Impact of oral health on physical and psychosocial dimensions: an analysis using structural equation modeling

Impacto da saúde bucal nas dimensões física e psicossocial: uma análise através da modelagem com equações estruturais

Impacto de la salud oral en las dimensiones física y psicosocial: un análisis de modelos de ecuaciones estructurales

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Abstract

This study aimed to estimate the prevalence of impact of oral health conditions on physical and psychosocial dimensions among adolescents and to identify factors associated with severity of impact. The impact of oral health status was assessed by the instrument Oral Health Impact Profile *(OHIP-14). The covariates were: socioeconomic status, habits and health care, use of dental services, and normative conditions of oral health. Structural equation modeling was performed, and 15.6% of adolescents reported impact in at least one dimension of the OHIP-14. The dimensions that showed the highest prevalence of impact were psychological distress (11.8%) and physical pain (6.6%). The number of teeth needing dental treatment, number of filled teeth, and CPI significantly affected severity of impact. In this adolescent population, unfavorable socioeconomic conditions were associated with reduced use of dental services, associated in turn with precarious oral health conditions and increased severity of impact.*

Oral Health; Health Evaluation; Multivariate Analysis; Adolescent

Resumo

O objetivo deste estudo foi estimar a prevalência do impacto das condições de saúde bucal nas suas dimensões física e psicossocial entre adolescentes, bem como identificar os fatores associados à gravidade do impacto. O impacto das condições de saúde bucal foi avaliado pelo instrumento Oral Health Impact Profile *(OHIP-14). As covariáveis foram: condição socioeconômica, hábitos e cuidados com a saúde, uso de serviços odontológicos e condições normativas de saúde bucal. Foi realizada a modelagem de equações estruturais. Quinze vírgula seis por cento dos adolescentes relataram impacto em, pelo menos, uma dimensão do OHIP-14, as dimensões que apresentaram maior prevalência de impacto foram desconforto psicológico (11,8%) e dor física (6,6%). O efeito do número de dentes com necessidade de tratamento, número de dentes restaurados e o CPI sobre a gravidade do impacto foram significativos. A condição socioeconômica desfavorável mostrou-se associada à menor frequência de uso dos serviços odontológicos, que estão associados às precárias condições de saúde bucal, que se relacionaram à maior gravidade do impacto.*

Saúde Bucal; Avaliação em Saúde; Análise Multivariada; Adolescente

Introduction

Adolescence is a phase of biological and psychosocial growth between childhood and adulthood, characterized by various body changes and adaptations to new psychological and environmental structures [1]. New behaviors and lifestyles are formed, involving eating habits, personal hygiene, physical activity, smoking, and alcohol and drug use, which can influence future disease patterns [2]. Adolescents prove more vulnerable to some of these behaviors, since they no longer benefit from the care and attention given to children, nor do they enjoy the protection afforded by the maturity of adulthood [3]. Adolescence is also a phase in which young people learn positive attitudes and behaviors that will last into the future, thus representing a crucial time for health promotion [4], including that of oral health.

Oral health is part of overall health and is essential to quality of life [5]. It is perceived as comfortable and functional dentition with an appearance that allows persons to fulfill their social roles and daily activities without physical, psychological, or social impediments [6]. Oral problems can cause pain, discomfort, problems in eating, communication, and appearance and thus in social contact and self-esteem [7]. Adolescents' oral health has also been assessed in studies that consider objective or normative conditions of oral health (conducted by dentists according to established standards) [8]. Such studies focus on dental and/or oral conditions and treatment assessment, while overlooking persons' subjective experiences. However, normative conditions alone do not indicate the degree to which people feel affected by their oral health status [9].

In this sense, based on the limitation of studies focused exclusively on normative aspects, researchers have studied oral health problems as important sources of negative impact on individuals' daily performance and quality of life [7,10]. Several instruments have been used to assess subjective oral health issues [11,12,13], including the *Oral Health Impact Profile* (OHIP-14), developed to assess the social impact of the dysfunctions, discomforts, and handicaps attributed to oral conditions. The scale has been translated and validated in various countries including Germany (2002), Sri Lanka (2003), Japan (2004), Italy (2005), and Spain (2009). In Brazil, several studies have assessed the instrument's psychometric properties [14,15,16], including the work by Oliveira & Nadanovsky [14].

However, few studies have investigated the impact of oral health on physical, psychological, and social dimensions in adolescents. In other population groups, this question has been studied using classical statistical techniques. However, such analyses do not allow identifying the effect size considering (through a cross-sectional study) the complexity of theoretical models that encompass multiple manifest and latent variables, which involve differences between groups, hierarchical effects, interaction, and mediation.

Structural equation modeling (SEM) emerged in the 1960s as the result of evolution in multiequation modeling, developed mainly in the fields of psychology, econometrics, and sociology [17]. Structural equation analysis is based on a theoretical framework defined *a priori* by the researcher, constructing a model for relations between the variables and later testing whether the data confirm the hypothetical model [18]. SEM allows the researcher to simultaneously analyze a series of relations of dependency, i.e., when a dependent variable becomes independent in subsequent relations of dependency, and not in isolation as is done traditionally in statistical analysis with classical techniques [18,19]. Another advantage of this technique is the possibility of incorporating latent variables into the analysis, i.e., variables that are not directly observable, but whose effects or manifestations are "felt" through other variables [18,19], like the impact of oral health, assessed by the OHIP-14 instrument.

The aim of the current study was to estimate the prevalence of impact of oral health conditions in their physical and psychosocial dimensions among adolescents and to identify the direct and indirect determinants of the impact's severity, using a multivariate structural equation model that allows a global analysis of the conditioning variables for oral health.

