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Do social inequalities persist in the distribution of dental caries in adolescents from Maranhão? Contributions of a population-based study

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Abstract *This study aimed to analyze the association of socioeconomic factors with the prevalence of dental caries in adolescents from São Luís, Maranhão, Brazil, to answer whether social inequalities persist in distributing this disease. This is a cross-sectional study nested in a prospective cohort. We included 2,413 adolescents aged 18-19 years evaluated in the 2016 second follow-up. The outcome was teeth with untreated dental caries (yes or no) assessed by the DMFT index. Socioeconomic and demographic characteristics were the independent variables. Descriptive statistical and Poisson regression analyses were performed, calculating crude and adjusted prevalence ratios (PRs) (alpha=5%). Belonging to economic classes C (PR=1.23; 95% CI: 1.11-1.37) or D-E (PR=1.48; 95% CI: 1.32-1.65), being married/living with a partner (PR=1.22; 95% CI: 1.07-1.39), having separated parents (PR=1.11; 95% CI 1.03-1.19) and a greater number of people in the household (PR=1.05; 95% CI: 1.03-1.07) were associated with a higher prevalence of dental caries. Social inequalities in adolescent oral health persist despite the implementation of the National Oral Health Policy. The current health care model should seek to reorient health education strategies, targeting them at vulnerable populations.*

Key words *Dental caries, Socioeconomic factors, Adolescent*

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Introduction

Due to the high frequency, economic impacts, and effect on people's quality of life[1-3], dental caries is a significant public health problem in Brazil[4]. It is a chronic disease resulting from the mineral dissolution of dental tissues from the production of bacterial acids when they metabolize carbohydrates, mainly sucrose, from the diet[5].

While the etiology of caries is well known, many aspects related to the role of socioeconomic factors have been gaining relevance. They have been addressed in several studies in association with the biological determinants interacting in the etiology of the disease[6-8]. However, some aspects related to the role of these factors are poorly explained.

The association between poverty and social inequalities with oral morbidities has been the subject of Brazilian[9-11] and international studies[6,12,13], and different theoretical explanations for social causation are raised, such as the social quality[1,2], life course[14], stress[15], and social support[16] theories. Several studies' thesis is that socioeconomic disadvantage is associated with a higher incidence and prevalence of caries, justified by bad behavioral habits, greater vulnerability to risk factors for the disease, and less access to treatment[1,6,17].

However, population-based studies with adequate control of confounding factors designed for this purpose are rare, and there is no consensus on exactly which socioeconomic factors have a more relevant role in the disease. Furthermore, declining social inequalities were expected[18,19] with the expanded coverage of PHC for health promotion, disease prevention, and treatment of the most prevalent conditions, changes in care models, and growth of oral health care in the public network.

This study aimed to identify the prevalence of dental caries in adolescents from São Luís, followed up at the RPS cohort (Ribeirão Preto, Pelotas, and São Luís Brazilian Cohort) and evaluate their relationship with different socioeconomic factors, considering whether social inequalities persist in the distribution of dental caries to contribute to the quality of oral health policies.

Methods

This is a cross-sectional study nested in a prospective cohort of live births conducted in São Luís, Maranhão, Brazil. The original cohort is called RPS (since it was developed in Ribeirão Preto, Pelotas, and São Luís). The study was held from March 1997 to February 1998 (at the children's birth), the baseline. The children were reevaluated in 2005 (school age: between 7-9 years), which was the first follow-up; and again in 2016, when they were in their teens (18-19 years), which was the second follow-up[20].

The baseline of the birth cohort included live newborns in hospital delivery from mothers living in the municipality of São Luís, from March 1997 to February 1998. It was conducted in ten public and private hospitals. Systematic sampling was used with stratification proportional to the number of births in each hospital. Thus, one in seven deliveries per hospital was recruited. A total of 2,542 live births participated in this stage. After excluding stillbirths, the sample arrived at 2,443 births[20].

