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ORIGINAL ARTICLE

Dental caries, fluorosis, oral health determinants, and quality of life in adolescents

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Abstract

Objective This study aimed to assess the extent to which dental caries and fluorosis, in addition to sociodemographic and oral health behavior determinants, impact the oral health-related quality of life (OHRQoL) of adolescents.

Methods All adolescents attending from sixth to eighth grades in the Region of Itapoã, Federal District of Brazil ($n = 1122$), were screened, and 618 10–15-year-olds were selected. Parents answered a questionnaire about their family's socioeconomic status. Adolescents answered a questionnaire about demographic and oral health behavior determinants in addition to the Child Perception Questionnaire.

Results Cavitated dentine lesions and fluorosis were observed in 39.5 and 48.5 %, respectively. The outcome was a high score on OHRQoL (median split >9). The prevalence of adolescents with at least one domain being impacted "often" or "every day/almost every day" was 34.8 %. Adolescents with tooth brushing frequency ≤once per day and with moderate or severe cavitated dentine lesions reported a significant impact on their OHRQoL ($p = 0.002$; $p = 0.001$). Fluorosis did not impact daily life performances ($p = 0.545$).

Conclusion Increased impact on OHRQoL was related to the severity of cavitated dentine lesions, but fluorosis resulting from combined fluoride exposure from early ages was not of concern for the adolescents.

Clinical relevance Combined fluoride exposure from fluoridated drinking water, consumption of food prepared with fluoridated water, and daily twice brushing with conventional fluoride toothpaste from early ages may be recommended to control caries progression at population level without impact on OHRQoL. This information is particularly relevant for supporting oral health police for disadvantaged populations.

Keywords Quality of life · Adolescents · Dental caries · Fluorosis · Oral health determinants

Introduction

In order to estimate the impact of oral conditions on an individual's oral health-related quality of life, clinical measures are associated with those reported through the application of structured and validated questionnaires. Jokovic et al. [1] developed and validated an instrument to assess the oral health-related quality of life of adolescents, i.e., the short-form Child Perception Questionnaire also known as CPQ_{11-14}. These authors documented both an acceptable reliability of the CPQ_{11-14} by adolescents and a marked impact of oral health conditions on their quality of life. Goursand et al. [2] and Barbosa et al. [3] validated the Portuguese language version of the CPQ_{11-14} for cross-cultural consistence by means of interview and self-applied questionnaire, respectively.

Oral health conditions, such as toothache, showed an association with school absenteeism of adolescents [4]. The adverse impact of gingivitis and periodontal destruction [5], in addition to that of traumatic injuries, on oral health-related quality of life were documented in adolescents [6–8]. The same trend was observed in studies dealing with malocclusion

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which was also related to manifestations of bullying in schools [9, 10]. Untreated dentine caries [11], mainly on anterior teeth [12], was equally related to lower the oral health-related quality of life of adolescents.

Few studies have simultaneously considered the influence of dental caries and fluorosis on the OHRQoL of adolescents in artificially fluoridated areas. These studies showed that caries, in contrast to very mild or mild dental fluorosis, lowers significantly oral health-related quality of life (OHRQoL) [13–16]. In one study, the impact of fluorosis could not be evaluated as it was almost absent [17]. A validity study on the $CPQ_{11–14}$ followed by a cross-sectional study found no significant association with either caries or with fluorosis indices [3, 18]. In an endemic hydrofluorosis area, caries and severe fluorosis negatively impacted the quality of life of schoolchildren [19].

Adolescents with limited access to oral healthcare and resident in the Region of Itapoã, a settlement in the Federal District of Brazil from the late 1990s [20], were likely to have higher caries experience than were the general population and to present a certain degree of fluorosis. The latter is due to combined fluoride exposure from early age: fluoridated drinking water, consumption of food prepared with fluoridated water, and use of conventional fluoride toothpaste [21–24].