Method

Type of study and target population

The cross-sectional study resulted from the *Epidemiological Survey of Oral Health Conditions in the Population of Montes Claros, Minas Gerais State, 2008* [20]. The target population consisted of adolescents 15 to 19 years of age living in the urban and rural areas of the Municipality (County) of Montes Claros, Minas Gerais State, Brazil, in 2008.

Sample size and selection of sampling units

Since this was an epidemiological oral health survey that aimed to estimate the prevalence rates for dental caries, periodontal disease, malocclusion, fluorosis, and other oral health conditions, the sample size was set to estimate population

parameters with a prevalence of 0.50, which guaranteed a larger sample size. The study adopted a 95% confidence interval and tolerable sampling error (margin of error) of 5.5%. Corrections were performed for finite population and design effect, adopting *deff* equal to 2.0. An additional 20% was added to compensate for possible non-responses and losses. The calculations showed the need to examine and interview at least 761 individuals.

In the urban area, the sampling units were selected using two-stage probabilistic cluster sampling. In the first stage, simple random sampling was used to select 52 of the 276 urban census tracts. In the second stage, simple random sampling was used to select a sampling fraction of the blocks in each of the 52 selected tracts (proportional to the number of blocks in the tract). All the households in the selected blocks were visited sequentially and all the residents belonging to the target age bracket were invited to participate in the study. In the countryside, a single-stage probabilistic cluster sample was used in which the primary sampling units consisted of the rural areas. Two of the eleven rural areas were picked, and all the households located within 500 meters from a reference institution were selected [21].

Training and calibration of examiners, data collection and tabulation

Twenty-four trained and calibrated dentists participated in the data collection, assisted by 20 note-takers. In order to be considered fit for data collection, examiners had to have shown that they had effectively adopted the standardized diagnostic criteria for the target oral diseases, i.e., those examiners that reached satisfactory levels on the inter-examiner agreement scores, beyond chance (kappa coefficient and intra-class correlation coefficient ≥ 0.60) [22,23]. Data were collected using a palmtop computer with software created specifically for this purpose, which allowed simultaneous and automatic construction of the databank [24]. The interviews and oral examinations were conducted in the homes, according to the biosafety standards recommended by the Brazilian Ministry of Health [25]. The oral examinations were performed in a roomy environment, under natural lighting, with a previously sterilized mirror and CPI probe from the World Health Organization (WHO) [26].

Study variables

Prevalence and severity of impact were investigated with OHIP-14. The instrument consists of 14 items and assesses seven different dimensions, considering the individuals' perception towards the impact of oral conditions on their physical, psychological, and social well-being in the previous six months. Each item in OHIP-14 has a group of answers distributed in a gradual Likert-type scale, assessing the following dimensions: functional limitation, physical pain, psychological discomfort, physical limitation, psychological limitation, social limitation, and handicap (Table 1) [12].

Prevalence of impact was analyzed as a categorical variable that classified individuals in two groups: without impact (2 = sometimes, 1 = rarely, and 0 = never) and with impact (4 = always and 3 = repeatedly). When individuals reported impact in at least one item of OHIP-14, they were classified as with impact, otherwise they were considered without impact [27,28].

Severity of impact was treated as a latent variable. It was estimated as a second-order construct of OHIP-14, i.e., the 14 items from OHIP-14 were used as a structural equation model to estimate this latent variable.

Socioeconomic status was also treated as a latent variable, estimated as a construct operationalized by four manifest variables: per capita income, household crowding, years of schooling, and number of rooms in the household. Per capita income was measured as the ratio between monthly family income and number of residents in the household; household crowding was measured as the ratio between the number of residents and the number of rooms in the household; schooling was the number of complete years of school as of the interview date; and number of rooms in the household was the number in the household where the adolescent lived.

The section on habits and health care consisted of the following variables: number of cigarettes smoked per day (discrete numerical variable) and daily frequency of brushing (0 = three or more; 1 = twice; 2 = once; and 3 = none). Use of dental services was expressed as time since last visit to the dentist (0 = less than a year; 1 = one to two years; 2 = three years or more; and 3 = never visited a dentist).

The section on normative conditions of oral health included the following variables: number of teeth needing treatment (discrete numerical), number of filled teeth (discrete numerical), number of missing teeth (discrete numerical), dental aesthetic index – DAI (continuous numerical) [29], and community periodontal index – CPI (0 = healthy periodontium; 1 = presence of post-probing bleeding; 2 = presence of calculus; 3 = 4 to 5mm pocket; 4 = pocket 6mm or more) [26].

Table 1

Frequency of responses to items in *Oral Health Impact Profile* (OHIP-14), descriptive measures of socioeconomic variables, habits and health care, oral health conditions, and use of dental services among adolescents 15 to 19 years of age. Montes Claros, Minas Gerais State, Brazil, 2008-2009.