In the first follow-up, based on a school census, all parents or guardians of children located who had been born with low or high weight and one-third of the others were invited for a reassessment, totaling 1,108 eligible participants.

The participants in this cohort underwent a new evaluation at 18 and 19, from January to December 2016, the second follow-up. We looked for enrollment in schools and universities, addresses and contacts on social networks, and military enrollment records (for men) to locate them. In total, 654 adolescents were identified and accepted to participate in this stage. We included the participants with two methods due to the difficulty in locating individuals and expanding the sample size of the study: drawing lots from the database of the Live Births Information System (SINASC) (n=1,716), and including volunteers identified in schools, universities, and social networks born in maternity hospitals in São Luís in 1997 (n=145). These new participants were subjected to the same tests and questionnaires as the original cohort[21].

Thus, this phase included the participation of 2,515 adolescents. However, 102 of these were excluded because they were using orthodontic appliances or refused to participate. In the end, 2,413 participants were considered for this study (Figure 1).

Trained health professionals performed data collection. Data on sociodemographic characteristics, lifestyle, and food consumption were obtained using standardized questionnaires. The information was recorded in the Research Electronic Data Capture[22] online program.

This sample size has been estimated with 90% power to identify relative risks from 1.5,

considering a 50% incidence of disease among those exposed, a 1:1 ratio between exposed and unexposed, a confidence level of 95%, and a design effect equal to 2.0.

The independent variables were adolescent age (in years); adolescent's school situation (currently studying, yes or no); adolescent's current work history (yes or no); adolescent's marital status (single, married, or living with a partner); the number of people in the household; parents' marital status (separated or not); household income; the Poverty Income Ratio (PIR)[23] income indicator, which is the relationship between household income divided by the number of people in the household, divided by R$ 140.00 (value referring to the poverty criterion, according to the World Bank and the Federal Government, 2016); social benefits received (yes or no); what social benefits received (retirement pension, LOAS, *Bolsa Família*, pension for death or illness); and economic class according to the criteria of the Brazilian Association of Research Companies (ABEP)[24,25], distributing them between classes A-B, C, and D-E.

The outcome was the occurrence of teeth with untreated caries (yes or no), according to the DMFT index modified by the World Health Organization[26]. This data was collected through clinical dental examination, in a mobile office, under artificial lighting, using a rounded tip millimeter probe N° 11.5 indicated by the World Health Organization[26], in the second follow-up.

Descriptive statistical analyses, bivariate tests, and Poisson regression analyses were performed, calculating crude and adjusted prevalence ratios (PRs). The software STATA version 14 (Stata Corp., College Station, TX, USA) was used, considering 5% alpha for H0 rejection.

The project was approved by the Research Ethics Committee (CEP) of HU-UFMA. The informed consent was granted in writing after receiving the information.

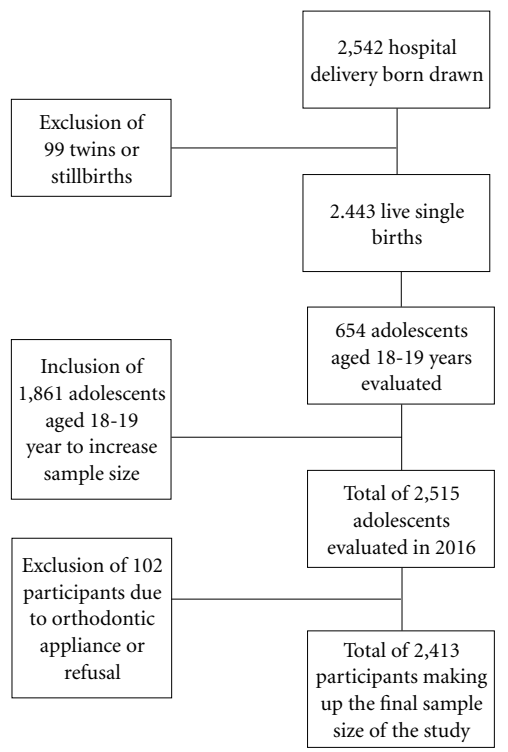

Figure 1. Study sample flowchart. São Luís, Maranhão, Brazil. 1997-2016.

