Tooth loss over 13 years of follow-up: can regular dental visits reduce racial and socioeconomic inequalities?

Tooth loss over 13 years of follow-up: **can regular dental visits reduce racial and socioeconomic inequalities?**

Running title (45 characters): inequities in tooth loss and dental visits

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Objectives: To assess if regular dental visits modify the effects of social and racial indicators on the incidence of tooth loss. **Methods**: This is a longitudinal analysis using data from the Pro-Saude Study. In 1999-2001, 3253 civil servants responded to self-administered questionnaires, and then in 2012-2013, with 19% attrition. The outcome was any increase in self-reported tooth loss, measured in four ordered categories (none, one or few, many, all or almost all). Main variables included income, education, race/ethnicity and an adapted version of Everyday Discrimination Scale. The

dental visit was dichotomized into regular and problem-oriented attenders. Potentially confounding factors were age and sex; effect modification was estimated using the relative excess of risk due to interaction (RERI). **Results**: An increase in the tooth loss category was reported by 23.1% of the individuals over 13 years of follow-up. Among problem-oriented attenders, 27.3% reported an increase against 20.4% in regular users ($p<0.01$). Interaction results are inconclusive. Even though not significant, either antagonism or synergism were observed: between lower income and problem-oriented (RERI = -0.22; 95%CI: -0.75 : 0.31), being Black+Brown and problem-oriented (RERI = -0.25; 95%CI: -0.64 : 0.14), discrimination and problem-oriented (RERI = -0.15; 95%CI: -0.55 : 0.25), and between having less than university degree and being problem-oriented (RERI = 0.21; 95%CI: -0.19 : 0.62). **Conclusions**: Regular attenders from advantaged groups seem to benefit more from dental care than disadvantaged groups, increasing unfair inequalities. Inconsistencies in current findings warrant further investigations.

Clinical Significance: Regular attenders from advantaged groups seem to benefit more from dental care than disadvantaged groups, increasing inequities, but the effect size of the Relative Excess of Risk due to Interaction were not large and were inconclusive.

Keywords: Socioeconomic Inequalities, Dental care, Oral Health, Cohort, social discrimination

INTRODUCTION

Socioeconomic and behavioural factors are related to tooth loss, and disadvantaged groups have shown the highest burden of this condition [1–3]. Explanations for this relationship usually include an extensive array of distal determinants [4]. However, the magnitude of socioeconomic inequalities in tooth loss varies considerably and are mostly unexplained [1,5]. Efforts to explain such variability can guide public policies to reduce socioeconomic inequalities and improve oral health.

A few general strategies for reducing health inequities have been described, but it is unknown how much they are applicable to oral health [6]. Accordingly, targeted policies may have a small effect because they demand individual behavioural changes [7], whereas universal policies would have better results using non-behavioural strategies [8,9]. Regarding oral health, it has been suggested that the size of socioeconomic inequalities may be modified or reduced by broad public policies [10], by the use and access to dental care[11], or life course exposure to fluoride[12,13].

One of the most controversial interventions to prevent tooth loss is the frequency of use of dental services [14]. This association has been reported as bidirectional and difficult to disentangle in cross-sectional studies. On the one hand, people with more dental problems visit the dentist more often and receive more treatment, including tooth extraction. On the other hand, those who visit more often may receive less tooth extraction because of early diagnosis and prevention. If routine and preventive visits are effective, then they can reduce social inequalities in tooth loss. Previous evidence shows that individuals in places that offer more preventive services seem to have fewer cavities [15], which would lead to less tooth loss. Also, users who visit dentists irregularly - problem-oriented attenders - tend to have more missing teeth [14,16]. However, longitudinal and randomized trials showed little evidence that regular attenders may benefit from dental care [17–20], and the possibility of a "healthy user effect" has been postulated to explain the better health status among regular attenders.