In the last six months, because of problems with your teeth, mouth, or dentures	**Frequency of responses (%)**					**Impact**
	0	**1**	**2**	**3**	**4**	**% (95%CI)**
Functional limitation						0.9 (0.3-2.8)
Item 1. Have you had trouble pronouncing any words?	92.9	3.3	3.3	0.3	0.3	
Item 2. Have you felt that your sense of taste has worsened?	95.0	2.1	2.4	0.2	0.3	
Physical pain						6.6 (4.0-10.8)
Item 3. Have you had painful aching in your mouth or teeth?	69.6	10.0	16.1	2.3	2.0	
Item 4. Have you found it uncomfortable to eat any foods?	75.6	8.5	11.8	1.9	2.4	
Psychological discomfort						11.8 (7.5-18.2)
Item 5. Have you felt self-conscious?	63.6	9.9	16.0	2.5	8.0	
Item 6. Have you felt tense?	82.9	4.5	7.3	1.6	3.7	
Physical limitation						2.8 (1.6-4.8)
Item 7. Has your diet been unsatisfactory?	86.3	5.3	6.1	0.8	1.5	
Item 8. Have you had to interrupt meals?	88.5	3.9	6.5	0.8	0.3	
Psychological limitation						4.1 (2.3-7.3)
Item 9. Have you found it difficult to relax?	87.6	5.8	4.9	1.0	0.7	
Item 10. Have you been a bit embarrassed?	83.4	5.6	8.0	0.7	2.2	
Social limitation						2.2 (1.0-4.7)
Item 11. Have you been a bit irritable with other people?	89.8	4.3	4.1	0.3	1.5	
Item 12. Have you had difficulty doing your usual jobs?	93.1	3.3	2.6	0.5	0.5	
Handicap						0.7 (0.3-1.6)
Item 13. Have you felt that life in general was less satisfying?	93.4	2.8	3.3	0.2	0.3	
Item 14. Have you been totally unable to function?	96.6	1.7	1.5	0.2	0.0	
Total						15.6 (10.4-22.8)

	Mean	**SD**	**Min**	**Max**	**S_K**	**K_U**
Socioeconomic characteristics and habits and care						
Years of schooling	9.9	2.0	2	16	0.32	0.36
Number of rooms in household	6.3	2.3	1	20	1.26	3.83
Household crowding	0.8	0.5	0.2	6.0	3.88	21.79
Per capita income	243.6	282.9	23.0	3000.0	4.97	23.61
Cigarettes per day	0.5	0.8	0	40	5.31	24.18
Frequency of brushing [times/day] (%)						
None	0.4					
1	3.4					
2	25.2					
≥ 3	71.0					
Normative conditions of oral health and use of services						
Number of decayed teeth	0.8	1.5	0	12	2.98	9.56
Number of teeth needing dental treatment	1.1	2.1	0	25	4.23	21.51
Number of filled teeth	2.4	3.2	0	19	1.70	3.39
Number of missing teeth	0.2	0.9	0	7	2.47	8.46
Dental aesthetic index (DAI)	23.4	6.9	13	61	1.55	3.74
Community periodontal index (CPI)	0.5	0.8	0	4	1.52	1.84
Time since last visit to dentist [years] (%)						
Never visited	6.0					
> 3	21.2					
1-2	22.5					
< 1	50.3					

SD: standard deviation; Min: minimum value; Max: maximum value; K_U: kurtosis; S_K: asymmetry.

Note: 0 = never; 1 = rarely; 2 = sometimes; 3 = repeatedly; 4 = always.

Theoretical model and statistical analysis

The categorical variables were described by the absolute and relative distributions of their frequencies and the numerical variables by the measures of central tendency and dispersion (mean and standard error), with correction for design effect (*deff*). To incorporate the structure of the complex sampling plan into the descriptive data analysis and correct the loss of precision in the estimates, each interviewee was assigned a weight, corresponding to the inverse likelihood of inclusion in the sample. This stage used the *complex sample* module implemented in SPSS 16.0 (SPSS Inc., Chicago, USA).

SEM was used to assess severity of impact of oral disorders on adolescents' physical, psychological, and social well-being [17,18,19]. According to the proposed model, socioeconomic status exerts direct effects on habits and health care, use of dental services, normative conditions of oral health, and severity of impact. Habits and health care and use of dental services exert direct effects on normative conditions of oral health, and the latter exert direct effects on severity of impact. Socioeconomic status indirectly affects normative conditions of oral health, mediated by habits and health care and use of dental services. The latter, mediated by normative conditions of oral health, indirectly influence the severity of impact. Figure 1 shows the hypothetical test model. The observed variables are represented by rectangles, the latent variables by ellipses, and the associations by arrows or lines (from the independent to the dependent variable) [18,19].

First, a measurement model was constructed using confirmatory factor analysis for the construct on socioeconomic status, operationalized by the following variables: per capita income, household crowding, schooling, and number of rooms in the household (Figure 2).

Next, to confirm the factor structure with seven factors from OHIP-14, a first-order measurement model was adjusted using confirmatory factor analysis. It was determined that the seven dimensions are manifestations of items from OHIP-14 (two for each dimension), as proposed by Slade [12] (Figure 3). Next, a second-order model was adjusted, based on the hypothetical existence of a latent higher-order factor in relation to the seven factors described previously: according to this model, the severity of the impact could affect the levels of functional limitation, physical pain, psychological discomfort, physical limitation, psychological limitation, social limitation, and handicap, which in turn are manifested in the items from OHIP-14, as illustrated in Figure 3.

Finally a structural model was adjusted that defined the relations between the latent variables and the observed variables. The models were adjusted with SPSS Amos (SPSS Inc., Chicago, USA), using maximum likelihood estimation [18].

Missing values were estimated by linear regression implemented in SPSS Amos.

Direct effects were estimated through standardized structural coefficient, the significance of which was assessed by the ratio between the coefficient's value and its standard error (critical ratio – CR). Standard errors of the structural coefficients were also estimated by bootstrap simulation.

The model's goodness of fit

The models' quality was assessed by the Bentler comparative fit index (CFI) and the goodness of fit index (GFI). Good fit was defined as values greater than 0.90 for these two indices [17,18,30]. We also used the root mean square error of approximation (RMSEA) with 90% confidence interval (90%CI) [26]. A 90%CI for RMSEA with an upper limit less than 0.10 was considered a good indicator of reasonable fit [18]. The absolute index χ^2/g.l. was also used, which tests the fit using the ratio between the model's χ^2 and its degrees of freedom. This index is considered absolute because it does not compare the test model to any other possible model [30]. Values less than five are considered an acceptable fit [18].

