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# Socioeconomic inequalities in oral health-related quality of life in adolescents: a cohort study

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## Abstract

**Purpose** Socioeconomic inequalities are recognized as a major problem with people in low socioeconomic groups having worse subjective oral health outcomes, including oral health-related quality of life (OHRQoL). However, only a few longitudinal studies assessed the impact of contextual and individual socioeconomic determinants in adolescents' OHRQoL. We estimate the impact of socioeconomic inequalities on adolescents' OHRQoL over a 2-year period.

**Methods** This study followed up a random sample of 1134 12-year-old schoolchildren for 2 years in Brazil. OHRQoL was assessed by the Brazilian version of the Child Perceptions Questionnaire for 11- to 14-year-old Children (CPQ11-14) at baseline and follow-up. Participants were clinically examined for dental caries, gingival bleeding, and malocclusion. The schoolchildren's parents answered a questionnaire regarding socioeconomic status, social capital, and adolescents' use of dental service. Socioeconomic contextual variables were collected from official city publications. Multilevel linear regression models fitted the associations between socioeconomic factors and overall CPQ11-14 scores over time.

**Results** A total of 747, 14-year-old adolescents were reassessed for OHRQoL (follow-up rate of 66%). Adolescents with lower mean income school's neighborhood ($P < 0.05$), household income ($P < 0.05$), and maternal schooling ($P < 0.05$) had higher overall CPQ11-14 scores. Female sex, attending a dentist by toothache, dental caries, and malocclusion were also associated with higher overall CPQ11-14 scores.

**Conclusions** Adolescents from low socioeconomic background reported worse OHRQoL at 2-year follow-up compared to those from high socioeconomic background. Actions toward health inequalities need to address socioeconomic factors in adolescence.

**Keywords** Socioeconomic factors · Health inequalities · Quality of life · Oral health · Observational study

## Introduction

There is an increased recognition that traditional clinical measures of health need to be supplemented by patient-reported outcomes, including oral health-related quality of life (OHRQoL), for planning public health policies [1]. OHRQoL is a multidimensional construct used to measure the impact of oral health conditions on everyday life and consequently, it affects the individual's perception of their life overall [2]. This subjective measure results from an interaction among oral health conditions, general health, social, and contextual factors [1].

Sischo and Broder [1] proposed a theoretical framework linking biological, social, psychological, and cultural factors to OHRQoL. This model recognizes the effects of contextual factors (e.g., sociocultural factors, education) and

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access to care on oral health perception and related quality of life. OHRQoL can change at different times along people's life course due to differential exposure to environmental and individual factors and may lead to health inequalities [3, 4]. Both clinical and subjective oral health outcomes are worse among those in low socioeconomic groups [5].

Material and psychosocial factors have been identified as key theoretical pathways in the explanation of socioeconomic inequalities in oral health [6–10]. Each of these pathways has different implications for how we think about health and disease and the policies needed to address health inequalities. The materialist theory emphasizes the relationship between socioeconomic position and access to material and structural conditions such as food, shelter, employment status, secure, services, and amenities [6–8, 10]. Individuals from lower socioeconomic position experience differential accumulation of negative exposures, lack of material resources and, consequently, worse levels of health [6, 10]. The psychosocial theory is based on the perceptions of the relative social status and how well people is able to cope with disease and poor health [6, 8–10]. Psychosocial stress, low coping, and anxiety as a result of negative life events and lower social support are unequally distributed to the people from lower socioeconomic position and thus contribute to inequalities in oral health [6, 10].

Several studies reported the negative impact of socioeconomic factors on OHRQoL in children and adolescents [4, 11, 12]. Factors, such as low parental educational level [12–16], low household income [12, 14, 16], low socioeconomic status [17], household overcrowding [18], low level of social capital [19], and worse school environmental [13] are associated with worse OHRQoL. Nevertheless, there is limited evidence regarding the influence of socioeconomic factors on adolescents' OHRQoL overtime. Such information is needed for planning and managing problems in this period of biopsychosocial development [20], when adolescents are more vulnerable to risk factors because they may not benefit from the care provided to children or the protections of adulthood [21].