Source: Elaborated by the authors.

Results

Table 1 summarizes the socioeconomic characteristics of the adolescents included in the study, totaling 2,413 participants. Some indicators cause a stir, as follows: 30.42% (n=734) were not attending school; 48.45% (n=1,169) had separated parents. The mean household income was R$ 2,421.03 (±5,132.72); 42.24% (n=1,007) of the households received some type of social benefit, such as the *Bolsa Família*, retirement or pension due to death/illness. According to ABEP criteria[24,25], 50.95% (n=1,229) of the adolescents were from class C; 24.96% (n=602) belonged to class D-E and, according to PIR[23], 24.09% (n=581) belonged to class A-B. According to the indicator, 44.03% (n=1,062) were three times or more above the poverty line, thus having a high income; 17.08% (n=412) had a median income; 18.16% (n=438) were poor; and 19.82% (n=478) were below the poverty criterion.

Fifty-six percent (n=1,349) of the adolescents evaluated had at least one tooth decay injury; 55.57% (n=1,336) had at least one tooth restored, and 19.93% (n=479) had already lost one or more permanent teeth. Table 2 shows that the mean DMFT was 3.69 (±3.26), representing, on average, 13.27% (±11.68%) of the evaluated teeth.

In the unadjusted analysis, the highest prevalence of untreated caries was associated with adolescents who were married or living with a

Table 1. Characteristics of the study sample (n=2,413). São Luís, Maranhão, Brazil, 2016.

Variables	n	%	Mean	SD
Currently studying				
No	734	30.42		
Yes	1,658	68.71		
Not informed	21	0.87		
Currently working				
No	562	23.29		
Yes	380	15.75		
Not informed	1,471	60.96		
Adolescent marital status				
Single	2,300	95.32		
Married	30	1.24		
Living with partner	61	2,53		
Widower	1	0.04		
Not informed	21	0.87		
Number of people in the household		4.41	1.58	1,58
Adolescent's parents are separated				
No	1,223	50.68		
Yes	1,169	48.45		
Not informed	21	0.87		
Household income		2,421.03	5,132,72	5.132,72
Poverty income ratio (PIR)[1]				
Poor (PIR<1.0)	478	19.82		
Almost poor (1.0≤PIR<2.0)	438	18.16		
Median income (2.0≤PIR<3.0)	412	17.08		
High income (PIR≥3.0)	1,062	44.03		
Not informed	22	0.91		
Does anyone in the household receive social benefits?				
No	1,368	57.38		
Yes	1,007	42.24		
Not informed	38	1.57		
Type of social benefit received				
Unemployment insurance	36	1.49		
Retirement pension	394	16.33		
Social Assistance Organic Law benefit	10	0.41		
Bolsa Família (Family Aid)	504	20.89		
Death or disease pension	81	3.36		
Economic class (ABEP)				
A-B	581	24.09		
C	1,229	50.95		
D-E	602	24.96		

n: absolute frequency. %: percentage frequency. SD: standard deviation. [1] Relationship between household income divided by the number of people in the household, divided by R$ 140.00 (value referring to the poverty criterion, according to the World Bank and the Federal Government, 2016). Values below 1.0 mean households below the poverty line.

Source: Elaborated by the authors.

partner (PR=1.33; 95%CI: 1.17-1.51), resided in homes with a higher number of people (PR=1.06; 95%CI: 1.04-1.08), those whose parents were separated (PR=1.13; 95%CI: 1.05-1.21), who received some social benefit (PR=1.14; 95%CI: 1.06-1.22), belonged to economic classes C (PR=1.26; 95%CI: 1.13-1.40) or D-E (PR=1.56; 95%CI: 1.41-1.74). Untreated caries was less

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Table 2. Prevalence of teeth with dental caries in adolescents. São Luís, Maranhão, Brazil, 2016.

