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The role of potential mediators in racial inequalities in tooth loss: the Pró-Saúde study

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Abstract – *Objective:* To assess the relation between race and tooth loss, as well as the influence of socioeconomic factors, health behaviours, routine dental care and self-reported discrimination on this association. *Methods:* This is a cross-sectional study with data collected from the baseline of the Pró-Saúde Study (Rio de Janeiro/Brazil), among 3253 civil servants in 1999–2001. Race was measured as self-reported skin colour (Black/Brown/White). The outcome was self-reported tooth loss, measured in four ordered categories (none/one or few/many/all or almost all). Three mediating pathways were explored between race and tooth loss. The first included self-reported discrimination assessed with a five-item scale. The second pathway included behavioural factors: routine dental care, marital status, smoking and alcohol consumption. The third considered socioeconomic factors: income, education, maternal education and early life poverty. Confounding factors were age and sex. Statistical analyses were carried out with ordinal logistic regression. *Results:* Absence of all or almost all teeth was reported by 8% of respondents. White individuals comprised 53% of the population, followed by Browns (26%) and Blacks (22%). After adjustment, Blacks had an odds ratio of being in a higher category of missing teeth equal to 1.39 (95% CI 1.12–1.72), and Browns, 1.33 (95% CI 1.10–1.60), when compared to Whites. Age, sex and socioeconomic variables explained most of racial inequalities in tooth loss, while behavioural and discrimination variables contributed very little. Behavioural and socioeconomic variables were associated with tooth loss, while discrimination was not. No statistically significant interactions were found. *Conclusions:* There is an association between race and tooth loss that is mainly explained by current and early life socioeconomic variables, but not by behavioural factors and self-reported discrimination.

Key words: discrimination; mediation; race; socioeconomic factors; tooth loss

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Several studies have shown that oral ill health is generally associated with race, such that worse oral health outcomes are particularly more frequent among nondominant or minority groups in societies worldwide, including Blacks, immigrants and indigenous peoples. For instance, race, measured in different ways, has consistently been associated with untreated dental caries (1), tooth loss in adults and children (2–6), as well as with worse self-rated oral health (7). A systematic review also reported that adverse periodontal outcomes were more frequent among Blacks and Browns (8). After adjusting for demographic factors, education and income, racial disparities persisted for different outcomes, such as tooth loss, perceived oral health and periodontitis (3, 9). A study also showed that

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Blacks had a higher risk of presenting untreated dental caries, even after adjustment for demographic, behavioural and material life conditions (1).

Most of this relationship is generally believed to be explained by socioeconomic factors (1, 9), and the persistent adjusted association between race and adverse oral health outcomes might be attributed, at least in part, to residual confounding by those factors or (implicit) discrimination (10). However, other pathways might also be involved and, thus, are worth exploring. Differences in behaviours among racial groups have been explored by some studies as sources of disparities in oral health; the results showed a rather limited contribution of oral health-related behaviour in explaining racial disparities in oral health (1, 9).

On the other hand, there is evidence that discrimination may play a role in racial inequalities in health (11). Specifically, tooth loss may be influenced by experiences of discrimination via, at least, two related pathways: (a) Acting as a particular psychosocial source of stress (11), that may affect host defence to microbiological insults in the periodontal tissue, leading to loss of periodontal attachment and tooth loss (12) and (b) Influencing the decision to retain or extract a decayed tooth by prejudiced attitudes and discriminatory behaviour held by dental professionals (13). A previous study showed that the dentist's decision on whether to extract or to retain a decayed tooth varied significantly according to the patient's race, with dentists deciding to extract more frequently for the Black patients (13).

In the USA, African Americans received less restorations than White Americans, although this pattern was not observed for other dental procedures, like diagnosis, prevention or oral surgery (14). Even when Blacks had the same clinical needs and access to dental care, they were more likely to experience tooth loss in 2 years time (15). Conversely, African Americans also seem to opt for less conservative treatment, which may be explained by ability to pay, education, importance of dental visits and related variables (16).