Assessing and understanding the impact of inequalities and its determinants on OHRQoL overtime is necessary to design interventions effective. However, the majority of the previous studies in children and adults are cross-sectional and have not considered multiple contextual and individual socioeconomic determinants, such as material and psychosocial factors. Therefore, this cohort study estimated the impact of socioeconomic inequalities on changes in OHRQoL over a 2-year period. We hypothesized that lower socioeconomic background impacts negatively OHRQoL in adolescence.

## Methods

### Study population

This 2-year prospective study included 747 14-year-old schoolchildren from Santa Maria, a southern city in Brazil. Full description of the cohort is published elsewhere [16, 22]. Briefly, we used a two-stage random sample in which the primary and secondary sampling units were public schools in Santa Maria and 12-year-old schoolchildren in 2012, respectively.

The sample size for assessing OHRQoL according to ethnic/racial groups in the main cohort was estimated considering the following parameters: a 5% standard error, 80% power, 95% confidence level, and a mean score of 13.0 [standard deviation (SD) = 8.7] in the exposed group (non-white adolescents) and 11.3 (SD = 8.2) in the unexposed group (white adolescents) on the Brazilian short version of the Child Perceptions for 11- to 14-year-old Children Questionnaire (CPQ11-14) [23]. Correction factors of 1.2 for effect design and 20% for non-response were applied to increase accuracy. Thus, the minimum required sample size was 1121 schoolchildren at baseline.

### Data collection

Individual variables were collected through interview, self-administered questionnaire, and clinical oral examinations using standardized procedures in the two assessments of the study.

OHRQoL was assessed using the Brazilian short version of the CPQ11–14 [24] at school through face-to-face interviews by trained examiners. The interview was performed before the dental examinations to avoid examiners' influence on adolescent's responses. The CPQ11–14 questionnaire contains 16 items that evaluated the oral symptoms, functional limitations, emotional well-being, and social well-being. Answers were recorded through a rating scale from 0 to 5: 0—"never", 1—"hardly ever", 2—"occasionally", 3—"often", 4—"very often", and 5—"do not know". The mean CPQ11-14 scores were calculated by overall scores ranging from 0 to 64, with higher values indicating poorer OHRQoL.

Adolescents' sociodemographic characteristics were collected from parents through a self-administered questionnaire regarding sex, skin color, maternal educational level, equivalent household income, religiosity, and adolescents' use of dental service. According to the Brazilian criteria [25], skin color was classified as "white", "black", "brown (pardos)", "indigenous", and "yellow". The maternal' educational level was assessed through years

of schooling. Equivalent monthly household income was measured from all monthly sources using the Brazilian currency, Real (R$) (US$ 1.0 is equivalent to R$ 3.3), divided by the square root of total household members. Social capital from religious activities was used as a psychosocial factor and it was assessed by the question: "How often do you devote your time to religious activities such as prayer, meditation, Bible reading or reading another religious text? 1—more than once a day, 2—daily, 3—two or more times on a week, 4—about once a week, 5—a few times on a month, and 6—never/almost never". Religious practice has been used as a proxy for social capital in previous studies [22, 26]. The adolescents' reason for using dental service was measured through the question: "What was the reason your child visited the dentist last time? 1—check-up/routine, or 2—toothache". The feasibility of the questionnaire was assessed in a sample of 20 parents during the calibration process. These parents were not part of the final sample.

Clinical examination used international criteria standardized by the World Health Organization (WHO) [27]. The severity of dental caries experience was assessed using the Decay, Missing, and Filled Teeth Index (DMFT) [27]. Gingival bleeding was assessed according to the Community Periodontal Index (CPI) [27] and was scored as 0 (healthy) or 1 (bleeding). All six gingival sites were examined. Malocclusion was measured by the Dental Esthetic Index [27]. Adolescents were examined in a room, with natural light using CPI probes ("ball point") and dental mirrors. Eight examiners were trained and calibrated in the two assessments of the study. The process included theoretical activities with discussion regarding the diagnostic criteria for all conditions and the examination of 20 adolescents. At baseline, inter- and intra-examiner reproducibility (Kappa statistics) for DMFT ranged from 0.77 to 0.82 and from 0.79 to 0.85. For DAI, these figures ranged from 0.76 to 0.92, and 0.75 to 0.92, respectively.