When two or more factors affect an outcome via the same mechanism, they may interact in antagonism or synergy [21]. This may be the case of dental care and socioeconomic factors. Although dental care may be a mediator between socioeconomic factors and tooth loss, socioeconomic factors also affect tooth loss by other paths that may be modified by dental care, making the latter a moderator. To evaluate properly an interaction, it is recommended the use of specific indicators on additive scale [21]. In our case, for example, a more radical treatment - such as tooth extraction – may be more often provided to disadvantaged groups with an irregular dental visit pattern (problem-oriented) than to disadvantaged groups with regular patterns. Then, the absolute difference in tooth loss between advantaged and disadvantaged groups is expected to be higher among those problem-oriented attenders than regular ones. A previous study using cross-sectional data could not find such interaction [16], but longitudinal studies in tooth loss have not reported this interaction. Nonetheless, social and racial discrimination in dental settings may have an important role, as lower socioeconomic position (SEP) individuals are more likely to be offered tooth extraction than their upper SEP counterparts [22,23] and black individuals [24]. Few studies have examined the association of racial discrimination and oral health with conflicting findings [25–28], and the study using tooth loss as the outcome reported an association only in unadjusted analysis[27]. Thus, we aim to assess if regular dental visits modify the effects of social and racial indicators on the incidence of tooth loss.

MATERIALS AND METHODS

Design and study population

This longitudinal study used data obtained from the Pro-Saude study, a cohort of civil servants at university campuses in the state of Rio de Janeiro, Brazil. In 1999, all active employees were considered eligible, excluding temporary workers and those transferred to other institutions. A total of 3,253 employees took part in the baseline of the cohort started in 1999 and completed in 2001, then followed until the last wave in 2012-13[29] with 2,619 participants (19.5%

attrition rate). Current analysis used only data from the baseline and the last wave, collected through a self-administered questionnaire with structured questions about socio-demographic characteristics and health conditions and behaviours. Methods to access data quality included pilot studies, test-retest reliability assessment and double data entry [16,30]. The University Research Ethics Committee approved the study (IMS/UERJ No 0041.0.259.000-11) and all participants signed an informed consent form.

Outcome variable

An increase in self-reported tooth loss was the outcome variable, with the same question asked in 1999-2001 and 2012-13: "During the lifetime, many people lose some or even all teeth. Which of the options below best represents the number of teeth you lost? 1- "I have not lost any teeth"; 2- "I have lost one or a few teeth"; 3- "I have lost several teeth"; and 4- "I have lost most or all of my teeth." The test-retest reliability (kappa coefficients) of the response about tooth loss was 0.75 (95% CI=O.64, 0.87) and of routine visits for dental check-up was 0.71 (95% CI=0.60, 0.80) [16]. For the current analysis, 331 individuals who indicated having "most or all of my teeth" at baseline were removed from the follow-up since they were not at risk of further tooth loss. Those who indicated an increase in tooth loss category during the longitudinal analyses were considered incident cases; participants could increase up to three categories (from 1 to 4). We identified some reversals in the missing teeth categories (n=183 individuals reporting an increase in number of teeth, 7.6%) and they were considered as non-incident cases as that measurement error is more likely to represent stability than progressive tooth loss.

Exposures and covariates

We used two SEP indicators and self-reported race/ethnicity. The first SEP indicator was monthly net household income at baseline collected in nine categories, then transformed in equivalized income using the square root of the number o people in the household [31] and dichotomised at 0-10 minimum wages (MW) or >10 minimum wages in Brazilian currency (reais). In 1999, the minimum monthly wage was BR$136,00 (US$ 72.3). Although income varies the over

life course, this is a cohort of stable employees, and we believe the baseline income may be more plausibly associated with future tooth loss than income in the end of the follow-up.

The second SEP indicator was individual own education at baseline, originally collected in seven categories (0=incomplete basic education / 6= graduate education). Then, it was dichotomised in less than high school or high school or more. There were some changes in educational level; accordingly, we opted to use only baseline information from 1999 because it may be better associated with future tooth loss than education at the end of the follow-up.

