

Effect of dental caries and socioeconomic status on social capital throughout adolescence: a 6-year follow-up

Gabriela Figueiredo MEIRA^(a) 

Jessica Klöckner KNORST^(a) 

Marília Cunha MARONEZE^(a) 

Fernanda Ruffo ORTIZ^(b) 

Thiago Machado ARDENGHI^(a) 

^(a)Universidade Federal de Santa Maria – UFSM, School of Dentistry, Department of Stomatology Santa Maria, RS, Brazil.

^(b)Universidade Federal de Minas Gerais – UFMG, School of Dentistry, Department of Pediatric Dentistry, Belo Horizonte, MG, Brazil.

Abstract: The aim of the study was to investigate the influence of clinical and socioeconomic factors on social capital throughout adolescence. A cohort study was performed in 2012 (T1) with a random sample of 1,134 12-year-old adolescents from Santa Maria, Brazil. Questions on socioeconomic factors (maternal education, household income, household crowding) were answered by the parents. Clinicians evaluated their dental caries (decayed, missing, and filled status of permanent teeth) and gingival bleeding (using the Community Periodontal Index). Contextual variables including the mean income of the neighborhood in which the school was located were used (T1). The adolescents were reevaluated in 2018 (T2) and answered questions regarding social capital (social trust, social control, empowerment, neighborhood security, and political effectiveness). A path analysis was used to test the relationship between the predictor variables (T1) and social capital (T2). A total of 768 adolescents were reevaluated at a 6-year follow-up (cohort retention rate of 67.7%). Most of the adolescents were girls, with a low household income, about 40% had caries experience (T1), and about 64% had high social capital (T2). The highest neighborhood's mean income was related to a lower household income in T1 ($p < 0.01$), and this was directly related to a low social capital in T2 ($p = 0.04$). Furthermore, caries experience at T1 was directly associated with low social capital at T2 ($p = 0.03$). Socioeconomic factors were also related to caries experience. Individuals who lived in neighborhoods with greater inequality such as families with a low household income and those with untreated dental caries in early adolescence, had a low social capital after follow-up.

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Corresponding Author:

Thiago Machado Ardenghi
E-mail: thiardenghi@hotmail.com

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Introduction

Social capital has been considered an important psychosocial construct in research, where its impact on health inequalities among adolescents is often highlighted.^{1,2} The concepts of social capital express characteristics of social structures, connecting levels of networks and trust, and it also involves individuals utilizing their resources, thus facilitating collective actions.^{3,4,5,6} In this context, psychosocial characteristics such as social

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capital are considered important factors that affect many areas of life, from differences in exposure and vulnerability to factors harmful to the health and quality of life of adolescents.⁷

Adolescence is a transitional period between 10 and 19 years of age, characterized by several behavioral, psychological, and social changes.⁸ These changes can generate immediate and life-long impacts,^{9,10} influencing individuals' perceptions about their oral health.^{11,12} Health is a multi-causal concept that involves psychosocial, behavioral, and biological circumstances.¹³ In this sense, social determinants frame health outcomes through exposure to different factors.¹³ Therefore, structural factors allow for opportunities and also inequalities to be generated, which can be moderated by proximal factors such as social networks established between family, friends and the community.^{11,12,14}

Some studies have explored the association between social capital and the oral health of adolescents.^{12,15,16} Adolescents with low social capital present with more dental caries,¹⁵ gingivitis¹⁶ and a worse oral health-related quality of life (OHRQoL).⁸ The literature also has highlighted that oral problems can affect the emotional and social well-being of adolescents, affecting their OHRQoL.^{17,18,19,20} Considering this aspect, we can hypothesize that oral problems also directly influence adolescents' social capital at this age.

However, to the best of our knowledge no study has evaluated the influence of oral problems on social capital in this age group, especially taking contextual factors into account. In addition, most studies have a cross-sectional design and do not consider the different influence pathways. Therefore, a longitudinal assessment of psychosocial outcomes in adolescence allows for the understanding of causal pathways and the main determinants of health-diseases processes during this period. Studying these relevant factors allows us to better understand the role of social connections and their relationship with oral health. In this sense, different strategies and a greater focus on distal factors can be implemented and related to public health.