Contextual socioeconomic data of the adolescent's schools were obtained from official city publications, which included the mean income of the school's neighborhood and the Basic School's Development Index (IDEB) of the school. The IDEB is calculated from the school approval rates and average performance on government mandatory standardized tests. It ranges from 0 to 10, with higher values corresponding to better quality of education [28]. The IDEB has been used by the Brazilian government to rank public schools according to the quality of education they provide.

## Explanatory and outcome variables

The main explanatory variables were the individual and contextual socioeconomic data at baseline. Maternal educational level was categorized as 8 years or more of schooling or < 8 years of schooling (incomplete primary education). Equivalent household income was used as a continuous variable. Social capital from religious activities was categorized as "often" (codes 1, 2, 3, and 4) or "never/almost never" (codes 5 and 6). The mean income of the school's neighborhood and the IDEB were defined as a continuous variables.

Other explanatory variables were categorized at baseline as follows: sex and skin color as "white" or "non-white"; the severity of dental caries experience was categorized as "DMFT < 4" or "DMFT 4 or more" [29]; gingival bleeding was categorized as bleeding in "< 15% of sites" or bleeding in "15% or more of sites" [30]; and malocclusion was classified as "without" (DAI = 25 or less) and "with" (DAI > 25) [31].

The outcome variable was considered the longitudinal changes in OHRQoL. The variable was obtained by the overall CPQ11-14 scores at baseline and follow-up.

## Statistical analysis

All analysis were conducted using Stata (StataCorp. 2014. Stata Statistical Software: Release 14.1. College Station, TX: StataCorp LP). Contextual, sociodemographic, and clinical oral health characteristics were described using Stata's "svy" command for complex data samples. The variation of overall CPQ11-14 scores at baseline and follow-up was also estimated.

Models were fitted by multilevel linear regression analysis to assess the association between contextual and individual socioeconomic variables and longitudinal changes in OHRQoL. In the multilevel structure, the CPQ11-14 scores measured overtime (level 1) were nested in adolescents (level 2), and adolescents were nested at schools (level 3). The multilevel model used the scheme of fixed effect with random intercept. The results are presented as coefficient ($\beta$) and its respective standard error (SE).

Four statistical models were tested according to a theoretical model [1]: Model 1 ("null model"), an unconditional model estimated the proportion of variance for each level before the incremental introduction of the contextual and individual independent variables; Model 2, contextual variables; Model 3, Model 2 plus individual sociodemographic variables; and Model 4, Model 3 plus clinical oral health measures. Variables with $P$ value < 0.20 in the unadjusted analysis were considered for the multivariable models; they were retained in the analysis only if they had a $P$ value < 0.05 after adjustment. The quality of the fit of the models was evaluated using the deviance (−2 log likelihood), and significant changes in the fitting of the models were assessed using the likelihood ratio test. In all models, the intra-class correlation coefficient (ICC) was calculated to estimate the fraction of variability at each nested level.

### Ethical considerations

The study protocol was approved by the Committee of Ethics in Research of the Federal University of Santa Maria and the University of São Paulo (CAEE: 0127.0.243.000-11, 2012 and 30613714.0.0000.5421, 2014). All adolescents and their parents signed a free and informed consent form in the two phases of the study.