Race/ethnicity was self-reported as the following open-ended [30] question: 'In your opinion, what is your race or colour?'. Then, it was categorized as White, Brown, Black, Yellow/Asians, or Indigenous. For analytical purposes, it was dichotomized into Whites and Blacks+Brown, collapsing Browns, Blacks. Asians, and Indigenous peoples comprised 21 individuals at baseline and were excluded.

Data about dental visits was collected only in 1999 and used as a proxy for lifelong dental visits. The question was: "In general, how frequently do you go to the dentist for a routine dental check?", with the following response options: l="I have never been to the dentist"; 2="I don't usually go for a routine dental check, I only go to the dentist when I have a problem"; 3="Less frequently than once every two years"; 4="Once every two years"; 5="At least once per year.". Option 2 was categorized as "Irregular/Problem-oriented", and options 3, 4, and 5 were considered "Regular" users. Individuals who had never been to the dentist (category 1) were excluded (n=16).

The discrimination instrument was an abridged and adapted version of the Everyday Discrimination Scale collected in 2001 [32,33]. Respondents answered yes/no to five items, such as "Have you ever felt that you were unfairly treated, due to discrimination, in your workplace, as, for example, being fired or not getting a promotion?" The five items included lifetime discrimination for any reason at public places, home, work, school/university, or by the police. Overall scores ranged between zero (no discrimination) and five (highest discrimination).

Statistical analysis

Descriptive analyses were conducted to describe the increase in tooth loss categories over covariates and stratified by dental visits pattern. When appropriate, associations were tested using the chi-squared test, chi-squared for trends, or Fisher's exact test. Age and sex-adjusted relative risks (RR) were estimated using log-binomial models to test for effect modification and the Relative Excess of Risk due to Interaction (RERI) [21]. It is a standard measure for interaction on the additive scale and estimate the extend in which the observed risk in a jointly exposed group exceeds the expected risk of the independent exposures. A RERI of zero means that the joint effect equals the independent effects and positive values reflect a synergy while negative values reflect an antagonistic effect. Mediators were not evaluated because the aim was to evaluate the total effect on exposures on tooth loss. Covariates had to be dichotomized to calculate those estimates, and the cut-off points were the median values because we assumed linear relations.

Logistic regression was used to model the association of independent variables with an increase in tooth loss category, after adjustment for age and sex. Multiplicative interactions of odds ratios were tested in regression analysis independently between dental visits pattern and: a) income, b) educational level, c) race and d) discrimination. The fit of all models was evaluated through two main parameters: Akaike Information Criteria (AIC) and McFadden's adjusted pseudo-R^2. All analyses were performed in Stata 16.1 software.

RESULTS

Our eligible population consisted of 3,253 individuals taking part in the study baseline 2-wave data collection (1999-2001). However, due to loss of follow-up, the final sample in 2012 was 2,619 (81%), and further individuals were removed due to exclusion criteria, leaving a study population of 2,407 participants. Losses did not affect the proportions at baseline (Appendix Table 1). For example, in 1999-2001, the sample consisted of 55.9% of women and 51.3% of whites, while in 2012-13, these proportions were 56.6% and 50.1%, respectively. Sensitivity analysis showed that losses did not affect associations at baseline (Appendix Table 2). The prevalence of

having several to all missing teeth was 34.3% among brown individuals and 27.4% among men in 1999 and 32.9% and 26.8%, respectively, after the 13-year follow-up. Because this is a fixed cohort, there was a change in age structure, increasing the percentage of individuals over 50 years from 15.5% to 61.5%. It was observed an increase in educational attainment but a decrease in income (see Appendix Tables 1 and 2). The correlation of baseline and follow-up income (in MW) was r= +0.62 and education attainment was r= +0.93.

The overall incidence of increasing at least one category of reported tooth loss was 23.1% (Table 1). The incidence among problem-oriented individuals was 27.3%, and among those visiting the dentist yearly was 20.4% ($p<0.01$). Incidence among women and men was respectively 23.0% and 23.3% ($p=0.85$), among Indigenous/Yellow/Asians, Blacks, Browns and Whites it was 30.8%, 25.8%, 24.3% and 21.3% ($p=0.13$). There were statistically significant associations ($p<0.01$) between tooth loss incidence and income, education, and age, but not with lifetime discrimination for any reason ($p=0.99$).