The variables' normality was assessed by the asymmetry coefficient (*sk*) and univariate kurtosis (*ku*) and multivariate kurtosis (ku_M). Absolute *sk* values greater than three and univariate and multivariate *ku* greater than ten indicate serious violation of normality assumptions [18,31].

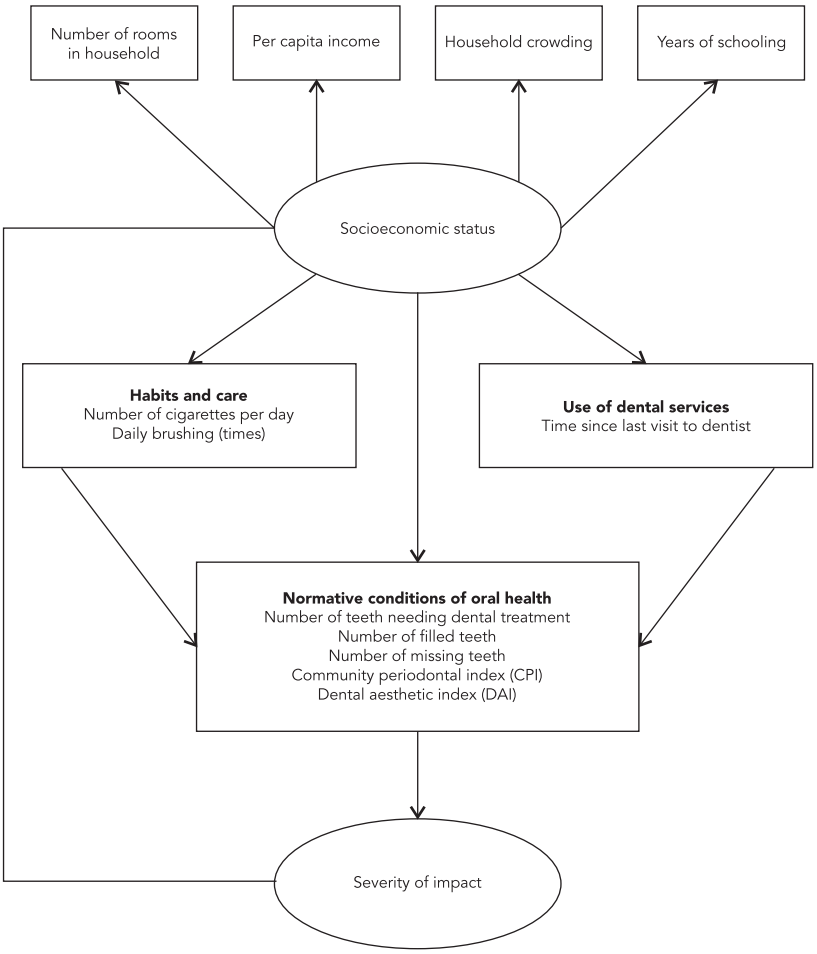
Results

A total of 763 individuals participated in the study (99.6% from the urban area), with a 91.5% response rate. The main reason for losses was inability to locate the individual after three visits to the households. Mean age of interviewees was 17.1 years, and the majority of the adolescents were female (52.7%), single (94.7%), self-identified as brown or mixed-race (52.8%), enrolled in school (73.9%), with more than eight years of schooling (77.2%), and not working (75.5%). Table 1 shows the adolescents' other characteristics.

Approximately 47% of the interviewees answered "never" (score = 0) to all the items in OHIP-14. Items 13 and 14 (handicap dimension) showed the highest proportions of responses corresponding to no impact (never, rarely, or sometimes), and items 5 and 6, comprising the

Figure 1

Hypothetical model tested to assess the impact of oral conditions among adolescents 15 to 19 years of age, mediated by socioeconomic conditions, use of dental services, and habits and health care. Montes Claros, Minas Gerais State, Brazil, 2008-2009.



dimension of psychological discomfort, showed the highest proportion of answers that detected impact (repeatedly and always). The dimensions with the highest prevalence of impact were psychological discomfort (11.8%) and physical pain (6.6%). When all the dimensions were analyzed jointly, 15.6% of the adolescents reported an impact on at least one dimension, as shown in Table 1.

Figure 2 presents the measurement model that operationalized the construct of socioeconomic status. It describes the values for the standardized factor weights of the manifest variables (number of rooms in the household, per capita income, household crowding, and years of schooling), as well as the percentage of variance explained by these variables. Path analysis between the latent factor and the manifest variables showed that the path "crowding in household← socioeconomic status" had the highest weight ($\beta = -0.72$; $p < 0.001$), followed by the paths "number of rooms in household← socioeconomic status" ($\beta = 0.71$; $p < 0.001$), "per capita income← socioeconomic status" ($\beta = 0.40$; $p < 0.001$), and "years of schooling← socioeconomic status" ($\beta = 0.28$; $p < 0.001$). The model for measuring socioeconomic status showed a good fit ($\chi^2/df = 1.30$; CFI = 0.998; GFI = 0.992; RMSEA = 0.020; 90%CI: 0.000-0.078).

Figure 2

Measurement model adjusted to the socioeconomic status construct.

