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Contextual and individual factors associated with dental pain in adolescents from Southeastern Brazil

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Abstract: The aim of this study was to assess the factors associated with dental pain in adolescents from the state of Minas Gerais, Brazil. Individual data on adolescents aged 15 to 19 years were collected from the SB Minas survey secondary database. Dental pain over the past 6 months, assessed by a questionnaire, was used as the dependent variable. Sex, income, skin color, prevalence of untreated dental caries, periodontal health, dental treatment needs, and time of last dental appointment were analyzed as individual covariates. Allocation factor, Human Development Index (HDI), Gini coefficient, illiteracy rate, unemployment, 50% and 25% of the Brazilian monthly minimum wage, primary healthcare coverage, oral health team coverage, access to individual healthcare, and supervised toothbrushing average rate were the analyzed contextual variables. A multilevel analysis was conducted for the individual and contextual variables. Statistical analyses used hierarchical linear and nonlinear modeling to infer an association between the different levels. Male adolescents had a lower prevalence of dental pain (OR = 0.53; 95%CI = 0.37–0.75). There was an association between dental pain and low income (OR = 1.58; 95%CI = 1.07–2.33), prevalence of untreated dental caries (OR = 1.25; 95%CI = 1.11–1.40), periodontal health (OR = 1.80; 95%CI = 1.04–3.09), and dental treatment needs (OR = 6.93; 95%CI = 3.96–12.14). Sociodemographic and clinical factors at the individual level were associated with the outcome but not with contextual variables. These findings reinforce the need to address these factors for effective community health actions.

Keywords: Adolescent; Social Determinants of Health; Multilevel Analysis.

Introduction

The physical, social, and psychological impacts of dental pain can exert a negative influence on quality of life.[1] The etiology of dental pain is commonly related to dental caries, periodontal disease, and traumatic tooth injury.[1,2] Dental pain is a public health problem.[1,3,4] In Brazil, caries experience increases from 43.5% to 76.1% during adolescence, affecting 99% of Brazilians aged 35 to 44 years,[5] and dental caries is strongly associated with dental pain. Moreover, dental pain has been associated with loss of work productivity, school absenteeism, difficulty sleeping, refusal to eat certain foods, and greater use of healthcare services,[1,2,3,6-9] which often

result in mutilating treatment (extraction)[7] and high treatment costs.[1]

The literature reports that individual (behavioral) and contextual factors are associated with dental pain, especially with lower socioeconomic status.[2,10,11] This outcome is also more common in individuals with less access to primary healthcare and with a lower degree of social development measured by the Human Development Index (HDI).[12]

Adolescence is the period of development between the ages of 10 and 19 years,[13] during which important biological and psychosocial changes occur.[13,14,15] A high prevalence of dental caries, gingival bleeding, and tooth loss has been commonly found in adolescents.[14,16] Despite the existence of public policies that benefit this group, such as a fluoridated water supply and universal healthcare, there are few specific programs directed at the oral health of adolescents. Moreover, the adoption of harmful behaviors, such as smoking, alcohol consumption, and inappropriate eating habits, increases the risk of dental caries in this group.[9,17]

Most studies with adolescents evaluate dental pain in terms of clinical aspects and/or socioeconomic issues at the individual level.[2,7] These individual clinical and socioeconomic aspects have been well documented in the literature. Adolescents from a worse socioeconomic background at an individual level are more exposed to risk factors for oral health problems.[2,10] However, this socioeconomic issue needs to be better addressed within a social context. Few studies have assessed a direct relationship between the context in which the individual is inserted and dental pain, mainly in adolescents.[15,18] Adolescents and their families from areas with a low HDI had a higher prevalence of dental pain than those in more developed areas, regardless of individual characteristics.[18] Therefore, it is fundamental to assess health outcomes using multilevel analysis. This strategy allows inferences at the contextual and individual levels[11] and it is essential to underpin public policies to tackle oral healthcare needs, mainly in adolescents. Health promotion actions and intersectoral policies focusing on social development through improvements and on the expansion of primary healthcare should be implemented to reduce social inequalities related to oral health disparities. In summary, the clarification of this issue could provide more precise actions for the planning of social and health policies.