INTERACTIONS OF INCOME, EDUCATION, RACE AND DISCRIMINATION WITH THE PURPOSE OF DENTAL VISIT ON TOOTH LOSS INCIDENCE: RERI

Income, education, race and discrimination were dichotomized to estimate RERI. Similar results were observed for income, race and discrimination. Tables 2 and 3 show that the incidence was six percentage points higher in the lower-income groups among problem-oriented individuals (22.2% vs 28.2%, $p=0.12$) but 8.4 percentage points higher among regular users (15.8% vs 24.3%, $p<0.01$). The RERI showed antagonism between low income and problem-oriented attenders (Table 3); although not statistically significant, the joint effect of both exposures was lower than expected in both indicators. The adjusted RERI was -0.22 (95%CI: -0.75: 0.31). Interaction of education and dental visit showed synergy; that is, the observed effect was higher than expected, although it was not statistically significant (RERI=0.21, 95%CI: -0.19: 0.62).

The association between the purpose of dental visits and discrimination was also tested. The percentage of problem-oriented attenders was 35.5% among those who reported no discrimination in the five-item scales, and it was 34.4%, 39.7%, and 34.7% among those reporting discrimination in one, two, or more than two items (p=0.60), respectively.

INTERACTIONS OF WITH DENTAL VISIT ON TOOTH LOSS INCIDENCE: REGRESSION MODELS

There were 76.9% of the individuals who remained in the same tooth loss category over time; the percentages of individuals who increased one, two or three categories were, respectively, 21.7%, 1.2% and 0.2%. Ordinal logistic regression estimated multiplicative interactions in the odds ratio scale (Appendix Table 3). Results using original categorization (non-dichotomized) of the predictors were like those of RERI. Lower levels of income and being Black+Brown were associated with a higher risk of tooth loss, being statistically significant among regular users ($p<0.02$) but not among problem-oriented attenders ($p>0.05$). Educational attainment was inversely associated with tooth loss among both groups. Discrimination was not associated with the risk of tooth loss neither among regular (p=0.48) nor problem-oriented attenders (p=0.55). All models have an adjusted pseudo-R^2 lower than 2.8%.

DISCUSSION

In this longitudinal study, over 13 years of follow-up with a diverse and large study population, two main findings were observed. Firstly, interaction results were inconclusive because of mixed direction and lack of statistically significance, we did not confirm our initial hypothesis that inequalities were larger among problem-oriented attenders; indeed, findings suggest that inequalities may be larger among regular users. Groups with social advantage may benefit more from preventive visits than others and may have increased inequalities. Secondly, race/ethnicity was associated with tooth loss, while discrimination was not. This somewhat contradictory result may

reveal challenges in measuring the direct effect of discrimination and racism in epidemiologic studies.

Problem-oriented individuals showed a higher risk of tooth loss than regular attenders, but inequalities were slightly larger among regular than problem-oriented attenders. A recent study showed that SEP had an independent direct effect on tooth loss, not mediated by the pattern of dental attendance [34]. Therefore, reducing social inequalities in dental attendance is necessary but not sufficient to tackle socioeconomic inequalities in oral health. Additionally, it has been shown that larger absolute socioeconomic inequalities in tooth loss were found in mid-adulthood and then declined in older age [35]; therefore, the role of dental care may be more important from adulthood to older life, differently from the current study. Finally, the healthy-user effect may explain the beneficial effect seen among regular users [19]; that reflects underlying risk factors for oral diseases, presumably social factors.