## Results

From 1134 12-year-old adolescents examined at baseline, we re-examined 770 14-year-old adolescents at 2-year follow-up. However, 747 (follow-up rate of 66%) adolescents answered the CPQ11-14 questionnaire. The reasons for adolescent's dropout included refusal to take part in the study ($n=162$), refusal to answer the CPQ11-14 questionnaire ($n=23$), or inability to find the adolescent ($n=202$). There were no statistical differences between the participants and dropouts (Chi square test) regarding sex ($P=0.27$), maternal educational level ($P=0.18$), severity of dental caries ($P=0.55$), and gingival bleeding ($P=0.17$). The mean of overall CPQ11-14 scores ($P=0.35$) and equivalent household income ($P=0.13$) were not different between the groups either (Mann–Whitney test).

Sociodemographic and oral health characteristics of the participants are summarized in Table 1. The participants' skin color was predominantly white, and most adolescents are girls in the two assessments. The mean equivalent household income was R$ 689.0 and R$ 951.5 at baseline and follow-up, respectively, and most mothers had at least 8 years of schooling. The overall CPQ11-14 score ranged from 0 to 43 [mean = 10.2 (SE = 0.3)] and 0 to 47 [mean = 9.3 (SE = 0.3)], at baseline and follow-up, respectively.

Table 2 presents the distribution of overall CPQ11-14 scores at baseline and follow-up according to sociodemographic and oral health characteristics at baseline. Adolescents with significant high overall CPQ11-14 scores were girls ($P<0.01$) and non-white ($P<0.01$). In addition, participants with poor oral health ($P<0.01$) and those from low socioeconomic status ($P<0.01$) presented statistically significant higher overall CPQ11-14 scores. Adolescents whose parents had low frequency to religious activities ($P=0.07$) had higher overall CPQ11-14 scores than whose had high frequency; however, this association was not statically significant.

Table 3 presents the unadjusted association between contextual and individual variables and overall CPQ11-14 scores. The overall CPQ11-14 scores were statistically associated with school contextual measures ($P<0.05$). Girls and non-white adolescents have higher overall CPQ11-14 scores than their counterparts. The overall CPQ11-14 scores were statistically higher among low-household income participants and those with lower maternal schooling. However, lower parental frequency of religious activities was not associated with overall CPQ11-14 scores. Adverse oral health conditions, including dental caries, gingival bleeding, and malocclusion, were also associated with overall CPQ11-14 scores.

The multilevel linear regression models are shown in Table 4. The "null" model shows that the individual and school random effect compose approximately 46% of the total residual for the CPQ11-14 scores (ICC: 0.458). In model 2, low-mean income of the school's neighborhood was associated with higher overall CPQ11-14 scores. Individual sociodemographic variables are inserted in model 3. In this model, sex (girls), low household income, and less maternal schooling at baseline were associated with higher overall CPQ11-14 scores over time. When individual oral health measures are inserted in the model (model 4), the reduction in the individual-within-school level was noted (ICC: 0.409). Individual oral health measures are inserted in model 4. In this final model, the overall CPQ11-14 scores over time were significantly higher among adolescents who visited a dentist by toothache, those with severe dental caries and malocclusion at baseline. Table 4 also demonstrated that the model 4 fit better than the previous models as a reduction on the deviance could be observed (Likelihood ratio test; $P\leq0.05$).

## Discussion

The present study supports the hypothesis that lower socioeconomic background, including mean income of the school's neighborhood, household income, and maternal schooling impact negatively the OHRQoL over 2-year period. Our findings also suggest that female sex, attending a dentist by toothache, dental caries, and malocclusion are related to poor OHRQoL in 14-year-old adolescents.

Adolescence is a period of gradual transition from childhood to adulthood, and it is characterized by physiological, psychological, and social changes [21]. This transition period is critical for health because the adolescents are vulnerable to socioeconomic risk factors and, consequently more likely to engage in unhealthy behaviors that may persist over time, including smoking, alcohol consumption, unprotected sexual activity, substance use, and unhealthy oral hygiene practices [20, 32]. In addition, these individuals can experience a social gradient in education performance and, consequently, different experiences of employment and unemployment in the labor market [9, 20]. Socioeconomic determinants in adolescence, such as income and education, can generate inequalities in general and oral health for those at the bottom of social position, and this can affect OHRQoL