Since the prevalence and severity of dental caries and fluorosis in this region have never been documented, evidence on their relative impact in addition to that of oral health determinants on OHRQoL could contribute to further recommendation in terms of caries control in disadvantaged populations.

This study assessed the extent to which dental caries and fluorosis, in addition to sociodemographic and oral health behavior determinants, are associated with the oral health-related quality of life of adolescents. The hypothesis was that impact on daily life performances would be associated with the severity of the oral conditions under study.

Subjects and methods

Ethics, study design, and sample

The study protocol was approved by the Ethical Committee of the University of Brasília, Brazil (Brazilian register number 1.096.882) and it conformed to STROBE guidelines [25]. Endorsement from the State Educational Division was granted for conducting the research in schools located in the Region of Itapoã, Federal District of Brazil. There are only public schools in this region ($n = 3$), two of them with primary schooling and one with primary and secondary schooling which was the school selected for present the study. Parents and adolescents were informed about the study and signed written informed consent.

The present study is part of the longitudinal clinical intervention trial on caries incidence and progression in these adolescents with erupting and fully erupted second molars to be followed for 3 years. The number of participants was estimated based on an expected difference in caries incidence and progression of 10 % between adolescents with erupting second molars and adolescents with fully erupted second molars. Given a power of 80 % and a confidence interval of 95 %, 219 children in each group were required at end of the study. Considering a dropout rate of 30 % after 3 years of the oral health program, around 313 adolescents in each group were foreseen. The sufficiency of the sample size for investigating the impact of oral health condition on OHRQoL was assessed, assuming that 30 % of the adolescents would be impacted, and it proved to be large enough.

Inclusion and exclusion criteria

Inclusion criteria were the ability to understand and fill in questionnaires, being adolescents, i.e., attending the sixth, seventh, or eighth grade of the selected school; willingness to participate in the study; accepting to be called for control visits in the future; and to have at least one permanent second molar without sealant, filling, or cavitated caries lesions in need for instant restorative treatment. Exclusion criterion was the presence of a serious chronic illness.

Questionnaires, examinations, reliability, and outcome

The questionnaire filled out by the parents inquired information about family sociodemographic variables which were reported in the following terms: mother's level of education (technical or university, secondary schooling, primary schooling or less), employment status of the head of the family (employed, unemployed, retired or other), family monthly income (from 1 to 4 minimum wages, less than 1 minimum wage), size of the household (1–3 persons, 4–6 persons, 7 or more persons), and car ownership (yes, no).

The adolescents were called in groups of five to answer the self-applied questionnaires and to be examined. The content of the questionnaires was explained to the adolescents, who were encouraged to ask questions in case of doubts, and their application was supervised by the first author (NAR). This was followed by instructions on how to answer questionnaires in a personal digital assistant (PDA—HP iPaq 116, Hewlett® Packard, USA). The adolescents answered a questionnaire about demographic (age and gender) and oral health behavior determinants: brushing frequency (≥twice per day, ≤once per day), use of fluoride toothpaste (yes; no/do not know), consumption of soft drink (seldom, sometimes per week, at least once per day), consumption of sweets (seldom, sometimes per week, at least once per day), consumption of alcohol beverages (no, yes), tobacco use ever (no, yes), overall self-

perceived oral health status (good, mediocre, poor), and self-perceived impact of the oral health status on daily life (none or little, some, much). The adolescents' place of birth and time of residence in the Federal District of Brazil were also registered to estimate their fluoride exposure from early ages.

In addition, the Child Perception Questionnaire (CPQ_{11-14}) was used for assessment of oral health-related quality of life. The CPQ_{11-14} measures several oral health dimensions including oral symptoms, functional limitation, emotional well-being, and social well-being. The 16 questions of the CPQ_{11-14} were answered on a five-point scale as never (score 0), once/twice (score 1), sometimes (score 2), often (score 3), and every day/almost every day (score 4). The possible total sum of scores given to each individual ranges from 0 to 64. The recall memory period was in the last 3 months. The outcome measure was a high score on OHRQoL (using a median split) indicating an adverse impact of oral health conditions [26]. The test-retest reliability of the CPQ_{11-14} in 5 % of the samples showed an intraclass correlation coefficient of 0.63.