Our study showed a weak and statistically non-significant association between tooth loss and discrimination but a stronger and significant one with race/ethnicity. It is possible that structural racism in access to dental care may be more relevant than the interpersonal discrimination, which was measured in our study. This explanation seems in line with previous studies that have reported a non-significant association between interpersonal discrimination and tooth loss after adjustments [27,36]. Nonetheless, there is clear evidence of racial discrimination in dental care services, but this may be subtle and not capture by our scale, dentists may provide less expensive treatment, presumably of lower quality [37]. Beyond that, it is very likely that people avoid exposing themselves to regular discrimination whenever possible, then currently reported discrimination may represent other unavoidable situations, unlike routine dental visits. Accordingly, some studies found that discrimination in healthcare settings was weakly or inversely associated with dental attendance [38,39]. Those results were obtained by the sole reporting of differential treatment, and it was highlighted that the addition of a question about “emotional impacts” was considered a better way to report situations that otherwise could be misperceived or overlooked

[39]. While a known scale includes the feeling of discomfort or unfairness as part the measurement [40], this dimension is not covered in the Everyday Discrimination Scale [32].

Some limitations must be considered. One is the use of baseline exposures which may not represent the overall exposure throughout the period. However, a long follow-up is needed to observe a considerable number of new cases, and an assumption is that the exposure remains relatively stable. Although it is especially important for time-varying factors (in this case, income and dental visits pattern), in terms of causality the baseline values preceded tooth loss and are expected to have a stronger association than the final measurement. Despite being a specific population, the Pro-Saude study has a diverse sample with a long follow-up. Moreover, a limitation is the use of self-reported number of remaining teeth, which has, on the other hand, been validated against clinically assessed number of lost teeth [41]. Measurement errors in the outcome may be random, in such case the associations presented are likely attenuated. Finally, Brazil offers free public dental services, but many people use the private sector either as out-of-pocket or health insurance. The current study was not able to evaluate the effect of different providers as we were not able to assess the effect of frequency of visits or decompose specific reasons for it.

Conclusions

We did not confirm our initial hypotheses, but the results showed the role of dental care in tooth loss. Regular attenders seemed to benefit from dental care, and this was more pronounced among socially advantaged groups. Further studies may explore the role of interpersonal discrimination specifically in the dental settings and use adapted scales that incorporate feelings discomfort or unfairness [40]. Policymakers have a difficult task in reducing socioeconomic and racial inequalities in health, and the impact of dental care needs to be better understood.

CRediT authorship contribution statement:

Roger Keller Celeste: Conceptualization, Validation, Formal analysis,, Writing – original draft. Mariel de Aquino Goulart: Conceptualization, Data Curation, Writing - Review & Editing. Eduardo Faerstein: Conceptualization, Investigation, Funding acquisition, Writing - Review & Editing

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Supplemental Data (online Appendix)
Appendix Table 1 – Comparison of baseline characteristics in two data collection waves in Pro-Saude Cohort Study.
Appendix Table 2 – Prevalence of having several or all missing teeth at joint baseline 1999-2001.
Appendix Table 3 – Odds ratio and 95% confidence interval of increase in tooth loss and social factors according to type of dental care received in logistic regression models.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1 - Relative distribution of variables at baseline (1999-2001) and bivariate associations with incidence of self-reported tooth loss over 13 years.

		Total		Tooth loss		
Variable	Category	%	n	%	Incident cases (n)	P-value*
Total		100.0	2407	23.1	551	
Sex	Male	43.4	1045	23.3	242	0.85
	Female	56.6	1362	23.0	309	
Age	20-29 years	8.7	210	17.6	37	<0.01
	30-39 years	41.0	986	17.8	175	
	40-49 years	39.6	952	27.3	256	
	>=50 years	10.8	259	32.8	83	
Dental visits	Problem-oriented	33.8	810	27.3	219	<0.01
	Every > 2 years	8.9	213	23.0	49	
	Every 2 years	13.7	328	21.5	70	
	Every year	43.6	1043	20.4	211	
Household income in Minimum Wages (MW) in BR$	>20	5.3	123	18.9	23	<0.01
	15-20	7.5	175	19.5	34	
	10-15	21.3	497	16.0	79	
	5-10	43.7	1018	23.5	238	
	0-5	22.2	516	30.5	154	
Educational attainment	University Degree	41.2	983	18.1	177	<0.01
	High School	38.6	921	22.7	207	
	Fundamental School	15.3	366	33.7	121	
	<fundamental school	4.9	116	36.0	41	
Race/Ethnicity	White	51.8	1244	21.3	263	0.13
	Brown	26.4	634	24.2	152	
	Black	21.3	512	25.8	130	
Lifetime discrimination for any reason**	None	64.4	1473	22.7	331	1.00
	One domain	21.4	488	23.1	112	
	Two domains	8.5	195	22.7	44	
	>Two domains	5.7	130	22.5	29	

