Does water fluoridation influence ethnic inequalities in caries in Brazilian children and adolescents?

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Abstract

Objectives. The present study aimed to investigate the influence of community water fluoridation on ethnic inequalities in untreated dental caries among children and adolescents in Brazil while taking the human development context into account. **Methods.** Data from a nationwide Brazilian epidemiological population oral health survey were used (SB Brazil 2010). Outcomes were caries prevalence measured by the proportion of individuals with one or more untreated decayed teeth and caries severity defined by the mean number of untreated decayed teeth (DT). Three different contexts were considered: 1 - cities with no water fluoridation; 2 - cities with water fluoridation and low Human Development Index (HDI); and 3 - cities with water fluoridation and high HDI. The exposure was ethnic/racial group (White, Pardo, Black) and covariates were age, sex, and household income. Multilevel logistic and negative binomial regressions were performed with 6,696 children (aged 5 years) and 11,585 adolescents (aged 12 and 15-19 years). **Results.** For both deciduous and permanent dentitions, ethnic differences in caries prevalence and mean DT were found in the non-fluoridated cities with low HDI and also in cities with high HDI, most of which were fluoridated. For example, in non-fluoridated cities with low HDI, 5-year-old Pardo children were more likely to have untreated decay (OR=1.22; 95% CI: 1.02, 1.46) and had more decayed teeth (RR=1.18; 95% CI: 1.04, 1.34) than their White counterparts after adjusting for sex and household income. No such differences were observed in fluoridated cities with low HDI. **Conclusion.** Water fluoridation appears to be associated with reduced ethnic inequalities in dental caries prevalence and mean DT among children and adolescents in more disadvantaged settings.

Keywords: water fluoridation, ethnic inequality, dental caries, Human Development Index

Introduction

Ethnic/racial inequalities in oral health are a major challenge globally[1-6]. Most studies suggest that ethnic differences in health result from social, cultural and economic characteristics rather than from increased biological susceptibility[7,8]. Poorer outcomes in oral health among disadvantaged ethnic groups have been linked to a number of structural factors, among others, living in poorer areas, lack of culturally sensitive models of oral health care, and insufficient exposure to fluoridated water[8]. Increasing evidence indicates that racial discrimination is a risk factor for disease and contributes to inequalities in health[7].

Among countries on the American continent, Brazil has the largest population of individuals with African ancestry[9]. According to the Brazilian census bureau, the skin color composition of the population in 2010 was 47.7% Whites, 43.0% Pardos (Brazilians of mixed ethnic ancestries), 7.8% Blacks, 1.1% of Asian ancestry, and 0.4% Indigenous[10]. Previous research has documented racial inequalities in oral health with higher caries levels among Pardos and Blacks than among Whites in 2000[6].

Dental caries is the most prevalent condition globally, affecting 35% of the worldwide population (2.4 billion people). Caries has substantial impacts on individuals, families and societies, causing pain, considerable social and economic burdens and reduced quality of life[11]. In Brazil, dental caries levels have declined in the overall population, but these improvements have not occurred equally across socioeconomic groups[12,13]. Improvements have been attributed to better living conditions and oral health policies, including improved access to fluoridated water and use of fluoride toothpaste[12-15]. The decline in dental caries in Brazil coincided with major social and economic development in the country. From 1991 to 2010, life expectancy at birth increased by 9.2 years, and the per capita monthly income grew 14.2%. The establishment of the universal health care system in 1998 improved the availability of publicly funded dental services and the percentage of Brazilian children that never had a dental appointment decreased from 20.9% in 1998 to 12.8% in 2008[16]. However, oral health inequalities persist affecting Blacks and Pardos, as well as rural, poorer, less educated and otherwise disadvantaged populations[14].

Evidence from Brazil has highlighted the relevance of human development levels for dental caries[12,17].The Human Development Index (HDI) assesses well-being from the geometric mean of three dimensions: income, education, and health. It is a continuous measure that can take on any value between 0 and 1 (the higher the value, the better the social conditions). In Brazil, the HDI increased from 0.49 to 0.72 between 1991 and 2010, denoting significant improvements in overall living conditions[18].

While clearly not the only means of caries prevention, the use of fluoride as a caries preventive measure is well established and the World Health Assembly resolution has confirmed the importance of water fluoridation as a public health measure to promote population oral health[19]. The British Fluoridation Society estimated that about 25 countries provided water fluoridation in 2012 including the USA and Brazil, where more than half of their populations were covered[20].

About 80% of the Brazilian population have access to treated water at least by filtration and disinfection, while nearly 15% have access to water provided by wells inside or outside the property[21]. As an effective public health intervention, fluoridation of public water supplies is mandatory since 1974 according to Federal Law, and the Ministry of Health recommends the fluoride concentration in tap water to be around 0.7 ppm[22]. Despite this, and although the fluoridation of public water supplies has increased between 2000 and 2008[21], it has been estimated that 25% of the population distributed across 40% of all cities did not have access to fluoridated water supplies in 2008[21].

Studies from other countries have shown that water fluoridation can reduce but not eliminate oral health inequalities[4,23-26]. A Brazilian study investigated the correlation between municipal HDI values and DMFT amongst 12 years-olds living in fluoridated and non-fluoridated cities. Exposure to fluoridated water attenuated the magnitude of the correlation between these variables, with lower DMFT in fluoridated cities[27]. Other research found that access to fluoridated water only slightly reduced the ethnic inequalities in dental caries in Brazil, however the HDI was not considered in these analyses[6].