Therefore, the aim of the present study was to investigate the factors associated with dental pain in adolescents from a state in Southeastern Brazil. The null hypothesis was that dental pain is associated with socioeconomic and clinical factors.

Methodology

In 2012, the Minas Gerais Oral Health Study was performed to evaluate the oral health status of residents of the state of Minas Gerais, which is located in Southeastern Brazil.[19] Minas Gerais is the second most populated state in Brazil, with 21,168,791 inhabitants, and the third wealthiest state based on gross domestic product data.[20] The state has 853 municipalities. It ranks ninth among the 27 Brazilian states in terms of HDI and eighth in active formal employment among residents aged 16 years or older.[21] The municipalities included in the study (n = 61) were grouped into three broad domains: Capital, Inland I, and Inland II, based on the "city allocation factor" used to distribute the state tax revenue for healthcare.[22,23] The Inland I group included more autonomous/less vulnerable municipalities, whereas the Inland II group comprised less autonomous/more vulnerable municipalities. Thirty municipalities chosen through careful randomization methods were included in each of these two groups.[19]

With the objective of maintaining the same methodology, the process used was the same as that employed for the SB Brazil 2010 survey. Sample size was also based on the severity of dental caries, estimated by the DMFT (decayed, missing, and filled teeth) index according to SB Brazil 2010 data for the southeastern region. For each age group and each domain, the prevalence of dental caries and the DMFT average were used as reference for sample size calculation in association with a predefined margin of error. The proposed design allowed estimating the number of dental caries in each domain for the state of Minas Gerais, considering each age group. For other healthcare problems, the degree of representativeness varied according to the estimated prevalence and severity. A representative sample for the state of

Minas Gerais was estimated and a 95% confidence interval and an 80% statistical power were obtained for the variables used in this study.[19]

Oral examinations were performed by teams that consisted of one dentist and one assistant. All examiners and assistants had undergone training and calibration exercises. Inter-examiner agreement (Cohen's Kappa) was > 0.65. The examinations were performed in a well-lit room with the aid of mouth mirrors and probes and followed the World Health Organization recommendations.[24] In addition, oral health indices (DMFT index and the Community Periodontal Index (CPI)), were used by the same calibrated teams for demographic and socioeconomic status, use of dental services, and dental treatment needs.

For this study, the data on adolescents aged 15 to 19 years were extracted from the Minas Gerais Oral Health Study database. The dependent variable consisted of dental pain experience, which was determined by the answers to the following question: "Have you had a toothache in the past six months?" The independent variables considered two levels: individual variables (Level 1) and contextual variables (Level 2). Level 1 included sex, family income, skin color, prevalence of untreated dental caries, periodontal health, dental treatment needs, and time of the last dental appointment, all of them extracted from the Minas Gerais Oral Health Study database[19] Level 2 comprised the HDI, which was extracted from the Brazilian section of the United Nations Development Programme;[25] Gini coefficient,[25] illiteracy rate, unemployment, earnings on the order of 50% of the Brazilian monthly minimum wage (BMMW), and earnings on the order of 25% of the BMMW, extracted from the Brazilian Institute of Geography and Statistics,[26] Primary Healthcare Coverage, Oral Health Team Coverage, records on the access to individual dental care, and from the supervised toothbrushing score.[13] Table 1 shows a description of the exposure variables for Levels 1 and 2.

Statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS for Windows, version 16.0) and the hierarchical linear and nonlinear modeling (HLM 6.08 statistical package).[25] Multilevel analyses were used to determine associations between the absence or presence of dental pain in the past 6 months and the exposure (contextual and individual) variables.

All analyses were made using the complex samples module to account for the complex sampling design of the Minas Gerais Oral Health Study. The multilevel analyses included 1,200 individuals from 57 municipalities. To achieve that, nonlinear logit link function analyses were conducted with fixed or random effects models. The parameters were estimated using a restricted maximum likelihood method (predictive quasi-likelihood). A multilevel logistic regression model was used. In the first stage, a null model estimated the basic partition of the data variability between the two levels before the individual and contextual characteristics were taken into account.