Given that tooth loss represents the accumulation of oral disease, it is reasonable to assume that current racial disparities may be only partially explained by current socioeconomic characteristics. Early life socioeconomic factors play an independent role in the causation of dental caries and tooth loss (17–21). Not only may early life socioeconomic variables accumulate with current socioeconomic hazards, but they may also be a marker of the quality of education, diet or access to fluoride across the life course. To our knowledge, whether or not discrimination mediates the relation between race and tooth loss has not yet been reported in the literature. Also, no early life socioeconomic factors have been explicitly incorporated into analyses of the relations between tooth loss and race. Therefore, this study aimed at evaluating the association between race and tooth loss, as well as assessing the role of socioeconomic and behavioural factors, and reported experiences of discrimination may play on this association.

Methods

Design and study population

This cross-sectional analysis uses baseline data from a longitudinal investigation, initiated in 1999 with civil servants at university campi in Rio de Janeiro, Brazil (Pró-Saúde Study). A second phase of baseline data collection was conducted in 2001. The main focus of the study is to investigate social determinants of health (22). All employees were considered eligible, excluding temporary workers, those transferred to other institutions, inactive or on sick/maternal leave. A total of 3253 employees took part in the baseline of the cohort. The research protocol was approved by the Ethics in Research Committee of the institution where it took place, and written consent was obtained from all participants.

Instruments and measures

Data were collected through a self-administered questionnaire with structured questions addressing, among others, issues related to sociodemographic characteristics, self-reported morbidities and health behaviours. The questionnaire was developed specifically for the longitudinal study. Methods to guarantee the quality of produced information were used, including a pilot study, a test–retest reliability assessment and double data entry (23, 24).

Self-reported race was defined based on skin colour assessed with open- and closed-format items, simultaneously (23). The present study used the open-ended question ('In your opinion, what is your race or colour?'), which was categorized *a posteriori* in four groups, according to Brazilian census categories: White, Brown, Black, Yellow or Indigenous. The last two included Asians, Indigenous peoples and other racial or ethnic minorities; given that they comprised only 15 individuals, their results were not displayed in this study.

Agreement between the two race items was 85.4%, with a kappa statistic of 0.80 (95% CI: 0.78–0.82); the test–retest reliability of the open-ended question (n = 192) showed an agreement of 91.8%, with a kappa statistic of 0.86 (95% CI: 0.85–0.90) (23).

The outcome variable was the self-reported tooth loss, derived by means of the following item: 'Over time, many people lose some or all of their teeth. Which of the following best corresponds to the number of teeth you lost?' The response options were presented in four categories: 1 – 'I lost no teeth', 2 – 'I lost one or a few teeth', 3 – 'I lost many teeth' and 4 – 'I lost all or almost all teeth'. This variable presented a test–retest kappa (quadratic weights) of 0.75 (95% CI: 0.64–0.87) (24).

Covariates were operationalized in three explanatory blocks, including sex and age in all models, as potential confounders. The first block had variables that reflect early and later life material conditions: current household income, categorized in minimum wages (measured in Brazilian currency and equivalized by the squared root of individuals in the household); respondent's own educational attainment (incomplete grade school, complete grade school, complete high school, university degree or more); maternal educational level (does not know or she died young, incomplete grade school, complete grade school, complete high school, university degree or more); and childhood poverty ('How would you classify the economic situation of your family when you were 12 years old, that is, the living standard of your family at that time?': rich/middle class, poor, very poor). The second block consisted of routine dental care (once a year, every 2 years or only when in trouble) and markers of health-related behaviours: cigarette smoking (never, former, current) and alcohol consumption in the previous 2 weeks (no day, 1–9 days, 10–14 days); this block also included marital status (single, married, divorced, widowed) as a potential surrogate for other health behaviours.