Variables	x	SD	Q1	Median	Q3	Min.	Max.
Absolute Frequency							
Decayed	1.59	2.15	0.00	1.00	2.00	0.00	16.00
Missing	0.34	0.82	0.00	0.00	0.00	0.00	8.00
Filled	1.76	2.42	0.00	1.00	3.00	0.00	16.00
DMFT	3.69	3.26	1.00	3.00	6.00	0.00	26.00
Relative Frequency (%)							
Decayed	5.71	7.71	0.00	3.57	7.14	0.00	57.14
Missing	1.23	2.94	0.00	0.00	0.00	0.00	28.57
Filled	6.33	8.67	0.00	3.57	10.71	0.00	57.14
DMFT	13.27	11.68	3.57	10.71	21.42	0.00	92.85

x: Mean. SD: Standard Deviation. Q1: first quartile. Q3: third quartile. Max.: Maximum value. Min.: Minimum value.

Source: Elaborated by the authors.

frequent in adolescents who were studying at the time of the research (PR=0.87; 95%CI: 0.81-0.94) and who belonged to households with per capita income three or more times above the poverty line (PR=0.81; 95%CI: 0.74-0.89).

After model adjustment, a higher prevalence of untreated caries remained associated with being married or living with a partner (PR=1.22; 95% CI: 1.07-1.39), a higher number of people in the household (PR=1.05; 95% CI: 1.03-1.07), with separated parents (PR=1.11; 95% CI: 1.03-1.19) and belonging to economic classes C (PR=1.23; 95% CI: 1.11-1.37) or D-E (PR=1.48; 95% CI: 1.32-1.65).

Discussion

Unfair inequalities were found in the distribution of caries among adolescents aged 18-19 years in São Luís concerning socioeconomic factors. Belonging to socioeconomic classes C, D-E, being married, the son of separated parents, and living in a household with a higher number of people were associated with a higher prevalence of dental caries. The greatest social vulnerability can influence the distribution of adverse oral conditions in adolescents, such as dental caries.

The prevalence of untreated caries among the adolescents in the survey was 56%, a result lower than that found in Brazil (76.1%) and in the Northeast Region (77.1%), according to the last National Oral Health Survey in 2010[27].

However, the prevalence of caries found in adolescents was higher when compared to Goiânia (54%)[28] and Campina Grande (38.5%)[9]. According to Silva et al.[29], the historical differences in the occupation process and the economic development of the Brazilian regions, and the unequal public health financing at the onset of the implantation of the Unified Health System (SUS) in Brazil, justify the social disadvantage of the North and Northeast Regions and, consequently, worse oral health indicators.

The moderate mean DMFT found (3.69)[26] was below the results of *SB Brasil 2010* for São Luís, which was 4.60[27], and to the Northeast Region in *SB Brasil 2003* (6.34)[30]. The "filled" component of the DMFT index was relevant (1.76) against the total DMFT (3.69), as it expresses a reality of greater access by the evaluated adolescents.

This best-recorded condition could be a consequence of national public oral health policies benefiting this group and other age groups in recent years[31-33]. The last major Brazilian survey of caries was held almost ten years ago, shortly after implementing the National Oral Health Policy (PNSB).

Our data collected, in 2016, point to reducing the disease in a population with significant socioeconomic vulnerability. However, a higher prevalence of caries has been identified in the less favored socioeconomic segments. Likely, access to health promotion, disease prevention, and treatment measures will also be unevenly distributed[34].

The efforts of the PNSB, with the creation of Dental Specialty Centers (CEO), the inclusion, albeit late, of the oral health team (acronym in Portuguese - eSB) in the Family Health Strategy (ESF) with a focus on longitudinal and family

care, and the changes in the Dentistry course curricular guidelines, emphasizing training general practitioners[35-37], have not yet been sufficient to eliminate oral health inequalities among adolescents, which is evidenced in this study conducted in one of the poorest Brazilian states.