Level 1 variables were first incorporated into the model one by one before being tested together ($p < 0.05$). Next, the contextual variables (Level 2) were incorporated one by one and associations were tested using the Student's *t*-test ($p < 0.05$). The multilevel model was created using all variables with a p-value < 0.25. Odds ratios (OR) and the respective 95% confidence intervals (CI) were estimated in each analysis. The reliability estimate was used to determine the adequacy of the final multilevel model, which included only variables with a p-value < 0.05.

Results

The prevalence of self-reported dental pain in the past 6 months was 23.1%. Most participants were female (55.3%) and non-white (59.6%) and had a monthly family income of up to R$ 1,500 (57.7%), which was equivalent to approximately US$ 830. A total of 34.6% of the participants had gingivitis or dental calculus, 46.6% needed dental treatment, 51.6% had their last dental appointment in the previous year, and 60.2% did not have untreated dental caries (Table 2).

The null model indicated differences in dental pain experience among the 57 municipalities evaluated in the present study ($p < 0.001$). Among the 61 municipalities that had been originally selected (Inland I, n = 30; Inland II, n = 30; Capital, n = 1), three withdrew from the study (Table 3).

Table 1. Description of independent variables according to the level of analysis involving adolescents, SB Minas Gerais, Brazil, 2012.

Variables	Description
Level 1 – Individual	
Sex	Male – Female
Family Income	Up to $830 – More than U$830
Skin Color	Self-reported skin color; a dichotomous variable was created from five original categories (white or non-white)
Prevalence of dental caries*	Dichotomous: presence or absence
Periodontal health	Absence of disease Gingivitis/Dental calculus Probing depth greater than 3 mm Less than two functional teeth in at least one sextant
Treatment needs	No need (healthy crown and root) One surface restoration Two or more surface restorations Prosthetic crown needed for any reason Dental facet Pulp treatment and restoration Tooth extraction White spot treatment Sealant
Last dental appointment	Less than 1 year More than 1 year Never
Level 2 – Municipal	
HDI	Human Development Index
Domain	Capital, Inland I, Inland II
Gini coefficient	Income or wealth distribution
Illiteracy	Percentage (%) of individuals who cannot read or write and have no language proficiency in the total resident population in the minimum age range in a geographic space within the considered year
Unemployment	Percentage (%) of economically active unemployed individuals during the reference week in a geographic space within the considered year
50% BMMW	Percentage (%) of residents with monthly family income per capita up to 50% of the Brazilian monthly minimum wage in a geographic space within the considered year
25% BMMW	Percentage (%) of residents with monthly family income per capita up to 25% of the Brazilian monthly minimum wage in a geographic space within the considered year
Oral health team coverage	Percentage (%) of the population covered by Oral Health Teams
Primary health care coverage	Percentage (%) of the population covered by Primary Health Care teams
Access to individual dental care (registered with scheduled treatment program)	Percentage (%) of residents who receive a scheduled primary dental consultation with the aim of diagnosing and drafting a preventive/therapeutic plan to address the detected needs, calculated as a percentage of the population
Supervised tooth brushing average	Percentage (%) of collective actions of supervised toothbrushing

HDI: Human Development Index; *decayed component.

The results of the unadjusted or crude analyses (Model 1) showed that, at the individual level, dental pain was associated with sex (male), skin color (non-white), family income (< $830), presence of dental caries, probing depth > 3 mm, and dental treatment needs. After adjusting for potential confounders, the final adjusted multilevel analysis (Model 2) showed that male adolescents were less likely to have dental pain compared to females (OR = 0.53; 95%CI: 0.37 to 0.75). Moreover,

Table 2. Descriptive analysis of individual variables for the sample of adolescents (n = 1,200), Minas Gerais Oral Health Study, Brazil, 2012.