The aim of the study was to investigate the clinical and socioeconomic factors that influence social capital throughout adolescence. Our hypothesis is that

adolescents with better clinical and socioeconomic conditions at baseline will have a higher social capital at follow-up.

Methodology

The 'Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)' guidelines were followed when composing this manuscript.²¹

Ethical precepts

This study was approved by the Research Ethics Committee of the Federal University of Santa Maria (CAEE 665531174.0000.5346). All subjects consented to participate, and their parents or guardians signed an informed consent form.

Study design and sample

This is a 6-year follow-up cohort study conducted at the city of Santa Maria, RS, Brazil. The Human Development Index (HDI) of the city is 0.784, which places the municipality in the high human development range (HDI between 0.700 and 0.799).²² The study started in 2012 (baseline), with adolescents enrolled in public schools in the city. During this period, the estimated population in Santa Maria was 261,031 inhabitants, which included 3,817 12-year-old adolescents, 85% of which were enrolled in public schools.²²

A random sample of 1,134 adolescents was obtained in a two-stage conglomerate process, considering the five administrative regions of the city. The first stage consisted of 20 of the 39 public schools in the municipality. The second stage consisted of 12-year-old adolescents from the selected schools. Thus, all 12-year-old schoolchildren enrolled in these schools were invited to participate in the study. Adolescents with some cognitive limitations were excluded. More information about the methodology used for the baseline has been previously published.^{18,19}

The sample size calculation was performed considering a standard error of 5%, with a 95% confidence interval, and using a prevalence of 1.9% for the exposed group (low social capital) and 68.1% for the unexposed group (high social capital).²³ We used a statistical power of 90%, with a ratio of unexposed to

exposed of 2:1. Considering a design effect of 1.6 and adding 30% for any losses, the minimum sample size required was 193 adolescents. This data collection also evaluated other outcomes; therefore, a larger sample was evaluated.

Follow-up assessment

At the 6-year follow-up, sample planning was based on all the adolescents who were assessed at baseline ($n = 1,134$). Therefore, different search strategies were adopted. First, the adolescents were contacted by phone and invited to participate in the reevaluation. A second search alternative was through the acquisition of listings of students enrolled in public high schools in the city. The third search alternative was the visits to schools and homes from the addresses registered in the baseline files. Lastly, the adolescents were located via online social networks (Facebook and WhatsApp).

Data collection

This study consists of the data collected at baseline (T1) and at the follow-up (T2). Oral examinations and structured questionnaires about socioeconomic and demographic factors were answered by the parents and collected at T1 and T2; however, the analysis was performed with only the baseline variables. In contrast, the questions regarding social capital were answered by adolescents at the follow-up.

Interviewers were previously trained, and the feasibility of both questionnaires was tested on a subsample. The questionnaires were administered in a face-a-face interview in an isolated room, in order to preserve the individuality of the participants. In addition, four examiners were previously trained and calibrated to assess their clinical conditions by following the criteria standardized by the World Health Organization for oral health epidemiological surveys.²⁴ The calibration process for the clinical conditions involved theoretical classes, a discussion of the diagnostic criteria, an examination of extracted teeth, and an assessment of 20 adolescents who were not included in the final sample.²⁴

The oral examinations were performed in an isolated room, with adolescents seated, under natural light, using CPI probes (“ball point”)²⁴ and dental

mirrors. Reproducibility among examiners was tested using the Kappa coefficient, and intra- and inter-examiner values ranged from 0.77 to 0.85 for dental caries.

Non-clinical data collection

Social capital, the outcome of the present study, was assessed at follow-up. Five questions involved five dimensions of social capital (social trust, social control, empowerment, neighborhood security, and political effectiveness), adapted from previous publications.^{1,25} The questions were selected according to results of a previous study, considering reliability and factorial analysis.¹ Thus, social capital was considered as a resource present in social structures, characterized by collective relations between individuals that generate reciprocity, interpersonal trust, and resources that facilitate collective actions.^{3,4,5}