There is a need to reduce socio-organizational and geographical barriers to facilitate access to more homogeneous[18] health services. It is also ideal to invest in training for a professional qualification, as it has effectively increased the quality of the APS attributes[38]. Besides strengthening the National Policy for Continuing Education in Health (PNEPS), in the elaboration of strategies to qualify health care and management[39].

Pró-Saúde and GraduaCEO were initiatives established by the Ministries of Health and Education, which aimed to bring the theory and practice taught in educational institutions closer to the reality of SUS to modify health education[40,41]. However, it is necessary to reflect on a new care model targeting training reorientation, in which commitment to care for the subject and social determinants and action focused on SUS should be demanded[42]. This can occur with the inclusion of trainees in internships within PHC, such as, for example, participants in the School Health Program (PSE), with the dissemination of lectures on tooth brushing and flossing, application of fluoride, and sealants to avoid reaching permanent restorations.

This study is probably one of the pioneers to find "being married or living with a partner" as a variable associated with a higher prevalence of caries in adolescents (22%), as no reports of such an association were found in the literature. An inverse relationship was found in a study carried out with adults, which states that adults involved in a relationship tend to have greater self-care and the existence of a spouse serves as an incentive agent for the partner to maintain health treatments[11]. Thus, it is believed that adolescents are faced with the responsibilities of an adult and married life and neglect aspects related to their health. Chronic diseases such as caries should be addressed in adolescents as it is possible to reverse adverse conditions interfering negatively throughout the life cycle[43].

The prevalence of caries was 11% higher among those who had separated parents than among adolescents with married parents. Similar data were found in the study by Ferrazano et al.[44] and Pinto et al.[45], in which the experience of caries among adolescents who did not live with both parents or only with the mothers was considerably more significant, which may be associated with emotional instability of parents who, involved in their problems, do not prioritize their children's oral health.

In the face of emotional and family stress, adolescents themselves may end up changing habits, affecting their health. The stress theory helps to support this hypothesis. According to some authors[6,15,46], a stressor can harm the individual health and psychological well-being. The quality of health and satisfaction with life are associated with individuals' social and economic characteristics and the environment in which they reside. Therefore, the more stressful the environment, the worse the quality of life.

In agreement with previous studies[47,48], living in homes with a more significant number of people was also considered a factor significantly associated with a higher prevalence of dental caries. In this situation, home overcrowding points to lower socioeconomic status, which, in turn, is associated with worse health conditions.

After adjustment, the model revealed that belonging to classes C and D-E, according to ABEP[24,25], is closely related to the higher prevalence of caries, and is 23% and 48% higher, respectively, than the prevalence found in class A-B adolescents. However, in Table 1, the results point to a divergence between the economic classification and the income indicator PIR[23]. Although most of the sample belongs to class C (50.95%), the predominant income was high (PIR≥3.0) among 44.03% of adolescents. In the adjusted analysis (Table 3), only the economic class was associated with caries, which reveals that the variable "economic class" was more sensitive to variations in the outcome, which can be explained by the fact that having an above-average household income does not necessarily imply socioeconomic improvements or a higher quality of life[49].

Much of the income came from social benefits, which can be interrupted with each change of government. As a result of this financial instability, income may not be a good indicator of household assets[50]. The mother-child binomial relates to maternal education and the prediction of caries in the child. Therefore, it would be interesting to consider education a more meaningful indicator than income in future studies[51].

Different mechanisms have been proposed to describe the possible effects of the socioeconomic status on health outcomes. A possible explanation is that the weak bonds of social cohesion, caused by social inequalities, result in scarce access to information and knowledge of funda-

mental aspects to promote good health conditions, including oral health[52].

Some limitations of this study refer to the collection of different indicators of socioeconomic conditions throughout the life cycle of the participants, which hindered analyzing social mobility precisely, which would help us understand its role in the prevalence of dental caries. Although the study used data from a follow-up of the RPS cohort, it was the first time that clinical dental examinations were performed on the participants, hampering the analysis of the incidence of the disease and leaving out only its prevalence.