Two mobile dental offices were installed at the school backyard for oral health examination and treatment of the adolescents. The adolescents were clinically examined for caries and fluorosis by one examiner (JCC). A second examiner (HDM) acted as bench marker for caries interexaminer reliability. For the training section, ten children were examined jointly by both examiners to clarify doubts about the criteria applied. For the calibration, 5 % of the samples were included and the examinations were carried out in individual dental offices. Interexaminer reliability was 0.81 (95 % CI 0.74–0.86, non-weighted Kappa).

Prior to the clinical examination for caries and fluorosis, the participants received professional tooth brushing and flossing. Dental caries was clinically diagnosed according to its activity and severity. The surface was classified as sound when it showed normal enamel translucency after drying. Active non-cavitated lesion was defined as an opaque area with a dull-whitish surface without loss of surface continuity. Active cavitated lesion was identified as a cavity in dentine with soft consistency. A lesion was considered inactive when it was seen on an enamel/dentine area which appeared shiny, smooth, of hard consistence, and of different degrees of brownish discoloration. A dental probe was used to differentiate between soft consistency and hard consistency of cavitated lesions. A tooth was considered extracted due to caries when there were clear indications of it; otherwise. it was considered as missing due to reasons other than caries. Caries experience was considered according to the following case status: (1) D_1MFT/S (D_1: the decayed component represented both active and inactive non-cavitated as well as cavitated lesions, M = missing due to caries, F: filled, T: tooth, S: surface); (2) D_3MFT/S (D_3: the decayed component represented active and inactive cavitated lesions, M = missing due to caries, F: filled, T: tooth, S: surface) [27]. Since non-cavitated

lesions were unlikely to influence the oral health-related quality of life of adolescents, these were not included in the analysis of the present study. The occurrence of active and inactive cavitated lesions was examined for their influence on the OHRQoL.

For the radiographic examination, at least two digital phosphor-based bitewing views were taken. The children wore a lead apron and collar to assure adequate protection during the exposure. For the training section, 10 pairs of bitewing radiographs were interpreted jointly by two examiners (HDM and JCC) and consensus for the criteria applied was reached. Thirty pairs of bitewing radiographs were examined for caries twice with an interval of 1 week by one examiner (HDM). Intraexaminer reliability was 0.86 (95 % CI 0.82–0.90, weighted Kappa). The severity of cavitated dentine lesions was radiographically defined as shallow when it showed radiolucency in the outer third of dentin. Moderate lesions had radiolucency in the middle third of dentin and severe lesions had radiolucency in the inner third of dentin or deeper.

For dental fluorosis, ten patients in the training section were jointly examined by two examiners (JCC and HDM) and consensus for the criteria applied was reached. Intraexaminer reproducibility for fluorosis scores (JCC) was performed by comparing the scores of the clinical examination with those obtained from examination of pictures taken of 50 adolescents with and without fluorosis ($\kappa = 0.85$, 95 % CI 0.74–0.96, weighted Kappa). The diagnosis was carried out on plaque-free and air-dried tooth surfaces and the severity was determined on the anterior teeth.

Dental fluorosis was assessed according to TF-Index [28] which describes the histopathological features of fluorosis on an ordinal scale of increasing severity from the very mild form (score TF-1) to the most severe form (TF-9). TF-0: the normal translucency of the glossy creamy-white enamel remains after wiping and drying of the surface; TF-1: thin white lines running across the tooth surfaces corresponding to the position of the perikymata. A slight "snow-capping" of cusp/incisal edges may be also seen; TF-2: the white lines are more pronounced and frequently merge to form small cloudy areas scattered over the whole surface. Snow-capping of the cusp tips is common; TF-3: merging of the white lines occurs, and cloudy areas of opacity occurs spread over many parts of the surface. In between the cloudy areas, white lines can also been seen; TF-4: the entire surface exhibits a marked opacity, or appears chalky white. Parts of the surface exposed to wear appear to be less affected; TF-5: the entire surface is opaque, there are round pits that are less than 2 mm in diameter, and brown discoloration may be visible. More severe scores were not recorded and therefore they are not described. The records were encoded in a PDA. Figure 1 illustrates the severity of dental fluorosis identified in the present study.