**Table 1** Sociodemographic and oral health characteristics of the participants and dropouts

| Variables | Baseline (T1)[a] ($n=1134$) | Follow-up (T2)[b] ($n=747$) | Dropout ($n=387$) | $P$ value[c] |
|---|---|---|---|---|
| Demographic variables | | | | |
| Sex [$n$ (%)] | | | | $P=0.27$ |
| Girls | 610 (54.0) | 393 (52.9) | 217 (56.2) | |
| Boys | 524 (46.0) | 354 (47.1) | 170 (43.8) | |
| Skin color [$n$ (%)] | | | | $P=0.49$ |
| White | 863 (77.8) | 576 (78.6) | 287 (76.2) | |
| Non-white | 250 (22.2) | 161 (21.4) | 89 (23.8) | |
| Socioeconomic variables | | | | |
| Maternal education [$n$ (%)] | | | | $P=0.18$ |
| ≥ 8 years | 702 (65.5) | 407 (68.9) | 247 (67.7) | |
| < 8 years | 382 (34.5) | 192 (31.1) | 119 (32.3) | |
| Equivalent household income in R$[d] [mean (SE)[e]] | 689.0 (55.4) | 951.5 (83.6) | 754.0 (75.2) | $P=0.13$ |
| Social capital variable | | | | |
| Frequency of religious activities [$n$ (%)] | | | | $P=0.38$ |
| Often | 795 (74.5) | 466 (78.6) | 261 (72.7) | |
| Never/almost never | 277 (25.5) | 131 (21.4) | 99 (27.3) | |
| Oral health measures | | | | |
| CPQ11-14 [mean (SE)] | 10.2 (0.3) | 9.3 (0.3) | 10.0 (0.6) | $P=0.35$ |
| Reason of visiting a dentist [$n$ (%)] | | | | $P=0.35$ |
| Check-up/routine | 778 (74.0) | 426 (76.1) | 272 (75.1) | |
| Toothache | 276 (26.0) | 134 (23.9) | 88 (24.9) | |
| Severity of dental caries experience [$n$ (%)] | | | | $P=0.55$ |
| DMFT[f] < 4 | 1042 (91.7) | 651 (87.5) | 353 (90.8) | |
| DMFT ≥4 | 92 (8.3) | 92 (12.5) | 34 (9.2) | |
| Gingival bleeding [$n$ (%)] | | | | $P=0.17$ |
| < 15% of sites | 851 (75.1) | 529 (71.3) | 300 (77.8) | |
| ≥ 15% of sites | 283 (24.9) | 213 (28.7) | 87 (22.2) | |
| Malocclusion [$n$ (%)] | | | | $P=0.86$ |
| Without | 651 (57.3) | 375 (50.7) | 221 (56.2) | |
| With | 482 (42.7) | 368 (49.3) | 166 (43.8) | |

Taking into account the sampling weight

[a]T1, baseline

[b]T2, 2-year follow-up

[c]Difference between participants followed up and dropouts. Chi-square test for categorical variables and Mann–Whitney test for continuous variables

[d]R$, Real (US$1.0 is equivalent to R$3.3 approximately)

[e]SE, standard error

[f]DMFT, Decay, Missing, and Filled Teeth Index

through material and psychosocial pathways [6, 9]. Therefore, understanding the effects of socioeconomic factors in this period is crucial to tackle inequalities in adolescents' oral health and prevent negative impacts in adulthood.

Previous studies investigated the contextual socioeconomic effects in the OHRQoL in adolescents [13, 16, 33]. However, the majority of the studies assessed the effect of clinical oral conditions on OHRQoL adjusted for contextual socioeconomic factors. One study assessed cross-sectionally the relationship between contextual factors and adolescents' OHRQoL [13]. Adolescents attending a poor school environment characterized by lack of security and bullying at school had a greater likelihood of a poor OHRQoL [13]. Our findings demonstrated that the mean income of the school's neighborhood was associated with higher overall CPQ11-14 scores overtime. It has been hypothesized that the environment may influence the adolescents' behavior and their perception of oral health [12, 13].