The third block was composed of self-reported discrimination. The discrimination instrument was an abridged and adapted version of the Everyday Discrimination Scale, developed by Wiliams et al. (25). Language adaptations and instrument refinement were achieved during pretesting rounds with nearly 50 participants, not included in the final study sample. The instrument's test–retest reliability was estimated (within a 2-week interval) among 92 noneligible civil servants, with a kappa coefficient of 0.85 (95% CI: 0.72–0.98). Confirming previous results observed in the United States (25), exploratory factor analysis indicated the retention of only one factor (eigenvalue of 2.2), with a Cronbach's alpha coefficient of 0.6. Respondents answered yes/no to 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 items included five discrimination domains: public places, at home, at work, by the police, at school/university. Two extra follow-up questions asked when these experiences happened, as well as the potential attribution for each of them (race, religion, age, gender, etc.). Overall scores ranged between zero and five. For analytical purposes, we dichotomized the score as 'not discriminated against' and 'discriminated against in at least in one of the five domains'. Three types of discrimination were examined: (i) discrimination due to any reason, (ii) discrimination due to social class/socioeconomic position and (iii) discrimination due to race.

Data analysis

The associations between the outcome and the main exposures were presented in a bivariate table. Multivariate analyses were carried out, fitting ordinal logistic regression with partial proportional models, according to Hosmer and Lemeshow (26). Brant's test was used to assess proportional odds assumption for all covariates (α was set to 1% significance level). When such assumption was violated, partial proportional odds model was fitted. Therefore, to avoid extensive tables, we chose to present results only for the main exposure, as three different sets of odds ratio (OR) would be needed for variables violating such assumption.

Multiplicative interactions were tested in regression analysis between discrimination and (i) race, (ii) routine dental care and (iii) educational level. We also tested interaction terms between race and routine dental care and between race and educational level. The fit of all models was evaluated through two main parameters: Akaike information criteria (AIC) and McFadden's adjusted pseudo-R^2. The final model was assessed with Hosmer–Lemeshow goodness-of-fit test (26). All analyses were performed in Stata, v.11.2 (College Station,Texas, USA).

Results

Our study population consists of 3253 individuals taking part of the study baseline (1999–2001).

However, due to missing data on some variables, the final analyses included 2791 individuals. The sample consisted of 55.9% of women. The average age of participants was 40.4 years (standard deviation = ±8.5, with min = 22.1 years and max = 81.7 years). Among study participants, 51.4% self-classified as White, 27.0% as Brown, 21.1% as Black and 0.5% as 'other'. Individuals who never lost any teeth accounted for 21.3% of the sample, and individuals who reported loss of all or almost all teeth accounted for 8.4% of the sample (Table 1). The prevalence of individuals reporting no tooth loss among whites, browns and blacks was 31.0%, 14.3% and 8.2%, respectively.

Behavioural markers and tooth loss

Regarding behavioural factors, 60.8% of the sample never smoked, whereas 17.8% was composed of former smokers; 60.1% were married, 20.9% single, 15.2% divorced and 2.9% widowed. Visiting the dentist at least once a year was reported by 42.6% of the individuals, while 34.4% reported problem-oriented dental attendance. Regarding alcohol consumption, 45.6% reported not drinking in any day in the previous 2 weeks. In the age- and sex-adjusted model, the odds of being in a higher tooth loss category increased among smokers (OR = 1.64, 95% CI 1.37–1.98), problem-oriented dental attenders (OR = 1.34, 95% CI 1.06–1.68), drinking in the previous 14 days (OR = 1.23, 95% CI 0.85–1.79) and the divorced (OR = 1.25, 95% CI 1.02–1.53).

After controlling for markers of health behaviour, racial inequalities did not differ much from the age- and sex-adjusted model (Table 2 – Model 1). The odds ratio of losing teeth varied, depending on the cut point of the tooth loss variable. For example, Black individuals were 3.71 times more likely to have one or more missing teeth than Whites, but 1.95 times more likely to have many missing teeth and were 1.83 times more likely to have all or almost all teeth missing.