Variables*	N	% (95%CI)†
Dependent		
Dental pain in previous 6 months*		
No	925	76.9 (73.7–79.8)
Yes	275	23.1 (20.2–26.3)
Independent (individual level)		
Sex		
Male	533	44.7 (41.2–48.3)
Female	669	55.3 (51.7–58.8)
Family Income*		
Up to U$830	742	57.7 (52.2–63.0)
More than U$830	402	42.3 (37.0–47.8)
Skin color		
White	469	40.4 (35.9–45.0)
Non-white	733	59.6 (55.0–64.1)
Dental caries*,**		
Absent	694	60.2 (56.0–64.2)
Present	506	39.8 (35.8–44.0)
Periodontal health*		
Absence of disease	663	52.6 (47.6–57.5)
Gingivitis/Dental calculus	392	34.6 (30.3–39.3)
Probing depth greater than 3 mm	81	8.2 (5.2–12.8)
Less than two teeth	50	4.6 (2.9–7.0)
Treatment needs		
None	619	53.4 (49.3–57.5)
Needs	583	46.6 (42.5–50.7)
Last dental appointment*		
Less than 1 year	618	51.6 (48.0–55.1)
More than 1 year	432	37.3 (34.3–40.5)
Never	146	11.1 (8.5–14.3)

*Missing values for some variables; **sampling design taken into account + decayed component

individuals with a monthly family income of less than < $830 were more likely to have dental pain compared to those who earned more than < $830 (OR = 1.58; 95%CI: 1.07 to 2.33). The presence of untreated dental caries increased the likelihood of dental pain (OR = 1.25; 95%CI: 1.11 to 1.40) (Table 4). In addition, adolescents with probing depth greater than 3 mm were more likely to have dental pain compared to those whose probing depth was within the normal range (OR = 1.80; 95%CI: 1.04 to 3.09). The risk for dental pain was 6.93% higher in individuals with dental treatment needs (95%CI: 3.96 to 12.14) (Table 4). No associations were observed for the contextual variables.

The descriptive analysis of the contextual variables is shown in Table 5.

In the final model, 20.1% of the variance in dental pain was explained by the contextual variables.

Discussion

The present study provides a panorama of the individual and contextual factors of an important oral health problem: dental pain. Nearly 25% of the adolescents reported at least one episode of dental pain and this problem was more frequent in adolescents with at least one caries-affected tooth, in those with periodontal disease, in those with dental treatment needs, and in those from low-income families.

Adolescence is a period of gradual transition from childhood to adulthood, and it is characterized by physiological, psychological, and social changes.[13-15] This period is critical for health, including oral health, because adolescents are more vulnerable to socioeconomic risk factors and, consequently, more likely to engage in unhealthy behaviors, including smoking, alcohol consumption, and unhealthy oral hygiene practices.[29] Dental pain is the most common symptom of oral diseases and it is strongly associated with treatment needs.[17] In this study, almost 25% of the adolescents had this outcome. The prevalence of dental pain is variable. In Brazil, the prevalence ranges from 21.2% to 36.4%.[2,7,17] Generally, there are differences in methodology and in the periods during which the outcome was measured.[2] Indeed, a longer period of investigation increases the likelihood of forgetfulness and underestimation of pain.[2] Furthermore, access to and use of oral health care may differ.[15]

Table 3. Final estimation of variance components in the multilevel analysis – "null model".

Random effect	Standard deviation	Variance component	df	Chi-square	p-value
Intercept, U0	0.91109	0.83009	55	178.61	< 0.001

df: degrees of freedom

Table 4. Multilevel models (1-crude and 2-adjusted) for individual and contextual variables associated with dental pain in adolescents. Minas Gerais. Brazil. 2012.