**Table 2** Sample distribution of overall CPQ11-14 scores according to sociodemographic and oral health characteristics at baseline (T1)

| Variables | CPQ11-14 (T1)[a] ($n=1134$) Mean (SE)[c] | CPQ11-14 (T2)[b] ($n=747$) |
|---|---|---|
| Demographic variables | | |
| Sex | | |
| Girls | 10.9 (0.4) | 10.4 (0.6) |
| Boys | 9.4 (0.4) | 8.1 (0.3) |
| Skin color | | |
| White | 9.9 (0.3) | 9.1 (0.4) |
| Non-white | 11.4 (0.5) | 10.1 (0.6) |
| Socioeconomic variables | | |
| Maternal education | | |
| ≥ 8 years | 9.3 (0.3) | 8.7 (0.3) |
| < 8 years | 11.9 (0.6) | 10.4 (0.3) |
| Social capital variable | | |
| Frequency of religious activities | | |
| Often | 10.0 (0.2) | 9.2 (0.3) |
| Never/almost never | 10.9 (0.7) | 9.9 (0.4) |
| Oral health measures | | |
| Reason of visiting a dentist | | |
| Check-up/routine | 9.3 (0.3) | 8.6 (0.4) |
| Toothache | 12.8 (0.7) | 11.2 (0.4) |
| Severity of dental caries experience | | |
| DMFT[d] < 4 | 10.0 (0.3) | 9.3 (0.3) |
| DMFT ≥ 4 | 12.4 (0.9) | 10.0 (1.3) |
| Gingival bleeding | | |
| < 15% of sites | 9.9 (0.3) | 9.1 (0.3) |
| ≥ 15% of sites | 11.1 (0.6) | 10.1 (0.5) |
| Malocclusion | | |
| Without | 9.6 (0.3) | 8.7 (0.4) |
| With | 11.1 (0.5) | 10.2 (0.3) |
| | Coefficient[e] | |
| Equivalent household income in R$[f] | −0.14 | −0.10 |

Taking into account the sampling weight

[a]T1, baseline

[b]T2, 2-year follow-up

[c]SE, standard error

[d]DMFT, Decay, Missing, and Filled Teeth Index

[e]Spearman correlation

[f]R$, Real (US$1.0 is equivalent to R$3.3 approximately)

Our findings support the evidence on the negative impact of low socioeconomic status on OHRQoL [17]. The mainly theoretical explanations for the effect of socioeconomic factors on OHRQoL inequalities are the materialist and psychosocial theories [6–10]. Materialist explanations are based on the relationship between socioeconomic status and access to material resources, such as food, amenities, and health services [10]. Consequently, people from lower socioeconomic status are more likely to be exposed to risk factors and suffer with worst levels of health compared to those from higher socioeconomic status [6]. On the other hand, psychosocial explanations explore the perception and personal experience of living in unequal societies [6]. This theory suggest that people in lower socioeconomic status have higher levels of psychosocial stress and lower social support that can lead to worse oral health outcomes [6]. According to this theories,

**Table 3** Unadjusted association between contextual and individual variables and overall CPQ11-14 scores at baseline and 2-year follow-up (T2), determined using multilevel linear regression