* Fisher exact p-values or chi-square test for trends in ordered categories

** Domains: at school, work, home/neighbourhood, public places, by the policy

Table 2 – Incidence of increase in self-reported tooth loss from 1999 to 2012 stratified by dental visit pattern.

	Regular Visit			Problem-oriented		
	% tooth loss	n	P-value*	% tooth loss	n	P-value*
Total	21.0	1574		27.3	801	
Sex						
Male	18.7	599	0.08	29.7	435	0.11
Female	22.4	975		24.6	366	
Age						
20-29 years	14.2	148	<0.01	25.8	62	<0.01
30-39 years	17.5	675		18.4	305	
40-49 years	24.6	601		32.4	333	
>=50 years	28.7	150		38.6	101	
Household income in Minimum Wages (MW) in BR$ at baseline						
>10	15.8	619	<0.01	22.2	171	0.12
0-10	24.3	903		28.2	607	
Educational attainment at baseline						
University Degree	17.8	746	<0.01	19.2	229	<0.01
Less than University	23.8	814		30.5	567	
Race/Ethnicity						
White	18.9	875	0.02	27.2	357	0.96
Black+Brown	23.5	697		27.3	443	
Lifetime discrimination for any reason** at baseline						
None	20.1	972	0.48	27.7	483	0.55
at least in one domain	21.6	532		25.7	272	

* Fisher exact p-values or chi-square test for trends in ordered categories
** Domains: at school, work, home/neighbourhood, public places, by the policy

Table 3 – Incidence, Relative Risk (RR and 95% confidence interval: CI) and Relative Excess of Risk due to Interaction (RERI) of increase in self-reported tooth loss from 1999 to 2012 according to covariates, stratified by dental visit type.

	%	n	RR (95%CI)	%	n	RR (95%CI)	RERI (95%CI)	
	Regular			Problem-oriented			Crude	Adjusted*
Household income in Minimum Wages (RS)								
>10 MW	15.8	619	1	22.2	171	1.40 (1.01 – 1.96)	-0.16	-0.22
0-10 MW	24.3	903	1.53 (1.24-1.90)	28.2	607	1.78 (1.43 – 2.22)	(-0.69 : 0.37)	(-0.75 : 0.31)
Educational attainment								
University Degree	17.8	746	1	19.2	229	1.08 (0.79 – 1.47)	0.30	0.21
Less than University	23.8	814	1.34 (1.10-1.63)	30.5	567	1.71 (1.40 – 2.09)	(-0.11 : 0.70)	(-0.19 : 0.62)
Race/Ethnicity								
White	18.9	875	1	27.2	357	1.44 (1.16 – 1.79)	-0.24	-0.25
Black+Brown	23.5	697	1.25 (1.03-1.51)	27.3	443	1.45 (1.18 – 1.78)	(-0.65 : 0.17)	(-0.64 : 0.14)
Lifetime discrimination for any reason								
None	20.1	972	1	27.7	483	1.38 (1.14 – 1.67)	-0.18	-0.15
At least in one domain	21.6	532	1.08 (0.88-1.32)	25.7	272	1.28 (1.01 – 1.63)	(-0.58 : 0.22)	(-0.55 : 0.25)

*age-sex adjusted values

Note: RERI<0 indicates antagonism, RERI>0 indicates synergy