Socioeconomic factors and tooth loss

In the sample, mean equivalized income amounted to 9.3 minimum wages (standard deviation = ±6.2, min = 0.5, max = 44.2), while 44.7% declared they were rich/middle class at the age of 12 and 8.7%, very poor. Regarding education, 20.8% of the participants indicated that their mothers had completed high school or more, whereas 76.0% of the respondents completed high school or more. The highest odds of being in a higher tooth loss category were reported by those who did not complete grade school (OR = 4.27, 95% CI 3.01–6.07), who did not know their mother/she died young (OR = 2.64, 95% CI 1.45–4.79) and who were very poor at age of 12 (OR = 2.32, 95% CI 1.76–3.07). Every unit increase in one minimum wage increased the odds of being in a lower tooth loss category (OR = 0.96, 95% CI 0.95–0.98).

The contribution of early life socioeconomic factors and current socioeconomic factors in reducing racial inequalities in tooth loss was very similar, and the combination of both factors reduced racial inequalities markedly (Table 2). In ordinal logistic regression, when the cut-off point was the last category (having all or almost all teeth lost), racial inequalities were not significant after adjusting for socioeconomic factors (OR-Browns = 1.14, 95% CI: 0.79–1.66; OR-Blacks = 1.06, 95% CI: 0.72–1.56). The contribution of current socioeconomic factors in explaining tooth loss was slightly greater (adjusted pseudo-R^2 = 19.5%) than the contribution of early life socioeconomic factors (adjusted pseudo-R^2 = 17.6%).

Self-reported discrimination and tooth loss

The prevalence of reported lifetime discrimination due to any reason was 34.7%. It was associated with race (White = 31.7%, Brown = 37.4%, Black = 40.9%, $P < 0.01$) and education (incomplete grade school = 21.6%, complete grade school = 28.3%, complete high school = 36.9%,

Table 1. Percentage of tooth loss category in three racial groups among civil servants in the Pró-Saúde study, Rio de Janeiro, Brazil, 1999

	Tooth loss				
	None *N* (%)	One or few *N* (%)	Many *N* (%)	Almost all or all *N* (%)	Total *N* (%)
White	496 (31.0)	792 (49.5)	237 (14.8)	74 (4.6)	1599 (100)
Brown	120 (14.3)	435 (51.9)	196 (23.4)	87 (10.4)	838 (100)
Black	53 (8.2)	356 (54.8)	171 (26.3)	70 (10.8)	650 (100)
Total	669 (21.6)	1583 (51.3)	604 (19.6)	231 (7.5)	3087 (100)

Chi-square for heterogeneity: $P < 0.01$.

Table 2. Comparison of odds ratio of being in any upper category of tooth loss in three racial groups in different ordinal logistic regression models among civil servants in the Pró-Saúde study, Rio de Janeiro, Brazil, 1999

Tooth loss (cut-off point)	Age–sex adjusted		Model 1 – Behavioural markers		Model 2a – Socioeconomic (early Life)		Model 2b – Socioeconomic (current life)		Model 2 – Socioeconomic		Model 3 – Discrimination		Fully adjusted	
	OR[a]	(95% CI)	OR[a]	(95% CI)	Proportional OR[b]	(95% CI)	Proportional OR[b]	(95% CI)	OR[a]	(95% CI)	OR[a]	(95% CI)	Proportional OR[b]	(95% CI)
(None = 0) versus (Few + Many + All = 1)														
White	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Brown	2.35	(1.86–2.98)	2.25	(1.77–2.87)	1.64	(1.38–1.94)	1.47	(1.24–1.76)	1.48	(1.15–1.91)	2.34	(1.85–2.96)	1.33	(1.10–1.60)
Black	3.87	(2.83–5.29)	3.71	(2.69–5.13)	2.52	(1.82–3.48)	2.54	(1.83–3.54)	2.12	(1.50–2.98)	3.79	(2.77–5.19)	1.39	(1.12–1.72)
(None + Few = 0) versus (Many + All = 1)														
White	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Brown	1.89	(1.54–2.33)	1.74	(1.40–2.18)	1.64	(1.38–1.94)	1.47	(1.24–1.76)	1.22	(0.97–1.54)	1.87	(1.52–2.31)	1.33	(1.10–1.60)
Black	2.00	(1.60–2.49)	1.95	(1.54–2.47)	2.52	(1.82–3.48)	2.54	(1.83–3.54)	1.17	(0.92–1.50)	1.94	(1.55–2.42)	1.39	(1.12–1.72)
(None + Few + Many = 0) versus (All = 1)														
White	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Brown	2.01	(1.43–2.82)	1.86	(1.30–2.68)	1.64	(1.38–1.94)	1.47	(1.24–1.76)	1.14	(0.79–1.66)	1.96	(1.39–2.76)	1.33	(1.10–1.60)
Black	2.02	(1.41–2.89)	1.83	(1.24–2.70)	2.52	(1.82–3.48)	2.54	(1.83–3.54)	1.06	(0.72–1.56)	1.96	(1.36–2.81)	1.39	(1.12–1.72)
Adj. pseudo-R^2	14.9%		16.3%		17.6%		19.5%		20.1%		14.7%		20.9%	
AIC	2.02		1.97		1.95		1.92		1.90		2.02		1.86	