Social trust and social control were assessed through the following questions: a) “How comfortable would you feel about borrowing R\$15 from your friends or colleagues?” With five answer choices: “I would not ask (0); very uncomfortable (1); more or less uncomfortable (2); more or less comfortable (3); very much comfortable (4)”. b) “How much would you agree with the following statement: at my school or at my job, I can count on my colleagues or friends to intervene if someone is painting walls, walls, or public buildings”. This question could be answered with one of: “I totally disagree (0); I disagree (1); I do not agree or disagree (2); I agree (3); I totally agree (4)”. Neighborhood empowerment, represented by bonds between individuals in the perception of community improvement, was measured by the question: c) “When was the last time you went to a meeting, or joined a group of people, to try solve some problem in your neighborhood? The possible answers were: “I have never done this (0), in the last 3 months (1), in the last 6 months (2), in the last 12 months (3), for over 12 months (4)”. Regarding political efficacy, adolescents were instructed to respond with how much they agree with the following statement: d) “Political parties are only interested in people’s votes, but not in their opinions: I strongly disagree (0), I disagree (1), I don’t agree or disagree (2), I agree (3), I strongly agree (4)”. Neighborhood

security was evaluated by the following question: e) “When was the last time there was a drug related case in your neighborhood or at your school? This has never occurred (0), in the last 3 months (1), in the last 6 months (2), in the last 12 months (3), for more than 12 months (4)”. The answers ranged from 0 to 4. The negative items from questions “c” and “e” were reverse-coded for all items from low to high.¹ For analysis purposes, the five questions were categorized by the medians, and later, the answers were summed, corresponding to a low and high social capital.²⁶

The individual and contextual predictor variables were obtained at baseline (T1) and included demographic, socioeconomic, and clinical characteristics. Demographic variables included sex (girls or boys). Socioeconomic factors were assessed based on monthly household income, maternal education, and household crowding. Household income was collected in *Reais* (Brazilian R\$ 5.44 equals approximately 1.00\$ US) and used as a continuous variable. Maternal education was collected in years of schooling and dichotomized into < 8 years and > 8 years of study (complete formal education in Brazil during the collection period). Household crowding was obtained by the number of people in the house divided by the number of rooms and used as a continuous variable. The contextual variable was obtained through official publications of the municipality, which included the neighborhood’s mean income where the school was located.

Clinical data collection

The untreated dental caries were evaluated using the Decayed, Missing and Filled permanent teeth index (DMFT),²⁴ and considered untreated caries if they classified under the “Decay” component of the index (D equal or different to 0). Gingival bleeding was assessed according to the criteria of the Community Periodontal Index (CPI) and dichotomized into “extensive levels of gingival bleeding” ($\geq 15\%$ of sites) and “low levels or absence of gingival bleeding” ($< 15\%$ of sites).^{24,27} Toothache was assessed by asking, “Have you had a toothache in the last 6 months?” The responses could be either yes or no, and this question has been used in many previous studies²⁸.

Statistical analysis

The descriptive analysis was performed using STATA 14 software (StataCorp. 2014. Stata Statistical Software: Release 14.1. College Station, TX: StataCorp LP). The differences between the followed individuals and the dropouts were assessed using the Chi-squared test.

Structural equation modeling (SEM) was performed using Mplus to test the pathways between demographic, socioeconomic, clinical characteristics, and social capital, using the covariates at baseline (T1) and outcome studied at follow-up (T2). Our theoretical model was based on a previous published study, which also explores social capital as an outcome.²⁹ SEM consisted only of a structural model, which analyzed the magnitude and direction of the paths between variables. The goodness-of-fit was evaluated using the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), the Tucker-Lewis index (TLI), and the Standardized Root Mean Square Residual (SRMR). An RMSEA value < 0.05 and a CFI and TLI > 0.95 indicates an adequate fit, respectively. The SRMR indicates an adequate fit at values lower than 0.8.³⁰ Two models were tested, and modification indices (MI) were used to evaluate the quality of fit. MI values equal or above 0.40 were considered paths that were not significant, and were removed systematically.

Results

From the 1,134 adolescents assessed at baseline, 768 were reevaluated at the 6-year follow-up (cohort retention rate of 67.7%). The reasons for loss of follow-up ($n = 366$) were due to inability to find the adolescent ($n = 354$), refusal ($n = 11$), and death ($n = 1$) (Figure 1). When the followed individuals were compared to the dropouts, (chi-squared test), we found no statistically significant differences in most characteristics ($p > 0.05$). There was a significant difference in the neighborhood’s mean income, however, we performed a Bootstrap sensitivity analysis and found that this difference did not affect the results.