This study is relevant because it has allowed confirming the persisting social inequalities, even in the face of numerous actions implemented decades ago, and identifying individual and collective risk factors for dental caries, represented by social, economic, and cultural conditions. This corroborates the need to qualify oral health care and implement public health promotion and disease prevention policies structured by contemporary theories and appropriate for more effective actions to curb inequalities.

Social capital elements such as norms of harmony or solidarity, mutual trust, and civic

Table 3. Effect of socioeconomic conditions on the prevalence of untreated dental caries in adolescents. São Luís Maranhão, Brazil, 2016.

Variables	Prevalence of untreated dental caries					
	Unadjusted			Adjusted		
	PR	95%CI	P-value	PR	95%CI	P-value
Is the adolescent currently studying?						
No	1.00			--	--	--
Yes	0.87	0.81-0.94	<0.001	--	--	--
Is the adolescent currently working?						
No	1.00			--	--	--
Yes	0.91	0.81-1.01	0.081	--	--	--
Adolescent marital status						
Single	1.00			1.00		
Married/Living with partner	1.33	1.17-1.51	<0.001	1.22	1.07-1.39	0.003
Number of people in the household	1.06	1.04-1.08	<0.001	1.05	1.03-1.07	<0.001
Adolescent's parents are separated						
No	1.00			1.00		
Yes	1.13	1.05-1.21	0.001	1.11	1.03-1.19	0.004
Not informed						
Does anyone in the household receive social benefits?						
No	1.00					
Yes	1.14	1.06-1.22	<0.001			
Economic class (ABEP)						
A-B						
C	1.26	1.13-1.40	<0.001	1.23	1.11-1.37	<0.001
D-E	1.56	1.41-1.74	<0.001	1.48	1.32-1.65	<0.001
Poverty income ratio (PIR)[1]						
Poor (PIR<1.0)	1.00			1.00		
Almost poor (1.0≤PIR<2.0)	1.10	0.99-1.21	0.062	1.07	0.97-1.18	0.180
Median income (2.0≤PIR<3.0)	0.95	0.85-1.06	0.381	0.97	0.87-1.08	0.571
High income (PIR≥3.0)	0.81	0.74-0.89	<0.001	0.92	0.83-1.01	0.090

PR: Prevalence Ratio. 95%CI: 95% Confidence Interval. (--) variables not maintained in the final model, with P<0.10. [1] Relationship between household income divided by the number of people in the household, divided by R$ 140.00 (value referring to the poverty criterion, according to the World Bank and the Federal Government, 2016). Values below 1.0 mean households below the poverty line.

Source: Elaborated by the authors.

engagement coupled with the growth of social epidemiology, addressing collective health, are themes that may bring new perspectives to the field of public health and health promotion. It is not only for proposing a healthier life for the populations based on behavioral changes but also for the possible reduction of social inequalities and a fundamental role in stimulating the participation of the community in formulating public policies and assuring their control[53,54].

Conclusion

The prevalence of dental caries in adolescents in São Luís, Maranhão, is associated with socioeconomic disadvantages, especially the number of people in the residence, social class, the marital status of their parents, and that of the teenager himself. Social inequalities in oral health persist even after significant investments.

The knowledge of risk factors for dental caries, represented by social, economic, and cultural conditions, helps understand the health-disease process in social groups and quickly identify groups at higher risk to receive preferential care in health programs.

Thus, we recommend investing in the qualification of oral health care in socially vulnerable populations and reflecting on a change in the care model to one that is directed towards the reorientation of training.

Collaborations

FS Sousa and BC Lopes contributed to the writing process, data analysis, and final review of the paper. EM Costa contributed to the data collection and final review of the manuscript. CMC Alves, RCS Queiroz, AS Tonello and CCC Ribeiro collaborated to design the study and final review of the manuscript. EBA Thomaz contributed to the study design process, statistical data analysis, and final review of the manuscript.

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