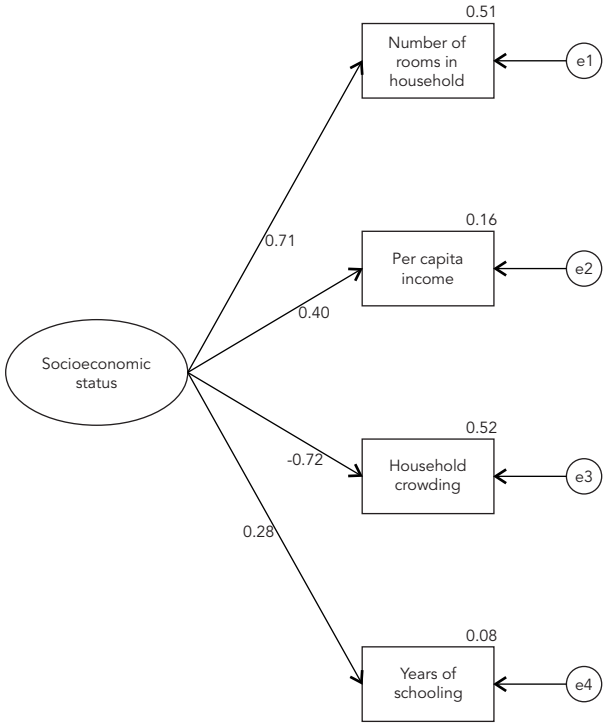


Figure 3 shows the results of the confirmatory factor analysis with the second-order model that operationalized the severity of impact construct. All the items in OHIP-14 showed significantly high factor weights (≥ 0.50). The factor weights of the paths in the second-order model for severity of impact varied from 0.52 (d1) to 0.92 (d3). The path "psychological discomfort (d3)← severity of impact" had the highest weight (β = 0.92; p < 0.001), followed by "social limitation (d6)← severity of impact" (β = 0.89; p < 0.001). The model displayed good fit (χ^2/df = 3.973; CFI = 0.957; GFI = 0.959; RMSEA = 0.063).

Figure 4 shows the adjusted structural model, with goodness of fit: χ^2/df = 2.976; CFI = 0.917, GFI = 0.935; RMSEA = 0.051 (90%CI: 0.046-0.079). This figure shows the estimated standardized structural coefficients for all the model's components and the percentage variance explained by the latent and manifest endogenous variables. Table 2 shows the standardized and non-standardized coefficients with their respective standard errors and standard errors estimated bootstrap simulation.

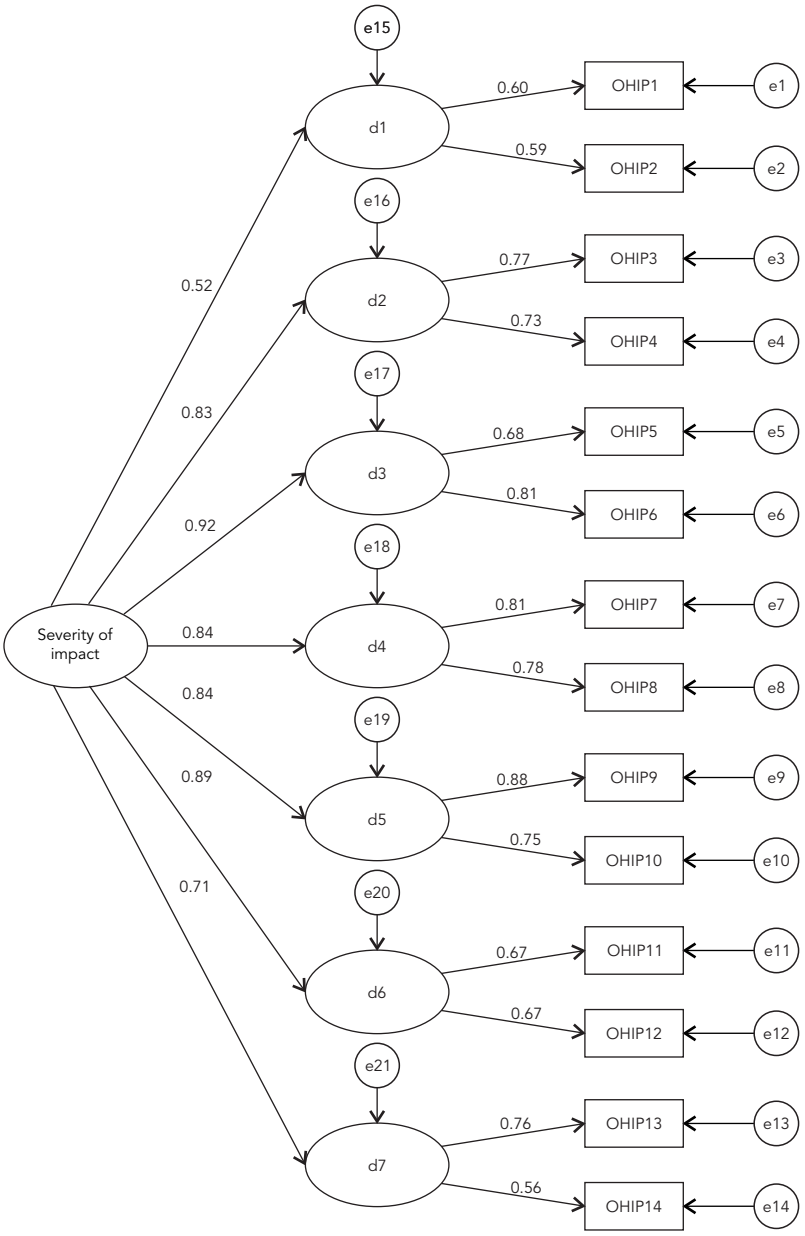
Socioeconomic status presented a significantly negative effect on: number of cigarettes/day (β = -0.14; p = 0.003), time since last visit to the dentist (β = -0.25; p < 0.001), number of teeth needing treatment (β = -0.16; p < 0.001), and CPI (β = -0.14; p = 0.004). The results indicate that better socioeconomic status correlates with fewer cigarettes per day, less time since last visit to dentist, and fewer teeth needing treatment.