Contextual and individual characteristics of the participants at the baseline (T1) and at the

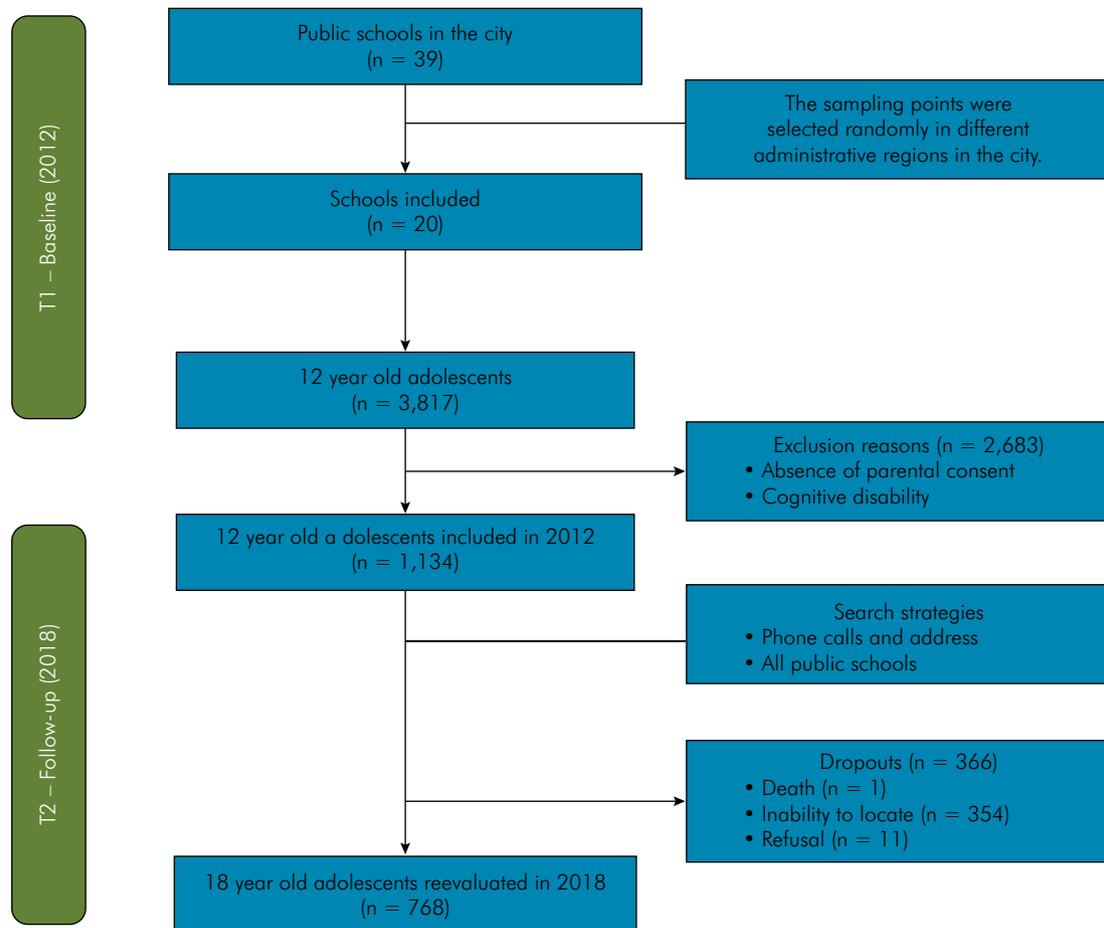


Figure 1. Flow diagram of study participants.

6-year follow-up (T2) are shown in Table 1. Most of the adolescents in both of the evaluations were girls. Regarding socioeconomic characteristics, the majority of the adolescents belonged to families with a household income > 1,000 *Reais* in T1 and T2. Considering the clinical characteristics, the prevalence of dental caries in T1 was 41.9%, and 41.3% in T2. Around 75% of the adolescents had low levels of gingival bleeding (<15%). In addition, approximately 26% of the adolescents in both assessments reported having a toothache. Regarding social capital at follow-up, 35.8% had a low social capital and 64.1% had a high social capital.

Table 2 shows the estimated effects of the initial and final structural model between the variables and different pathways. The model presented a good fit (RMSEA = 0.02 (90% CI = 0.00-0.05), CFI = 0.99, TLI = 0.96, and SRMR = 0.01).