Models	OR[1]	(95%CI)	p-value	RE	OR[2]	(95%CI)	p-value	RE
Individual level								
Sex								
Female	1.00				1.00			
Male	0.52	(0.37–0.74)	< 0.001	0.633	0.53	(0.37–0.75)	0.001	
Family income								
≥ U$830	1.00				1.00			
< U$830	1.64	(1.12–2.40)	0.012	0.632	1.58	(1.07–2.33)	0.021	
Skin color								
White	1.00							
Non–white	1.51	(1.06–2.16)	0.024	0.632				
Dental caries*								
Absence	1.00				1.00			
Presence	1.39	(1.26–1.53)	< 0.001	0.657	1.25	(1.11–1.40)	< 0.001	
Periodontal health								
Absence of disease	1.00				1.00			
Gingivitis/Dental calculus	1.39	(0.73–2.64)	0.316		1.22	(0.63–2.35)	0.553	
Probing depth > 3 mm	2.35	(1.48–3.75)	< 0.001	0.633	1.80	(1.04–3.09)	0.034	
≤ 2 teeth	2.33	(0.97–5.60)	0.059		2.08	(0.85–5.05)	0.108	
Treatment needs								
None	1.00				1.00			0.696
Needs	9.45	(5.73–15.56)	< 0.001	0.672	6.93	(3.96–12.14)	< 0.001	
Last dental appointment								
≤ 1 year	1.00							
> 1 year	1.96	(0.82–4.70)	0.129	0.631				
Never	1.27	(0.85–1.91)	0.245					
Contextual level								
Allocation factor	1.01	(0.20–4.95)	0.989	0.634				
HDI	0.43	(0.00–67.41)	0.742	0.634				
Gini coefficient	0.39	(0.00–1786.4)	0.823	0.634				
Illiteracy	1.00	(0.97–1.05)	0.726	0.634				
Unemployment	1.13	(1.01–1.27)	0.025	0.608				
50% BMMW	1.01	(0.99–1.03)	0.172	0.631				
25%BMMW	1.01	(0.99–1.04)	0.197	0.631				
Oral Health Team Coverage	1.00	(0.99–1.01)	0.480	0.634				
Primary Healthcare Coverage	0.99	(0.99–1.01)	0.944	0.634				
Access to individual dental care	0.98	(0.94–1.02)	0.283	0.626				
Supervised toothbrushing average	0.98	(0.87–1.11)	0.808	0.634				

RE: reliable estimation; SD: standard deviation; BMMW: Brazilian monthly minimum wage; OR: odds ratio HDI: Human Development Index.

In the present study, male adolescents were less prone to have dental pain than were girls. There is no consensus in the literature yet. Some investigations have shown that female adolescents/women report more dental pain, whereas men are less likely to complain given the stereotype of men as strong.[14,17,29] In addition, another possible explanation is that the difference between sexes may be related to the hormone cycle, which exerts an influence on the pain threshold. It is important to bear in mind that dental pain may be influenced by biological, cultural, and psychological factors as well as expectations about social roles.[9]

Table 5. Descriptive analysis of contextual variables. Minas Gerais. Brazil. 2012.

Variable	Mean	SD	P25	P50	P75
Allocation factor	1.416	0.203	1.237	1.402	1.594
HDI	0.693	0.061	0.639	0.697	0.751
Gini coefficient	0.499	0.046	0.473	0.495	0.524
Illiteracy	11.674	7.890	5.250	9.100	16.850
Unemployment	38.922	17.459	21.985	35.780	55.210
50%BMMW	15.613	10.625	6.050	12.540	22.900
25%BMMW	66.620	33.349	35.900	73.370	100.000
Oral Health Team Coverage	50.259	39.312	12.825	46.890	94.925
Primary Healthcare Coverage	10.803	9.401	4.070	7.190	16.425
Access to individual dental care	3.536	3.829	0.660	1.820	5.830
Supervised tooth brushing average	11.674	7.890	5.250	9.100	16.850

Adolescents from low-income families were more prone to develop dental pain than those from a better socioeconomic background. The association between the greater occurrence of dental pain and unfavorable socioeconomic status is a common finding.[6,9,10,12,16,17] Individuals from poor families tend to be at a higher risk for a wide variety of stressors and for some physical exposures that can influence psychosocial, physiological, and behavioral aspects during their lifetime.[30] Moreover, family income can lead to inequalities in oral healthcare as a result of differences in the availability of economic resources, which interferes with the frequency of visits to the dentist.[31] All these aspects can contribute to or compromise their overall health, including oral health.