Fig. 1 Dental fluorosis diagnosed in the present study (TF-Index). TF1: thin, white, and opaque lines running across the tooth surface. TF2: white and opaque lines are more pronounced and snow-capping of incisal edges and cups tips is common. TF3: white and opaque lines merging in cloudy areas over the tooth surface. TF4: the entire surface exhibits a marked opacity (see maxillary right canine). TF5: the entire surface exhibits a marked opacity and there are round pits that are less than 2 mm in diameter (see maxillary lateral incisors)

Statistical analysis

Descriptive statistics in terms of percentage, mean (±standard deviation) were used to describe the distribution of oral health conditions and sociodemographic and oral health behavior determinants. Adolescents were distributed into two age groups (10–12 and 13–15 years old) and categorized in three groups according to the presence and severity of cavitated dentine lesions in the dentition (no lesions, only shallow lesions, and moderate or severe lesions). TF-index scores were dichotomized in two categories (scores 0–1 and scores 2–5).

The outcome measure, a high score on OHRQoL (dependent variable), was established as follows. The total CPQ_{11-14} score was calculated to each adolescent and the median CPQ_{11-14} score was determined. Chi-square test was performed to verify whether categorical variables and D_3S scores were associated. The theoretical hierarchical model for the impacts of sociodemographic and oral health behavior determinants, in addition to dental caries and fluorosis on CPQ_{11-14} outcome of adolescents, is described in Table 1. In the hierarchical logistic regression model applied, the independent variables were categorized into four blocks, and in each block, the variables were selected using the forward LR method, i.e., only variables significant at the 0.05 level entered in the equation. The reason for using this approach was to take into account the hierarchical relationships between the determinants and the outcome and to prevent the underestimation or dismissing of the effect of a distal determinant [29]. Data analyses were carried out using IBM SPSS Statistics (Version 21.0.01, USA).

Missing data

The number of missing answers in the questionnaire answered by parents is described in Table 2. Only fully completed questionnaires were included in the regression analysis. The adolescents answered a self-completed questionnaire by using the PDA which did not allow missing data.

Results

All 1120 adolescents attending the sixth, seventh and eighth grades in the Region of Itapoã were screened; 501 did not fulfill the sampling criteria either because they had no erupted second molar or because all their second molars were either sealed, filled, or had cavitated caries lesions in need for instant restorative treatment. One screened child did not accept to participate in the trial and was therefore excluded. The final sample was formed by 618 10–15-year-old adolescents (54.2 % female), who underwent clinical examination for caries and fluorosis as well as radiographic examination. The adolescents and their parents answered self-completed questionnaires.

The majority of the adolescents (84.0 %) were born and raised in the Federal District of Brazil or in other municipalities where the water has been fluoridated. A total of 9.2 % of the adolescents benefited from fluoridated water after they moved to the Federal District of Brazil (median = 9.5 years). No information was obtained for 7.8 % of the adolescents.

The percentage of caries-free adolescents was 22.2 % at D_1MFT level and 47.4 % at D_3MFT level. The mean D_1MFT/S scores were 4.60 (SD ± 3.56) and 6.37

Table 1 Theoretical hierarchical model for sociodemographic and oral health behavior determinants in addition to oral health conditions of CPQ_{11-14} outcome in adolescents

Level 1: adolescent's age and gender

Age	10–12 (reference)
	13–15
Gender	Male (reference)
	Female

Level 2: family's sociodemographic determinants

Mother's educational level	≥Technical (reference)
	Secondary (8–11 years of education)
	Primary (<8 years of education)
Employment status of the head of the household	Employee (reference)
	Unemployed
	Retired or other
Family monthly income	1–4 minimum wages (reference)
	<1 minimum wage
Size of the household	1–3 (reference)
	4–6
	≥7
Car ownership	Yes (reference)
	No