Model 1: age, sex + behavioural variables (dental visit, marriage status, smoking, alcohol consumption).
Model 2a: age, sex + socioeconomic (mother's education, early life poverty).
Model 2b: age, sex + socioeconomic (income, education).
Model 2: age, sex + socioeconomic (income, education, mother's education, early life poverty).
Model 3: age, sex + discrimination for any reason (ever).
Fully adjusted: age, sex + Model 1 + Model 2 + Model 3
[a]Partial ordinal logistic regression producing one set of odds ratio for each cut-off point.
[b]Full proportional odds assumption producing the same odds ratio for each cut-off-point.

university degree of more = 37.8%, $P < 0.01$), but not with sex or income. Discrimination related to social class/socioeconomic position was 13.4%, while racial discrimination was reported by 6.6% of the participants.

The crude association between any type, racial or social discrimination with tooth loss showed, respectively, an OR = 0.87 (95% CI 0.76–1.00), OR = 1.53 (95% CI 1.19–1.98) and OR = 0.87 (95% CI 0.71–1.00). Age/sex-adjusted odds ratio of discrimination of any type, racial or social with tooth loss showed, respectively, an OR = 1.18 (95% CI 1.02–1.37), OR = 1.26 (95% CI 1.09–1.45) and OR = 1.22 (95% CI 1.06–1.39). After further adjustment for social and racial confounders (race, education, maternal education, income and early life poverty), individuals reporting any type of discrimination showed an OR = 1.13 (95% CI 0.97–1.32) of being in a higher tooth loss category; those reporting racial discrimination had an OR = 1.09 (95% CI 0.78–1.55), and those reporting social class discrimination, an OR = 1.08 (95% CI 0.87–1.34). In the final model, only discrimination attributed to any reason was included because it was the most significant one among the three types of discrimination assessed.

Race, tooth loss and full model results

In the unadjusted ordinal logistic regression model, race violated the assumption of proportionality of odds ratio (Brant's test, $P < 0.01$). Therefore, for each dichotomization of the outcome, a measure of association was estimated (Table 2). The odds of Blacks being in a higher category than the first one (no missing teeth) were 5.06 times (95% CI: 3.88–6.58), compared with Whites. However, the odds of the Blacks being in the highest category (all or nearly all missing teeth) was 2.50 times (95% CI: 1.86–3.38) higher than that of Whites.

In the final model, after adjusting for potential confounders and postulated mediators (age, sex, marital status, smoking, routine dental care, income, education, maternal education and child poverty), race did not violate the assumption of proportionality. However, the variables dental visits, smoking, maternal education and own educational level violated this assumption, and therefore, we performed a partial ordinal logistic regression. In this model, the odds of being in any upper category of tooth loss among Blacks (OR = 1.39, 95% CI 1.12–1.72) and Browns (OR = 1.33, 95% CI 1.10–1.60) remained higher, compared with Whites (Table 2).

