]. In addition, the difference between the age groups studied[4,5,9,19] and access to orthodontic treatment may differ between countries[5,18], which limits direct comparisons[6]. The lack of standardization in the measurement of events and obtaining samples that are not representative of the reference population, among other aspects, can significantly compromise the estimates generated and, consequently, the comparison of results[20].

The DAI used in the epidemiological survey is recommended by the WHO[3] and has been used worldwide in studies without modifications[3,5,14,18,19]. The use of standardized and globally recognized measures brings more confidence in the estimates generated and the comparison of the results.

Literature evidences that the demand for orthodontic treatment is higher among female adolescents than among male adolescents[21]. However, corroborating with several studies conducted in Brazil[4,6,8] and in other countries[5,9], in this study, the gender variable was not related to severe and very severe malocclusion. The difference in the search for orthodontic treatment between genders appears to be related to differences in perceived health and the value of oral health among them[22], since studies have already shown that female adolescents seek treatment for less severe conditions of malocclusion[21].

Also corroborating with previous national studies[6], in this study, severe and very severe malocclusion was not associated with the place of residence, either between capital and rural area or between the five Brazilian regions.

Dental loss, which has been reported to be the main risk factor for malocclusion[15], is the most important component in the calculation of DAI, an index used in the 2003 and 2010 surveys. Early tooth loss due to caries can lead to dental migrations that change the occlusal characteristics of individuals[7,8]. Adolescents with caries experience evaluated by the DMFT are more likely to show midline, open bite and Angle Class II and III molar relationships[7].

In this study, the association between front and back teeth loss due to caries and malocclusion was also significant, and remained in the hierarchical model. Due to the association between malocclusion and tooth loss, and considering its high weight in the classification of malocclusion by the DAI, we can consider that reduced prevalence rates of severe and very severe malocclusion among Brazilian adolescents are related to the great reduction in dental loss rates in this age group during the same period[3,17]. While at SBBrasil 2003 the median number of missing teeth for this age group was 0.89[17], this value dropped to 0.38[3] in the SBBrasil 2010.

In the studied age range, the frequency of severe and very severe malocclusion was significantly higher among non-white individuals. This association was maintained after hierarchical multiple logistic regression analysis. Previous studies on malocclusion in the Brazilian population have shown similar results[4,6]. In addition to association with malocclusion, non-white individuals were associated with the highest risk of early dental loss among Brazilians[23].

Racial inequalities in oral health in Brazil have already been evidenced, with a greater vulnerability of the black population against whites[24], and contextual factors related to the human development profile, income distribution and access to health care policies seem to play an essential role in the characterization of the vulnerability of population groups to oral health

diseases[24]. In this study, the observed relationship between malocclusion and ethnicity may be an important indicator of Brazilian socioeconomic inequities. It has already been shown that both tooth loss[25] and severity of malocclusion[16,26] are associated with household income. The loss of permanent teeth due to caries is associated with severe malocclusion and may be a social exclusion marker, characterizing adolescents with fewer life opportunities[6].

Socioeconomic aspects and schooling of each individual directly influence their oral health conditions, because these factors are associated to the level of knowledge of healthy life habits and, consequently, to a greater or lesser degree of recognition of the need for dental care[27]. An example of this is the fact that the search for orthodontic treatment is greater among individuals with higher schooling[28,29].

In the interval between the epidemiological surveys in oral health, Brazil was experiencing a period of economic growth that was mainly responsible for reducing extreme poverty (people living on less than US$ 1.25 per day) in the country[25]. Brazil reduced extreme poverty to less than one-seventh of the 1990 level, from 25.5% to 3.5% in 2012, exceeding the overall goal of the United Nations Millennium Development Goals of reducing extreme poverty to half the 1990 level by 2015[30].

Risk and protection factors may have unequal effects on social strata, with deleterious or salutary effects that affect the population in heterogeneous fashion and increase health inequalities[31]. Reduced poverty in a country brings improvements to people's living conditions, which reflects positively on the health of the population[25]. In this study, individuals with lower household income had a higher prevalence of severe and very severe malocclusion, and there may be a possible relationship between Brazilian economic growth and decreased prevalence of malocclusion among Brazilian adolescents.

In addition to the Brazilian economic growth for the period, we must consider the fact that, prior to SBBrasil 2003, the country had no State policy focused on oral health, but rather specific and isolated actions of health promotion and prevention of diseases and injuries[25]. The implementation of the National Oral Health Policy in 2004, the increased oral health teams in the Family Health Strategy and the increased population covered by these programs may have contributed to reduce the number of teeth lost due to caries in adolescents and, consequently, curb the prevalence of severe and very severe malocclusion found by SBBrasil 2010 in this age group.

These aspects demonstrate the existence of a complex interrelationship between socioeconomic determinants and access to basic oral health services with severe and very severe malocclusion among Brazilian adolescents, and its prevalence among adolescents living in conditions of greater vulnerability may point to it as a social exclusion indicator.

The inclusion of orthodontic treatment in the Brazilian public health system[2] requires the establishment of screening methods to identify those with the greatest needs for treatment. The DAI allows this screening, since linking mathematical, objective and clinical factors to subjective aesthetic factors produces a unique score that reflects both aspects of malocclusion[5]. The cutoff point in this study was based on the classification of the need for treatment, separating individuals without indication or requiring elective treatment (DAI<31) from those who, according to the DAI, require a highly desirable and maximum priority treatment (DAI > 30)[11]. The prioritization of this part of the population would allow the best use of the limited resources available in the public service.

Although DAI is recommended by the WHO[11] and has been used worldwide in studies on the need for orthodontic treatment[14,32], this index may underestimate the occurrence of malocclusion because it does not include conditions such as posterior crossbite, deep bite or midline changes[19], which may bring limitations to this study. In addition, factors frequently related to malocclusion, such as prolonged retention of deciduous teeth, facial region trauma[15], buconasal respiratory pattern, sucking habits, lingual interposition and atypical swallowing[33] were not evaluated in SBBrasil and it was not possible to assess the association of these disorders with malocclusion.

Malocclusion is a multifactorial public health problem and access to orthodontic treatment must be ensured to those with lower household income and who are more vulnerable to oral health problems in order to achieve oral health equity.

Conclusion

Following hierarchical multiple logistic regression analysis, we concluded that the lower the household income, the greater the number of front and back units lost due to caries, the greater the odds of severe and very severe malocclusion (DAI > 30), as well as that the black/brown ethnic group are more likely to have severe and very severe malocclusion.

Collaborations

AG Rebouças, LZ Souza and FM Flório devised the study; GMB Ambrosano performed the statistical analysis and contributed to the final and critical review of the manuscript; AG Rebouças conducted the study and writing of the manuscript; FM Flório and LZ Souza contributed with the final and critical review of the manuscript.

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