Level 3: adolescent's oral health care and dietary habits

Brushing frequency	≥2 times per day (reference)
	≤1 time per day
Use of fluoridated toothpaste	Yes (reference)
	No/do not know
Consumption of soft drink	Seldom (reference)
	>Once per week
	≥Once per day
Consumption of sweets	Seldom (reference)
	>Once per week
	≥Once per day
Alcohol consumption	No (reference)
	Yes
Tobacco use ever	No (reference)
	Yes

Level 4: adolescent's oral health conditions

Fluorosis TF-index	Scores 0–1 (reference)
	Scores 2–5
Presence and severity of cavitated dentine lesions	No lesions (reference)
	Only shallow cavitated dentine lesions
	Moderate or severe cavitated dentine lesions

Outcome: adolescent's quality of life

Impact on OHRQoL	Scores ≥9

(SD ± 6.05). Females scored significantly higher than males did ($p \leq 0.03$; t test). The values of the mean D_3MFT/S scores

were 1.43 (SD ± 2.05) and 2.43 (SD ±4.11). The D_3 component which indicates the presence of cavitated dentine lesion in the dentition was observed in 39.5 % of the adolescents. The prevalence of dental fluorosis was 48.5 % being the major TF-1 score (32.7 %) followed by TF-2 score found in 13.6 % of the adolescents; the TF-3 score limited to 1.3 % and TF-4 in addition to the TF-5 scores only in 1.0 % of the studied population.

Twenty-three parents (3.7 %) sent their questionnaires with one or more missing answers. The most frequent missing answer was about family month income (3.1 %). Only 11 adolescents scored 0 on the overall CPQ_{11-14}. The median CPQ_{11-14} total score was 9. The adolescents were classified as having low OHRQoL scores in the range from 0 to 9 and high OHRQoL scores with values equal to or higher than 9 (Tables 1 and 2). The outcome was a high score on oral health-related quality of life. The prevalence of CPQ_{11-14}, defined as the number of adolescents with at least one domain being impacted often or every day/almost every day, was 34.8 %. The severity of impacts defined as the number of reported questions scored often or every day/almost every day were from 1 to 8 (33.1 %) and from 9 to 16 (1.7 %). The domain with highest impact was the oral symptoms with 95 % of the adolescents being impacted at least once during the last 3 months, followed by the functional limitations (69.3 %), the emotional well-being (67,3 %), and the social well-being, which had the lowest impact scored by 57.3 % of the adolescents.

Table 2 describes univariate associations between the adolescents' absolute D_3S scores and sociodemographic, oral health behavior determinants, fluorosis index, and severity of cavitated dentine lesions. Significant associations were observed for age group, self-perceived oral health status, and occurrence of moderate and severe cavitated dentine lesions ($p < 0.001$).

The distribution of adolescents according to CPQ_{11-14} performances (median split) for sociodemographic and oral health behavior determinants of oral health-related quality of life in addition to oral health conditions is illustrated in Table 3. Significant univariate associations were found for employment status of the reference person of the household ($p < 0.32$), tooth brushing frequency ($p = 0.004$), self-perceived oral health status ($p < 0.001$), self-perceived impact of oral health conditions on OHRQoL ($p < 0.001$), D_3S absolute scores ($p < 0.008$), and occurrence of moderate and severe cavitated dentine lesions ($p < 0.001$).