| Variables | $\beta$[a] (SE)[b] | *P* value |
|---|---|---|
| Contextual variables (school) | | |
| Neighborhood's mean income in R$[c] | −0.01 (0.00) | $P<0.01$ |
| Basic School's Development Index (IDEB) | −0.72 (0.33) | $P=0.03$ |
| Individual variables (adolescent) | | |
| Sex | | $P<0.01$ |
| Girls | 1 | |
| Boys | −1.91 (0.40) | |
| Skin color | | P < 0.01 |
| White | 1 | |
| Non-white | 1.49 (0.48) | |
| Maternal educational level | | $P<0.01$ |
| ≥ 8 years | 1 | |
| < 8 years | 2.27 (0.42) | |
| Equivalent household income in R$[c] | −0.45 (0.08) | $P<0.01$ |
| Frequency of religious activities | | $P=0.07$ |
| Often | 1 | |
| Never/almost never | 0.84 (0.47) | |
| Reason of visiting a dentist | | $P<0.01$ |
| Check-up/routine | 1 | |
| Toothache | 3.23 (0.46) | |
| Severity of dental caries experience | | $P<0.01$ |
| DMFT[d] < 4 | 1 | |
| DMFT ≥ 4 | 1.93 (0.73) | |
| Gingival bleeding | | $P<0.01$ |
| < 15% of sites | 1 | |
| ≥ 15% of sites | 1.26 (0.46) | |
| Malocclusion | | $P<0.01$ |
| Without | 1 | |
| With | 1.63 (0.40) | |

[a]$\beta$, coefficient

[b]SE, standard error

[c]R$, Real (US$1.0 is equivalent to R$3.3 approximately)

[d]DMFT, Decay, Missing, and Filled Teeth Index

adolescents from low socioeconomic background tend to adopt unhealthy behaviors as an expression of underlying material and psychosocial influences [10].

In our study, we considered household income and maternal schooling as proxies to individual socioeconomic status. It has been recognized that socioeconomic status is a multidimensional construct including different socioeconomic factors, such as material resources, power, and prestige that could affect health at different times along people's life course [6, 34]. Our findings demonstrated that low household income and low maternal schooling impacted negatively the adolescents' OHRQoL in accordance with previous studies [12, 13, 16, 17]. Income and education can lead inequalities in oral health through differential exposition of economic resources in adolescence, such as regular attendance at the dentist [6]. These factors also can reflect a set of non-economic resources, such as the emotional and social meanings of inequalities for adolescents' own life, which can influence the healthy habits and coping behavior [17, 34].

Girls reported higher impacts of OHRQoL than boys in accordance with previous observations [12, 16, 35]. The association between sex and higher overall CPQ11-14 scores may be explained by the most self-conscious and concern of women about their oral health. Thus, women may be more likely to feel worried or upset about their functional and aesthetic-related health [12]. Moreover, men may be less conscious about their appearance and they are less likely to complain of health problems than women [12, 35].

Clinical oral health measures were also associated with OHRQoL in adolescents. Adolescents who visited a dentist by toothache, those with severe dental caries and malocclusion, had worse OHRQoL. The impacts of toothache on OHRQoL have been studied in children and adolescents [36–38]. Toothache impacts daily activities, such as talking, eating, cleaning teeth, sleep pattern, and ability to learn [36, 38]. Therefore, pain affects physical, social interactions, and psychosocial well-being [36]. It has also been shown that the reason of attending a dentist by pain is associated with low socioeconomic status [39]. Previous studies also demonstrated the negative impacts of dental caries [33, 40] and malocclusion [41, 42] on OHRQoL. Adolescents with severe dental caries are more likely to experience pain and impaired chewing [12, 36]. In addition, they can be more worried about their oral health, which may negatively impact on their quality of life. Additionally, social life and appearance becomes more important in the adolescence, and consequently the malocclusion is closely related to aspects of quality of life, including emotional well-being [42].

There are some limitations in our study. The non-response rate was approximately 34%, which could be a source of bias. However, the participants and dropouts did not present statistical differences, allowing representativeness of our findings. Additionally, previous studies have reported higher non-response rate in a similar follow-up [33, 40]. Another limitation is that the Sisho and Broder conceptual framework was not fully addressed to important contextual and individual characteristics. We also included a few contextual characteristics that may not capture the influence of school environmental. However, others studies used the same variables as reliable measures provided by the Brazilian government [16, 23]. We also recognized that one limitation of this study is that the only aspect of religion investigated was parental religious practice and that in itself might lead to some bias since it may not reflect the social capital of adolescents. However, previous studies showed religious practice can be considered an individual attribute related to social