Time since last visit to the dentist also showed a statistically significant direct effect on number of teeth needing treatment (β = 0.14; p < 0.001) and CPI (β = 0.07; p = 0.050) and a significant inverse effect on number of filled teeth (β = -0.21; p < 0.001). This suggests that the longer the time since the last visit to the dentist, the more the teeth needing treatment, the higher the CPI (worse periodontal status), and the fewer the filled teeth.

Number of teeth needing treatment, number of filled teeth, and CPI all had a significant effect on severity of impact: 0.22 (p < 0.001). 0.08 (p = 0.05) and 0.16 (p < 0.001), respectively. These results suggest that the more the teeth need-

Figure 3

Second-order model for severity of impact assessed by the *Oral Health Impact Profile* (OHIP-14), adjusted to a sample of adolescents 15 to19 years of age. Montes Claros, Minas Gerais State, Brazil, 2008-2009.

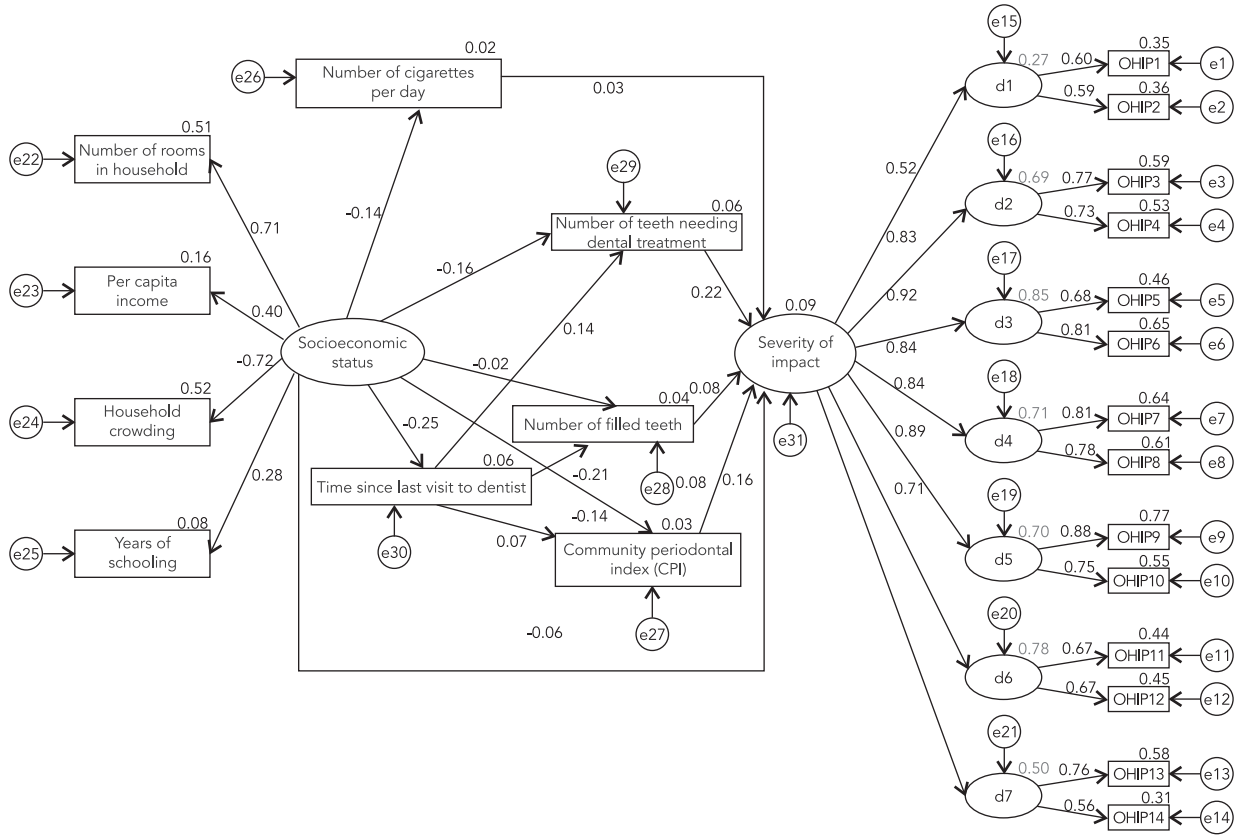


Note: d1: functional limitation; d2: physical pain; d3: psychological discomfort; d4: physical limitation; d5: psychological limitation; d5: psychological limitation; d6: social limitation; d7: handicap.

ing treatment, the more the filled teeth, and the higher the CPI, the greater the perceived severity of impact on the physical and psychosocial dimensions. Number of missing teeth and dental aesthetic index (DAI) did not significantly affect severity of impact and were removed from the model. Socioeconomic status and number of cigarettes per day showed low, non-significant effects on severity of impact.

Figure 4

Structural equation model for severity of impact of oral health on physical and psychosocial dimensions in adolescents 15 to 19 years of age. Montes Claros, Minas Gerais State, Brazil, 2008-2009.



Discussion

The study aimed to investigate dysfunctions, discomforts, and handicaps attributed to oral conditions in adolescents 15 to 19 years of age using OHIP-14. This instrument is considered valid and reliable for capturing perceptions on the physical, psychological, and social dimensions of the impact of oral disorders [27] and has been used in various epidemiological studies [27,32,33].