The hierarchical logistic regression analysis (Table 4) included adolescents whose parents answered all questions of the questionnaire ($n = 595$). The analysis showed that none of the sociodemographic determinants investigated were significantly associated with a high score on OHRQoL. Adolescents with a daily brushing frequency of

Table 2 Univariate associations between adolescents' absolute D_3S scores, sociodemographic and oral health behavior determinants, fluorosis index, and severity of cavitated dentine lesions ($n = 618$)

Determinants		% in the sample	D_3S 0	D_3S 1–4	$D_3S \geq 5$	X^2 test p value
Age	10–12	56.3	233	89	26	<0.001
	13–15	43.7	141	90	39	
Gender	Female	54.2	193	105	37	0.267
	Male	45.8	181	74	28	
Mother education (missing = 13)	≥Technical	5.3	22	8	2	0.395
	Secondary	31.9	108	65	20	
	Primary	62.8	239	102	39	
Employment reference person (missing = 14)	Employed	68.5	263	144	37	0.369
	Unemployed	24.7	85	46	18	
	Other	6.8	21	14	6	
Family monthly income (missing = 19)	1–4 minimum wages	54.3	203	94	28	0.456
	<1 minimum wage	45.7	164	78	32	
Size of the household (missing = 15)	1–3	19.9	80	28	12	0.060
	4–6	67.0	252	113	39	
	≥ 7	13.1	37	32	10	
Car ownership (missing =17)	Yes	30.8	111	57	17	0.735
	No	69.2	257	116	43	
Tooth brushing	≥2× day	85.3	320	155	52	0.425
	1× day	14.7	54	24	13	
Fluoride toothpaste	Yes	93.0	351	161	63	0.103
	No/do not know	7.0	23	18	2	
Soft drinks	Seldom	19.4	82	31	7	0.208
	>Once per week	40.0	149	69	29	
	≥Once per day	40.6	143	79	29	
Sweets	Seldom	12.9	56	21	3	0.218
	>Once per week	23.6	88	41	17	
	≥Once per day	63.4	230	117	45	
Alcohol	No	93.2	354	164	58	0.168
	Yes	6.8	20	15	7	
Tobacco use ever	No	93.4	353	163	61	0.335
	Yes	6.6	21	16	4	
Self-perceived oral health status	Good	12.3	50	23	3	<0.001
	Mediocre	30.3	136	41	10	
	Poor	57.4	188	115	52	
Self-perceived impact of oral health status	None or little	58.7	229	103	31	0.255
	Some	31.6	113	58	24	
	Much	9.7	32	18	10	
TF fluorosis index	Scores 0–1	84.1	319	147	54	0.614
	Scores 2–5	15.9	55	32	11	
Presence and severity of cavitated dentine lesions	No lesions	60.5	374	–	–	<0.001
	Only shallow lesions	16.5	–	99	3	
	Moderate/deep lesions	23.0	–	80	62	

once or less were likely to have higher impact on their OHRQoL than were their peers with two or more daily tooth brushings (OR = 2.12; 95 % CI 1.31–3.43; p = 0.002). Additionally, adolescents with moderate or severe cavitated dentine lesions were significantly more likely to report a high impact on their oral health-related quality of life than were those who had no cavitated dentine lesions (OR = 1.99; 95%CI 1.31–3.02; p = 0.001). Fluorosis resulting from combined fluoride exposure had no impact on the adolescents' oral health-related quality of life (p = 0.545). The hypothesis that impact on daily life performances would be associated with the severity of the oral conditions under study was only accepted for dental caries.

Table 3 Distribution of adolescents ($n = 618$) according to CPQ_{11-14} performances (median split) for sociodemographic and oral health behavior determinants and oral health conditions