Figure 2 presents the final structural model with the best fit of the data. Through the analysis of direct pathways, it was shown that the highest neighborhood's mean income was related to a lower household income in T1 ($\beta = -0.13$, $p < 0.01$) and this was directly related to the low social capital in T2 ($\beta = 0.08$, $p = 0.04$). In addition, untreated dental caries at T1 was directly associated with the low social capital at T2 ($\beta = -0.08$, $p = 0.03$). Socioeconomic factors, such as low maternal education, lower household income, and high household crowding, were associated with untreated dental caries and toothaches at T1 ($p < 0.05$).

Discussion

This is the first prospective study that verified the pathways between the contextual, socioeconomic,

Table 1. Contextual and individual characteristics of the 12 years-old adolescents at the baseline (T1) and at 6-year follow-up (T2). Santa Maria, Brazil.

Variables	Baseline (T1) (n = 1,134) ^a	Follow-up (T2) (n = 768) ^b	Dropout (n = 366)	p-value
Individual-level variables				
Demographic and socioeconomic variables				
Sex [n (%)]				0.07
Girls	610 (54.0)	427 (55.6)	183 (50.0)	
Boys	524 (46.0)	341 (44.4)	183 (50.0)	
Household income in R\$ [n (%)]				0.30
≥ 1000.00 mensal	556 (54.36)	386 (54.8)	170 (51.4)	
< 1000.00 mensal	480 (45.64)	319 (45.2)	161 (48.6)	
Maternal education [n (%)]				0.88
³ 8 years	702 (65.5)	473 (64.6)	229 (70.5)	
< 8 years	382 (34.5)	259 (35.4)	123 (29.5)	
Household crowding in people per room [mean (SD)]	0.85 (0.56)	0.81 (0.55)	0.91 (0.57)	0.18
Oral health measures [n (%)]				
Untreated dental caries				0.43
Without	657 (58.02)	451 (58.7)	206 (56.3)	
With	477 (41.98)	317 (41.3)	160 (43.7)	
Gingival bleeding [n (%)]				0.35
< 15% of sites	851 (75.1)	570 (74.2)	281 (76.8)	
> 15% of sites	283 (24.9)	198 (25.8)	85 (23.2)	
Toothache [n (%)]				0.65
Not	778 (73.8)	530 (74.2)	248 (72.9)	
Yes	276 (26.2)	184 (25.8)	92 (27.1)	
Contextual-level variables				
Neighborhood's mean income in R\$ [mean (SD)]	1247.73 (575.54)	1271.30 (566.95)	1198.25 (590.87)	0.000

T1: baseline; T2: follow-up; SD: standard deviation; R\$: reais (R\$ 4.05 equals approximately US\$ 1.00)
 Values less than 1,134 (T1) and 768 (T2) are due to missing data.

clinical characteristics, and social capital throughout adolescence. The present findings support the hypothesis that clinical and socioeconomic conditions in early adolescence influence the level of social capital over time.

Untreated dental caries were directly related to low social capital. Social capital was considered an individual attribute, measured according to social participation, community perception, level of empowerment, trust, networks, and social support.¹ One possible explanation for our findings is that dental caries can be associated with toothaches,³¹ which negatively influence OHRQoL and self-reported oral health.^{28,32} Furthermore, adolescents worry about what other people will think about their oral problems at this age, leading to psychosocial stress, and difficulties in smiling and talking during conversations, which can affect their social relationships and quality of life.¹⁷

Consequently, these problems can cause a decline in the social capital of adolescents.

A neighborhood's mean income was related to a low individual income, and a low individual income was related to a low social capital. It is assumed that the evaluated individuals lived in socially unequal neighborhoods. One possible explanation for these findings is based on the social cohesion theory.^{5,33} This theory points out that more egalitarian societies are more cohesive than unequal societies. In this context, an egalitarian income distribution leads to a positive social environment that is characterized by trust and social cohesion among people, providing greater access to social support and lower stress levels, and consequently, greater social capital.^{13,33} Similarly, unequal societies have greater status differences between citizens, creating distrust and decline in social cohesion and social capital.⁵ It

Table 2. Standardized estimated effects of indicators in initial and final structural models.