The socioeconomic status construct was associated directly with per capita income, years of schooling, and number of rooms in the household and inversely with household crowding. The model showed adequate goodness of fit and suggests that in this group of adolescents, the combination of these four indicators is a good estimator of socioeconomic status. The variables number of rooms in the household and household crowding had the highest factor weights in the socioeconomic status construct. These two indicators were moderately correlated (r = -0.53), but this level of correlation is so high (r > 0.85) as to indicate presence of multicolinearity [34], suggesting that each of these indicators measures a distinct aspect of the socioeconomic status construct. Years of schooling showed a significant coefficient and had the lowest weight in the construct. This probably relates to the low variability observed in the sample, since approximately 70% of adolescents had 8 to 11 years of schooling (data not shown). Monthly per capita income showed medium weight in constructing socioeconomic status, and a larger coefficient was expected (β > 0.50). It was the only variable in the model with missing responses (10.5% of observations). To mitigate this limitation, estimates of missing values were obtained by linear regression

Table 2

Standardized and non-standardized coefficients and respective standard errors from the structural equation model for severity of impact of oral health on physical and psychosocial well-being of adolescents 15 to 19 years of age. Montes Claros, Minas Gerais State, Brazil, 2008-2009.

Effects	Standardized coefficient	Non-standardized coefficient	Standard error	Bootstrap standard error	p-value
Time since last visit to dentist← socioeconomic status	-0.25	-0.15	0.03	0.05	< 0.001
Number of teeth needing dental care← socioeconomic status	-0.16	-0.21	0.06	0.06	< 0.001
Number of filled teeth← socioeconomic status	-0.02	-0.04	0.09	0.08	0.600
CPI← socioeconomic status	-0.14	-0.07	0.02	0.03	0.004
Cigarettes/day← socioeconomic status	-0.14	-0.25	0.08	0.17	0.003
Severity of impact← socioeconomic status	-0.06	-0.005	0.004	0.005	0.193
Number of teeth needing dental care← time since last visit to dentist	0.14	0.29	0.08	0.10	< 0.001
Number of filled teeth← time since last visit to dentist	-0.21	-0.70	0.12	0.11	< 0.001
CPI← time since last visit to dentist	0.07	0.06	0.03	0.04	0.050
Severity of impact← number of teeth needing dental care	0.22	0.02	0.003	0.005	< 0.001
Severity of impact← number of filled teeth	0.08	0.003	0.002	0.002	0.050
Severity of impact← CPI	0.16	0.03	0.007	0.009	< 0.001
Severity of impact← cigarettes/day	0.03	0.001	0.002	0.003	0.413

CPI: community periodontal index.

performed in SPSS Amos 19, considered the best alternative for dealing with missing data [18,31]. Even so, the estimated per capita income coefficient in constructing socioeconomic status may have been underestimated.

In the first-order model, which assessed the factor structure with seven factors from OHIP-14, all the items showed factor weights higher than 0.50 and a good fit, suggesting the instrument's factor validity. No other studies were identified that assessed the factor validity of OHIP-14 using confirmatory factor analysis. The second-order model also displayed high structural coefficients. The results suggest the existence of a higher-order construct, namely severity of impact, that produces effects on the levels of seven factors (dimensions) operationalized in the first-order model. The results confirm that OHIP-14 is a valid instrument for measuring the impact of oral disorders on functional, social, and psychological dimensions.

Among the variables in the structural model, the number of teeth needing treatment was the variable that most influenced severity of impact. In the study sample, approximately 43% of the adolescents needed some dental treatment, and 36.5% presented dental caries (data not shown). This association may be explained by the fact that dental caries can cause pain, functional limitation, concern, or disappointment in relation to one's mouth or teeth, thereby jeopardizing physical, social, and psychological aspects of adolescents' lives. Previous studies also identified an association between need for dental treatment and severity of impact [35,36].

A direct and significant effect of CPI was observed on severity of impact. Adolescents with worse periodontal conditions perceived greater severity of impact. Approximately 30% of the adolescents examined in the sample presented some periodontal alteration (data not shown). The signs and symptoms of these alterations, such as halitosis and bleeding, probably caused discomfort in the individuals, thereby increasing their perception of impact. Some studies in the literature report the impact of periodontal alterations on individuals' physical and psychosocial well-being [33,35,36].

It was observed that more filled teeth were associated with greater perception of severity of impact. OHIP-14 was applied to the adolescents in this study, requesting that they report any oral

health-related discomfort in the previous six months. This may explain the observed positive correlation, since the adolescents may have reported discomfort perceived prior to their dental restorations. Another hypothesis is that the probable poor quality of fillings caused this positive correlation. The cohort effect is also possible, i.e., older individuals are more tolerant of fillings, while adolescents are more demanding (for them, the ideal situation is to have healthy teeth). Only one study was identified that assessed this association [35], and its findings corroborate the current study.

The number of missing teeth and DAI did not show significant effects on severity of impact and were removed from the model. In the sample, the number of missing teeth varied from zero to seven, with a mean of 0.2 missing teeth per person. The low figures for this variable may have contributed to the low perception of impact. Studies in adults reported a positive association between tooth loss and severity of impact [36], and one study in adolescents also found this association [35]. The lack of association between DAI and severity of impact may be explained by the fact that OHIP-14 was not developed specifically to measure the impact of dental problems, and most of its items are not necessarily relevant to individuals with malocclusion. For these individuals, issues pertaining to the emotional and social domains, such as embarrassment, self-consciousness, feeling irritable, and avoiding smiling are more relevant [37]. Another study in adolescents in Paraná State, Brazil, may corroborate the current study's results [38]. However, other studies have identified an association between OHIP-14 and DAI [32,35].