**Table 4** Adjusted association of contextual and individual variables with overall CPQ11-14 scores at baseline (T1) and 2-year follow-up (T2), determined using multilevel linear regression

| Variables | Model 1[a] ("null") $\beta$[e] (SE)[f] | Model 2[b] $\beta$ (SE) | Model 3[c] $\beta$ (SE) | Model 4[d] ("full") $\beta$ (SE) |
|---|---|---|---|---|
| Fixed component Intercept | 9.92 (0.25) | 11.16 (0.48) | 11.63 (0.70) | 10.11 (0.74) |
| Contextual variables (school) | | | | |
| Neighborhood's mean income in R$[g] | | −0.01 (0.00)* | −0.01 (0.00)* | −0.01 (0.00)* |
| Basic School's Development Index (IDEB) | | −0.37 (0.36) | ** | ** |
| Individual variables (adolescent) | | | | |
| Sex | | | | |
| Girls | | | 1 | 1 |
| Boys | | | −1.78 (0.42)* | −1.78 (0.42)* |
| Skin color | | | 1 | ** |
| White | | | 0.29 (0.53) | |
| Non-white | | | | |
| Maternal educational level | | | | |
| ≥ 8 years | | | 1 | 1 |
| < 8 years | | | 1.51 (0.48)* | 1.51 (0.48)* |
| Equivalent household income in R$[g] | | | −0.30 (0.09)* | −0.30 (0.09)* |
| Frequency of religious activities | | | | ** |
| Often | | | 1 | |
| Never/almost never | | | 0.54 (0.48) | |
| Reason of visiting a dentist | | | | |
| Check-up/routine | | | | 1 |
| Toothache | | | | 2.45 (0.50)* |
| Severity of dental caries experience | | | | |
| DMFT[h] < 4 | | | | 1 |
| DMFT ≥ 4 | | | | 1.77 (0.75)* |
| Gingival bleeding | | | | ** |
| < 15% of sites | | | | |
| ≥ 15% of sites | | | | |
| Malocclusion | | | | |
| Without | | | | 1 |
| With | | | | 1.60 (0.42)* |
| Random effect | | | | |
| Deviance = (−2 loglikelihood) | 12741.09 | 12734.29 | 11093.83 | 10529.48 |

[a]Model 1: null model, represents unconditional model

[b]Model 2: mutually adjusted for contextual variables

[c]Model 3: mutually adjusted for contextual and individual sociodemographic variables

[d]Model 4: full model adjusted for contextual, individual sociodemographic and oral health variables

[e]$\beta$, coefficient

[f]SE, standard error

[g]R$, Real (US$1.0 is equivalent to R$3.3 approximately)

[h]DMFT, Decay, Missing, and Filled Teeth Index

*Significant at $P < 0.05$ level

**Variables not included in the final multiple model after the adjustment

capital (social network) reflecting the reciprocal exchange of social support among members and the encouragement of good health behaviors [43, 44]. Thus, high frequency of religious practice may motive individuals and, consequently, their family to adopt healthier lifestyles and improve the ability to resist disease and cope with adverse events.

The strength of this study is the assessment of the impact of socioeconomic inequalitities on longitudinal changes in

adolescents' OHRQoL. Being in transition period, adolescents are more vulnerable to present and future risk factors to general and oral health. Thus, it is crucial understand the effect of socioeconomic determinants on inequalities in OHRQoL. In addition, the study followed up for 2 years the adolescents and it included different contextual and individual variables in the analysis.

## Conclusion

Our findings indicate that lower mean income of the school's neighborhood, household income, and maternal schooling were associated with worse OHRQoL among adolescents over time. Lower socioeconomic background is an important predictor of longitudinal changes in OHRQoL. Multiple strategies toward the socioeconomic determinants at contextual and individual levels should be addressed, such as improvement of schools' environmental and access to oral health service.

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### Compliance with ethical standards

**Conflicts 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 Human Research Ethics Committee of the Federal University of Santa Maria and the University of São Paulo (CAEE: 0127.0.243.000-11, 2012 and 30613714.0.0000.5421, 2014), Brazil, 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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