Pathway	Standardized coefficients	
	Initial model	Final model
Social capital (T2) ^a		
Household income (T1) ^b	0.08 (p = 0.04)	0.08 (p = 0.04)
Household crowding (T1)	0.04 (p = 0.31)	0.04 (p = 0.31)
Untreated dental caries (T1)	-0.08 (p = 0.04)	-0.08 (p = 0.03)
Gingival bleeding (T1)	-0.00 (p = 0.95)	-
Neighborhood's mean income (T1)	0.00 (p = 0.82)	-
Maternal education (T1)	-0.06 (p = 0.15)	-0.06 (p = 0.12)
Toothache (T1)	-0.03 (p = 0.38)	-0.04 (p = 0.38)
Toothache (T1)		
Untreated dental caries (T1)	0.18 (p < 0.01)	0.19 (p < 0.01)
Household income (T1)	0.11 (p < 0.01)	0.11 (p < 0.01)
Maternal education (T1)	0.19 (p < 0.01)	0.19 (p < 0.01)
Household crowding (T1)	0.12 (p < 0.01)	0.12 (p < 0.01)
Household income (T1)		
Neighborhood's mean income (T1)	-0.13 (p < 0.01)	-0.13 (p < 0.01)
Maternal education (T1)	0.26 (p < 0.01)	0.26 (p < 0.01)
Household crowding (T1)	0.17 (p < 0.01)	0.17 (p < 0.01)
Untreated dental caries (T1)		
Household income (T1)	0.11 (p < 0.01)	0.12 (p < 0.01)
Maternal education (T1)	0.07 (p = 0.03)	0.07 (p = 0.02)
Household crowding (T1)	0.08 (p < 0.01)	0.09 (p < 0.01)
Sex (T1)	-0.02 (p = 0.60)	-0.02 (p = 0.60)
Model Fit		
RMSEA ^c (90% CI) ^d	0.04 (0.02–0.05)	0.02 (0.00–0.05)
CFI ^e	0.954	0.991
TLI ^f	0.874	0.966
SRMR ^g	0.024	0.013

^aT2: 6-year follow-up; ^bT1: Baseline; ^cRMSEA: root mean square error of approximation; ^dCI: confidence interval; ^eCFI, Comparative Fit Index; ^fTLI: Tucker-Lewis Index; ^gSRM: standardized root mean square residual.

has been described that the relationships of trust established between individuals within a society stimulate cooperation and mutual aid, which can lead to better oral health conditions.^{1,5} In addition, previous studies have shown that adolescents living in more egalitarian neighborhoods had higher OHRQoLs, and this relationship was mediated by psychological factors such as social capital and social cohesion.³⁴

Considering the different levels of coverage of social capital, the resources generated through human relationships have been described as beneficial to both individuals as a collective.²⁹ In regards to individual benefits, individuals with high individual social capital are more likely to adopt better health-related behaviors due to peer pressure, have greater emotional

support which generates less stress, as well as receive more information and have access to resources that can benefit their health.^{3,4,6,29} In regards to collective benefits, it has been suggested that in societies where the level of social capital is higher, people live longer, are less violent, have lower rates of mortality and morbidity, and assess their health better.^{5,25,29} In addition, the development or maintenance of local health services and awareness of health information can be facilitated in areas with high social capital.^{5,29} In this sense, social capital is an important outcome with benefits at the individual and collective levels.

In this study, the socioeconomic factors, such as low maternal education, lower household income, and high household crowding, were associated