Effect size is essential information for any impact analysis, in addition to statistical significance as measured by the p value. In structural equation models with latent variables, the estimated coefficients are usually presented in their standardized form. However, standardized coefficients present difficulties in interpreting the effect size, especially for latent variables. The adjusted model showed that the correlations are not linear between scores for the latent variable severity of impact and number of cigarettes/day, number of teeth needing dental treatment, number of filled teeth, CPI, and socioeconomic status. It is thus possible that these non-linear relations attenuated the estimates in the adjusted model.

One of this study's limitations was that the theoretical model did not include the supply of dental services, which conditioned the use of these services (with such use being defined in the model). It was thus impossible to distinguish the adolescents that failed to use services due to lack of supply from those who simply failed to seek such services. Therefore, the effect of use of dental services on number of teeth needing dental treatment, CPI, and number of filled teeth may have been modified.

Another limitation relates to the sampling plan. In the selected sample, we identified households with more than one adolescent 15 to 19 years of age, which suggests non- independence between the individuals. However, these individuals belonging to the same household represented a small percentage of the sample (n = 23; 3%), and we thus believe that the assumption of independence between study subjects was not extensively violated. In addition, in the rural area the sampling process excluded the households located more than 500 meters from a reference institution, which may have produced a selection bias, since in rural areas 500 meters is not a great distance. This may have been the reason for the small percentage (0.4%) of adolescents in the rural area identified in the sample. It is thus reasonable to assume that this sample is only representative of adolescents from the urban area of Montes Claros.

Another limitation to the study is that in order to adjust the structural model, a maximum likelihood method was used, which requires univariate and multivariate normality, in addition to variables on a continuous measurement scale [18,19,30,31]. However, the only continuous variables were per capita income and household crowding. And the OHIP-14 items CPI and time since last visit to the dentist are on an ordinal measurement scale with four or five ordinal categories, and they do not theoretically allow a parametric analysis. In addition, the variables number of cigarettes per day, number of teeth needing dental treatment, per capita income, and household crowding showed high asymmetry coefficients ($ski > 3$) and kurtosis ($ku > 10$), in addition to a high rate of multivariate kurtosis da ($ku_M > 10$), indicating violation of the normality assumption. Importantly, however, the maximum likelihood method is usually resistant to violation of the normality assumption as long as the asymmetry and kurtosis of the distributions are not too high [18] and there are at least four categories in the ordinal variables [14]. Meanwhile, it has been suggested that even in severe cases of violation of normality, the maximum likelihood method produced centered estimates of parameters, i.e., the estimates tend towards the true population value, even though their statistical significance tends to be inflated [18]. For this analytical method, when the data violate the assumptions of multivariate normality, the proportion of respondents per estimated parameter needs to be in a generally

accepted ratio of 15 [17]. In the adjusted model, 38 parameters were estimated, thus requiring at least 570 respondents (38x15). Therefore, the study's sample size (n = 763) was greater than the necessary minimum. Besides, the standard errors of the estimated coefficients according to bootstrap simulation were very close to the results obtained by maximum likelihood, confirming the method's robustness vis-à-vis deviations from normal distribution. Thus, although not all the method's assumptions of maximum likelihood held true, based on the above we believe that the model's estimates can be guaranteed.

The current study's results confirm the knowledge accumulated from epidemiological surveys in oral health: the relevance of social determinants of adolescents' oral health conditions. However, we highlight that it was the practical advantage of this approach through structural equation modeling that allowed the reader a more precise view of the different impacts of oral health when it considered the variables simultaneously rather than singly as is done traditionally in statistical analyses with classical techniques, besides allowing the visualization of a global model that integrates and allows a macro analysis of the conditioning variables for oral health and their relative importance.

A multidimensional approach is important when evaluating a population's oral health. In addition to the objective parameters, it is important to consider the study population's specificities, its setting, patterns, and concerns. A significant number of valid and reliable instruments exists, among which the OHIP-14, capable of capturing subjective aspects of oral health and the impact on functional, social, and psychological dimensions.

Conclusion

The impact of oral health conditions on physical and psychosocial dimensions was reported by one-sixth of the adolescents in this study. Psychological discomfort and physical pain were the dimensions with the highest prevalence rates for impact. In general the adjusted model allowed simultaneously assessing a series of relations of dependency: unfavorable socioeconomic conditions were significantly associated with less frequent use of dental services, which in turn was associated with precarious oral health conditions, related respectively to increased perception of impact.

Resumen

El objetivo de este estudio fue evaluar el impacto de las condiciones de salud bucal en sus dimensiones físicas y psicosociales entre adolescentes. La gravedad del impacto fue tratada como variable latente, medida por medio de un cuestionario Oral Health Impact Profile *(OHIP-14). Las covariables fueron: el nivel socioeconómico, los hábitos y el cuidado de la salud, utilización de servicios dentales y condiciones de salud bucal. Se realizó un modelado de ecuaciones estructurales y los modelos fueron estimados por máxima verosimilitud. El efecto del número de dientes con necesidad de tratamiento, número de dientes restaurados y el CPI de la gravedad del impacto fue significativo. En esta población, las condiciones socioeconómicas desfavorables se asocian con una menor frecuencia de uso de los servicios dentales, que están asociadas con malas condiciones de salud oral, y que a su vez se correlacionaban con una mayor gravedad del impacto.*

Salud Bucal; Evaluación en Salud; Análisis Multivariante; Adolescente

Contributors

M. F. Silveira participated in all stages of the study, from the planning to the data analysis and writing of the article. J. P. Marôco participated in the data analysis and contributed to the final revision. R. S. Freire contributed to the data analysis, literature review, and writing of the article. A. M. E. B. L. Martins conceived the study, coordinated the examiner training and data collection, and collaborated in the final revision of the article. L. F. Marcopito participated in the elaboration of the study and contributed to the final revision.

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