Determinants		Percent	<Median 9 n	>Median 9 n	χ^2 test p value
Age	10–12	56.3	187	161	0.067
	13–15	43.7	125	145	
Gender	Female	54.2	158	177	0.072
	Male	45.8	154	129	
Mother education (missing = 13)	≥Technical	5.3	17	15	0.580
	Secondary	31.9	103	90	
	Primary	62.8	186	194	
Employment reference person (missing = 14)	Employed	68.5	224	190	0.032
	Unemployed	24.7	64	85	
	Other	6.8	17	24	
Family monthly income (missing = 19)	1–4 minimum wages	54.3	170	155	0.368
	<1 minimum wage	45.7	133	141	
Size of the household (missing = 15)	1–3	19.9	55	65	0.271
	4–6	67.0	213	191	
	≥ 7	13.1	36	43	
Car ownership (missing = 17)	Yes	30.8	89	96	0.428
	No	69.2	215	201	
Tooth brushing	≥2× day	85.3	279	248	0.004
	1× day	14.7	33	58	
Fluoride toothpaste	Yes	93.0	291	284	0.875
	No/do not know	7.0	21	22	
Soft drinks	Seldom	19.4	57	63	0.764
	>Once per week	40.0	126	121	
	≥Once per day	40.6	129	122	
Sweets	Seldom	12.9	46	34	0.394
	>Once per week	23.6	71	75	
	≥Once per day	63.4	195	197	
Alcohol	No	93.2	294	282	0.340
	Yes	6.8	18	24	
Tobacco use ever	No	93.4	295	282	0.260
	Yes	6.6	17	24	
Self-perceived oral health status	Good	12.3	44	32	<0.001
	Mediocre	30.3	121	66	
	Poor	57.4	147	208	
Self-perceived impact of oral health status	None or little	58.7	220	143	<0.001
	Some	31.6	75	120	
	Much	9.7	17	43	
TF fluorosis index	≤1	84.1	264	256	0.745
	≥2	15.9	48	50	
D_3S Status	0	60.5	199	175	0.008
	1–4	29.0	92	87	
	≥5	10.5	21	44	
Presence and severity of cavitated dentine lesions	No lesions	60.5	199	175	0.001
	Only shallow lesions	16.5	60	42	
	Moderate/deep lesions	23.0	53	89	

Discussion

The results of the present study showed a significant influence of moderate or severe cavitated dentine lesions on the oral health-related quality of life of disadvantaged adolescents, in contrast to dental fluorosis resulting from combined fluoride exposure which had no impact. The most important finding was that more than one third of the adolescents (34.8 %) reported that their oral health-related quality of life was adversely impacted either often, every day, or almost every day on at

Table 4 Hierarchical logistic regression model for the association between oral health determinants OHRQoL outcome in adolescents

Determinants	Block I OR[95 % CI] p	Block II OR[95 % CI] p	Block III OR[95 % CI] p	Block IV OR[95 % CI] p
Adolescent age				
10–12 year (n = 338)	1.0	1.0	1.0	1.0
13–15 year (n = 257)	1.39 [1.00–1.92] 0.047	1.39 [1.00–1.92] 0.047	1.33 [0.96–0.86] 0.082	1.25 [0.89–1.75] 0.192
Brush frequency				
≥twice/day (n = 507)	–	–	1.0	1.0
≤once/day (n = 88)			2.03[1.26–3.25] 0.003	2.12 [1.31–3.43] 0.002
Presence and severity of dentine lesions				
No (n = 374)	–	–	–	1.0
Shallow (n = 102)				0.81 [0.51–1.28] 0.368
Moderate/severe (148)				1.99 [1.31–3.02] 0.001

least one performance during the last 3 months. Such high prevalence of moderate and high impacts [4] deserves attention as adolescents might be quite severely compromised in terms of performing daily activities [30]. Overall, adverse impacts were described in the domain of oral symptoms with most of impacts associated with toothache, bad breath, and food impaction due to the presence of cavities between teeth in accordance with previous studies [12–14, 18, 31].

For the outcome OHRQoL, the median value was used and adverse impacts were observed with CPQ_{11-14} scores ≥9, substantially lower than the CPQ_{11-14} scores ≥19 reported by de Souza Barbosa et al. [18]. The CPQ_{11-14} questionnaire reported impacts in 89 % of the adolescents, comparable to that of 88.7 % by Castro et al. [17] using the Child Oral Impacts on Daily Performances questionnaire in adolescents (Child-OIDP).