Untreated dental caries may predispose to dental pain. This finding is similar to those described in the literature.[6,10,32] More advanced stages of dental caries require more invasive treatment and involve greater pain experience, thereby restricting the daily activities of affected children and adolescents.[33] Untreated caries on permanent teeth is the most prevalent condition, affecting 2.5 billion people around the world.[34] One of the most serious consequences of untreated caries is dental pain and/or tooth loss. This reflects the oral health history of individuals and their access to health services, including oral health.[35] In addition, this finding suggests that more appropriate approaches and interventions are necessary to reduce and/or control dental caries.[6]

Periodontal diseases (probing depth greater than 3 mm) were associated with the outcome. This finding may be related to gingival bleeding and dental plaque, important factors that exert a negative impact on the quality of life of adolescents, with psychosocial consequences such as embarrassment when smiling and difficulty brushing one's teeth because of the fear of gingival bleeding.[14] A study conducted in Brazil has shown that periodontal health status, such as probing depth greater than 3 mm, was associated with dental pain in adults.[11] This condition may perpetuate unhealthy oral habits that cause dental pain.

In this study, adolescents with dental treatment needs were more likely to have dental pain. Dental treatment needs are important for the effective planning and implementation of oral healthcare services.[32] In addition, dental pain may be related to the use of dental services.[4] According to data from the Brazilian Ministry of Health,[5] dental pain was one of the main reasons for dental visits in Brazil in different age groups. Concerning municipal variables, we assessed the access to oral health services and oral health coverage. Despite the lack of association between them, it is important to increase access to oral health and oral health coverage in municipalities[11] to reduce inequalities.

As for the contextual variables in this study, no association was found for dental pain in adolescents. The literature has shown that adolescents from areas with a high HDI had a lower dental pain prevalence than those from areas with a low HDI.[17] The literature reports that HDI can have an impact on the prevalence of dental caries,[36] which is the main factor for dental pain. Some authors suggest that residents of poorer

municipalities are at greater risk of disease due to poorer eating patterns, inadequate oral hygiene, lower level of education, and less access to and use of healthcare services.[2,8] However, pain is a complex phenomenon influenced by biological, cultural, and psychosocial factors.[2] One explanation for this negative association was the homogeneity of the sample.

Among the implications of the present findings for oral health policies and programs, the association of family income (at the individual level) with oral health outcome underscores the need to understand the underlying effects of oral health inequalities on dental pain so that enable effective actions can be taken to tackle this important public health problem.

Regarding the implications for administrators, health services, and dentists, primary, secondary, and tertiary health prevention/promotion protocols should consider the high prevalence of dental pain among adolescents, and include some strategies such as reducing sugar consumption, increasing access to fluoride, and focusing on appropriate approaches for those adolescents with dental pain.[15]

The literature points out that oral health problems can be exacerbated in adolescence, especially as a result of socioeconomic and demographic (sex) factors, among other determinants.[16] To optimize the general well-being of adolescents, it is necessary to plan comprehensive oral health actions to promote treatments that meet their needs.[37,38]

The present study has limitations that should be considered. The use of a cross-sectional study to test associations does not allow determining the cause-and-effect relationship between the variables. Longitudinal studies are thus needed to analyze clinical, social, and economic factors in the longer term to establish causal relations. There is also the possibility of recall bias, since the outcome source data relied on adolescents' memories. However, the main methodological strengths of this study are the use of a large representative population-based sample, providing better external validity. In addition, dental examiners were regarded as highly reliable, wielding sufficient power for the detection of important associations and multilevel analyses, which may contribute to a broader understanding of dental pain among adolescents.

Conclusions

Individual factors such as sex, family income, clinical oral conditions, and dental treatment needs were associated with dental pain in 15- to 19-year-old adolescents. In addition, in this study, there was no association between contextual variables and the outcome. Thus, the data of this study contribute to the identification and planning of interventions focused on the prevention and reduction of dental pain.

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