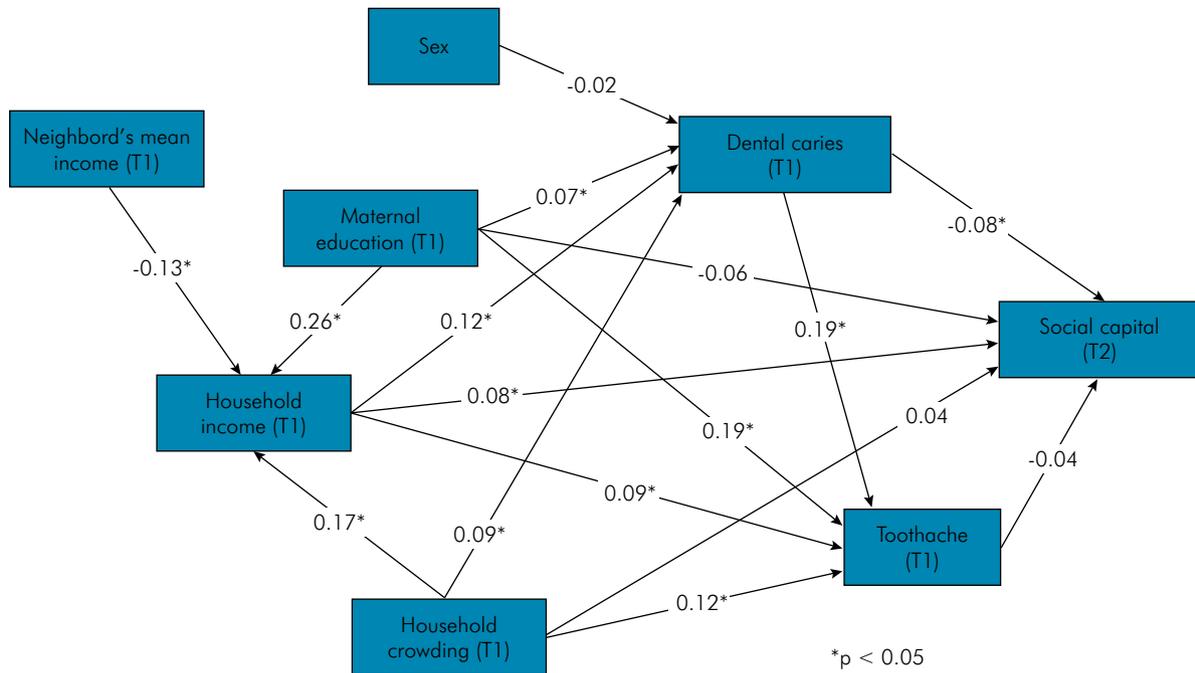


Figure 2. Path analysis of the variables observed in the adolescents' social capital.

with untreated dental caries and toothaches. These findings corroborate with previous studies.^{34,35} Socioeconomic inequities in oral health can be explained by materialistic and psychosocial theories. Materialist theory explains that individuals from families with low socioeconomic status are more susceptible to several health risk factors, such as lack of shelter and food, lower access to dental services, and worse environmental factors,³⁶ which may be related to worse oral conditions.³⁴ The psychosocial theory emphasizes that people who live in unequal societies are more likely to experience anxiety and psychosocial stress, which negatively affects health and coping.³⁶

This study has some limitations. Social capital was measured only at the individual level; however, we strive to encompass the main constructs that make up social capital and used in previous studies.¹ In addition, we only used social capital indicators, which may also limit the validity of the results. However, the use of indicators has been encouraged in previous studies.³⁷ In addition, factors related to dental aesthetics such as malocclusion, as well as other psychosocial factors (such as the sense of coherence and quality of life) that may interfere with

social relations at this stage, were not considered. Moreover, gingival bleeding did not remain in the model, likely due to the low burden of the disease; therefore, studies with more severe oral conditions should be investigated. The strength of this study is that it is a longitudinal study, which investigated the influence of contextual, socioeconomic, and clinical factors during an important period of biopsychosocial development, adolescence. This period is extremely critical, as adolescents undergo numerous behavioral and psychological changes, which may affect at them this stage and throughout their life.³⁸

Previous studies have shown that a lower social capital was related to decreased parental support and poor social networks in schools. It has been associated with delinquent behavior, aggression, alcohol and drug use, adolescent pregnancy³⁹ and lower OHRQoL.⁴⁰ In this context, an investigation of the social capital in adolescence is essential, because at this stage the individual needs greater social support, access to information, and also needs to create social skills, all of which result in better school outcomes, better insertion into the job market, and creation of behaviors that may perpetuate into adulthood.^{7,39}

Conclusion

Our findings suggest that individuals who lived in neighborhoods with greater inequality, from families with low income, and with untreated dental caries in early adolescence presented with a low social capital over their adolescence. This study provides evidence for the implementation of public policies that include psychosocial aspects, aiming to alleviate oral problems and improve social networks. In addition, intervening in a distal factor such as social capital can be beneficial for several other factors in the lives of individuals and the community in general. Future

studies should include the use of broader social capital questionnaires as well as the use of social capital variables at a contextual level.

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