Comparing the fit of each block of variables, the best one was the model with socioeconomic variables (adjusted pseudo-R^2 = 20% and AIC = 1.90) followed by health-related behaviours (adjusted pseudo-R^2 = 16% and AIC = 1.97). The full model showed the best fit (adjusted pseudo-R^2 = 20% and AIC = 1.86) and was submitted to Hosmer and Lemeshow test; this showed it was an acceptable model ($P > 0.05$). No interaction term was significant in the data set.

Discussion

In this Brazilian population of civil servants, the odds of tooth loss, after adjustment for age and sex, were higher among Blacks compared with Browns, and Browns compared with Whites, which confirms previous findings (9, 15, 27). Socioeconomic factors explained most of the association, as previously reported (1, 9). Current and early life socioeconomic hazards were independently associated with tooth loss and markedly reduced the estimates of racial inequalities in tooth loss. Although current socioeconomic factors explained more of the racial variation in tooth loss than early life variables, both were equally important in explaining racial inequalities. This is an important finding, which shows that racial inequalities in tooth loss are a product of exposures occurring over the life course.

Not surprisingly, in our study, behavioural factors did not explain much of racial inequalities in tooth loss, confirming previous studies (1, 3). However, they were associated with tooth loss in our study. It is plausible that they are a product of the socioeconomic and structural factors, so they did not add much to the model. Furthermore, those variables may not be good markers of risk factors, such as sugar consumption or tooth cleaning habits (with fluoridated toothpaste).

Previous studies have postulated that discrimination could be a plausible mediator between race and tooth loss (2, 13, 28), and, to our knowledge, there is no published study empirically investigating with such a mediation hypothesis. The association between physical health outcomes (in our case, tooth loss) and discrimination is not as clear as that observed between discrimination and mental health conditions. While a review reported a number of studies with no association between discrimination and physical health (29), others showed significant associations for outcomes, such

as hypertension, low birth weight, diabetes, heart disease and increased body mass index (11, 30). It is well described the association between discrimination and unhealthy behaviour, especially those induced by stress. A study on the effects of discrimination on oral health, using the Everyday Discrimination Scale, concluded that it was not associated with self-reported oral health (31).

In the present study, there was a residual association between race and tooth loss, which was not explained by postulated confounding factors and mediators. Some authors suggest that this residual effect may be related to nonperceived racial discrimination (6, 9, 10, 15). Other explanations include residual confounding by socioeconomic status and that our discrimination measure did not thoroughly assess the experiences of discrimination in the domain of health care. The plausibility of the association between discrimination and tooth loss may be explained by discrimination in the use of routine dental care. In such cases, Blacks and Browns could be undertreated or subjected to a treatment that is less conservative (13, 15, 32). Under this hypothesis, Blacks who attend to routine dental care more frequently would be prone to such discrimination and, therefore, to tooth loss. However, in our analysis, there was no interaction between race and use of dental care.

Some limitations of the present study must be pointed out. Our adaptation of the 'Everyday Discrimination Scale', developed by Williams et al. (25, 33), refers to self-reported discrimination; hence, we cannot evaluate those situations in which this phenomenon was not perceived by the individual. In addition, at the time of the study, there was no widely adopted discrimination instrument for Brazilian populations (34, 35). Furthermore, imperfect measurement in any other covariate could have occurred, especially because some of them are proxy variables, like behavioural factors. Although the assessment of the outcome could be seen as imperfect, self-reported number of missing teeth has shown good validity, when compared to clinical examination (36, 37). In addition, the sample is not representative of the general population, as it is an economically active population, with stable state employment. Thus, aspects of discrimination related to unemployment or job insecurity could not be evaluated. Finally, the cross-sectional nature may be a limitation. However, although longitudinal studies would be desirable, it is unlikely that cross-sectional studies would bias the measurement of our outcome (i.e. tooth loss).

Racial inequalities associated with tooth loss are determined by many aspects. The material condition of life and educational levels were the most important factors in this study. Discrimination, use of routine dental care and adverse health behaviours did not explain the studied association. It is recommended the use of other discrimination instruments to evaluate aspects related to dental and general health in other populations, as well as the assessment of the role of discrimination in the health services as a potential source of racial disparities in health.

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