The application of the CPQ_{11-14} questionnaire in adolescents aged 10–15 years could raise concerns about its appropriateness for the youngest ones. A total of 25 participants were 10 years old (4 %) and the other 17 were 15 years old (2.8 %). The limited numbers, in addition to a careful application of the questionnaire by small groups, made it possible to clarify any doubts, and it seems unlikely that difficulties related to the youngest ones should have affected the results.

Among several sociodemographic and oral health behavior determinants in addition to caries status investigated for their influence on the oral health-related quality of life, only two determinants predicted the outcome: tooth brushing once or less than once per day (OR = 2.12; p = 0.002) and moderate or severe cavitated dentine lesions in the dentition (OR = 1.99; p = 0.001). Caries experience in disadvantaged adolescents was almost twofold higher when non-cavitated lesions were considered in the D_1MFS index. This finding supports the implementation of school programs including regular tooth brushing with high concentration fluoride vehicles to control further caries progression in this population. The impact of moderate or severe cavitated dentine lesions in the dentition

on OHRQoL is supported by findings of Krisdapong et al. [31] who showed that impacts increase significantly with the number and severity of untreated decayed teeth. It is worth mentioning that the presence of only shallow cavitated lesions in the dentition had no significant impact on the oral health-related quality of life of adolescents (OR = 0.81; p = 0.368).

There are a limited number of studies in artificially fluoridated areas dealing with the impact of dental caries and fluorosis on the oral health-related quality of life of adolescents. These studies agreed that very mild or mild dental fluorosis, which is found in most populations, is not of esthetic concern [13–18]. In the present study, the prevalence of fluorosis TF scores from 1 to 5 was 48.5 %, which was higher and more severe than that documented by Do and Spencer [13] who found 26.0 % of TF scores from 1 to 3. Others studies using Dean's criteria for fluorosis showed that 14.9 % of the adolescents had very mild fluorosis [14], 28.2 % had very mild and mild fluorosis, and 0.9 % had moderate and severe fluorosis [15]. Further studies registered prevalence of very mild and mild fluorosis in adolescents of 16.7 % [3] and of 30.1 % [18]. Differences in the examination indices and conditions may partially explain the higher prevalence of fluorosis in the present study. Besides, since the 1990s, the water in the Region of Itapoã has been controlled monthly to ensure fluoride concentrations at standard levels between 0.6 and 1.0 mg/l [21] and the use of conventional toothpaste has been recommended [22–24].

Our study supports previous findings and adds relevant information about populations of disadvantaged adolescents with combined fluoride exposure from early ages. Combined fluoride exposure from early ages may increase the prevalence of dental fluorosis, but this increase in prevalence manifests itself by high percentages of TF-1 and TF-2 scores (very mild and mild fluorosis) in addition to very low percentages of TF-3, TF-4, and TF-5 scores (moderate and severe dental fluorosis). In the present study, fluorosis had no impact on the oral health-related quality of life of adolescents as evidenced by

the regression analysis. Although TF-2 score can be readily identified clinically, previous studies [15, 19] reported TF ≥ 3 scores as the degree of severity that fluorosis may adversely impact OHQoL. In our sample TF ≥ 3 scores was limited to 2.3%.

One may consider that the reduced number of adolescents who presented TF-3, TF-4, and TF-5 scores ($n = 14$) limits the reliability of the estimates of the impact of more severe forms of fluorosis on maxillary anterior teeth on OHRQoL since negative effects was demonstrated in the literature [15, 19]. We recognize this constraint, but we also consider it relevant that there were only few cases with more severe forms of fluorosis in a sample comprising 50 % of the adolescents in the region.

In conclusion, increased impact on oral health-related quality of life was related to the severity of cavitated dentine lesions, but fluorosis resulting from combined fluoride exposure from early ages was not of concern for the adolescents. Combined fluoride exposure from fluoridated drinking water, consumption of food prepared with fluoridated water and daily twice brushing with conventional fluoride toothpaste from early ages may be recommended to control caries progression at population level without impact on OHRQoL. This information is particularly relevant for supporting the oral health police for disadvantaged populations.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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