The present study aimed to investigate the influence of community water fluoridation on ethnic inequalities in untreated dental caries among children and adolescents in Brazil while taking the human development context into account.

Methods

Data came from the SB Brazil 2010 Project[28], a nationwide representative epidemiological oral health survey of the urban Brazilian population conducted in 177 cities and using probability cluster sampling. These were the capital cities of each of the 27 Brazilian states (including the country capital, Brasília), and 30 cities randomly selected in each of the five main regions of Brazil (North, Northeast, Central-West, Southeast, and South). In each city, urban census tracts and households were randomly selected and eligible individuals interviewed and examined. More than 70% of the selected residences agreed to participate. The final survey sample included 37,519 individuals and was representative for each of the five surveyed age groups (5, 12, 15-19, 35-44, 65-74 years)[29]. Interviews and clinical examinations followed WHO criteria[30] and were carried out in respondents' homes by teams consisting of a general dentist and an assistant. Approximately 570 dentists and 570 assistants were trained and calibrated for the survey. Depending on the field characteristics, two to five teams per district were selected and trained. Examiners with Kappa values above 0.65 were approved for data collection[29]. Ethical approval for the SB Brazil 2010 was granted by the Ethics Commission, Resolution CNS 15498, on July 1, 2010. All participants provided their informed consent.

To enable the assessment of associations for both deciduous and permanent dentitions, the current study included three age groups: children aged five years (deciduous dentition) and adolescents aged 12 and 15-19 years (permanent dentition). Outcome measures were prevalence of any untreated caries and mean number of untreated decayed teeth (mean DT). Caries prevalence was a binary variable, distinguishing between those without untreated caries (D=0) and those with one or more untreated decayed teeth (D≥1). Mean DT was a count variable defined as the number of untreated decayed teeth (D). In line with WHO criteria, untreated dental caries was recorded at the clinical examination if a lesion in the pit and fissure or on a smooth tooth surface had an unmistakable cavity, undermined enamel, or a detectably softened floor or wall; or where a temporary restoration (except glass ionomer) was present[30]. The CPI probe was used to confirm visual evidence of caries on the occlusal, buccal, and lingual surfaces.

For the 15-19-year-old participants, determination of ethnic group was based on self-assessment, whereby respondents identified themselves according to the ethnic classifications categories based on skin color that are used by the Brazilian Institute for Geography and Statistics: White, Asian, Pardo (skin color between white and black), Black, and Indigenous ethnic groups[10]. For 5- and 12-year-old participants, ethnic category was reported by one of the parents.

Brazilian cities were divided into three different groups: a) cities without water fluoridation; b) cities with water fluoridation and a low HDI; and c) cities with water fluoridation and a high HDI. Information on water fluoridation was obtained from three different sources, including assessment of the fluoridation status of Brazilian municipalities with more than 50,000 inhabitants between 2012-2015[22], the National Survey of Basic Sanitation (PNSB) in 2000 and 2008[31,32], and the National System of Sanitary Information (SNIS) in 2010 and 2014[33]. The provision of water fluoridation was determined based on at least two of the above data sources. The municipal Human Development Index (HDI) for Brazilian cities was calculated from 2010 data on income, education and health. The cut-off point to distinguish between cities with low and high HDI was the median HDI of all cities that were part of the survey (0.73). Using this HDI cut-off point, 53 cities were classified as having water fluoridation and lower HDI, while 51 cities were classified as having water fluoridation and higher HDI. Because the vast majority of non-fluoridated cities (63 out of 73) had low HDI values, cities that were not fluoridated were not further subdivided into low and high HDI. The geographical distribution of the three groups of cities is shown in Figure 1 (Appendix 1).

As dental caries varies with age[6], age was used as a covariate to adjust models pertaining to adolescents. Sex (male; female) and household income were also included as covariates. Income was measured using equivalized monthly household income[34] and dichotomized to distinguish between households living below the Brazilian minimum wage (<1MW) and those at or above the minimum wage (≥ 1 MW). In December 2010, the Brazilian minimum wage was 510.00 BRL (Brazilian Reais) or 301.70 USD (US Dollars).

Analyses were carried out using Stata Version 14 (College Station, TX, EUA)[35]. Qgis software version 3.8.2 was used to create Figure 1[36]. Sampling weights were employed throughout to account for the geographical clustering of the data. All analyses were based on complete cases as the rate of missingness was less than 10% (8.9% among 5-year-olds and 9.3% among 12- and 15-year-olds). Characteristics of initial and analysis samples were compared (Appendix 2). Descriptive analyses included cross-tabulations of outcome variables by ethnic group, covariates, and by city group. We then undertook multilevel regression analyses, with individual respondents at level 1 and cities at level 2. Associations between ethnic group and caries prevalence were estimated using multilevel logistic regression and expressed as Odds Ratios (OR). Mean decayed teeth were analyzed using multilevel negative binomial regression and rate ratio estimation (RR), due to overdispersion of the outcome variable (variance at least three times higher than the mean in all contexts). All models were adjusted for sex and monthly household income and satisfied the goodness-of-fit criteria (AIC and BIC). Preliminary analyses showed that water fluoridation and HDI moderated associations between ethnic group and caries outcomes (interaction terms statistically significant), therefore analyses were stratified by city group. Data for children (5-year-olds) and adolescents (12- and 15-year-olds) were analyzed separately. The proportions of children belonging to Indigenous and Asian ethnic groups were very small (0.8% and 2.3% respectively among 5-year-olds; and 0.6% and 1.9% respectively among 12 and 15-to-19-year-olds). Therefore, these ethnic groups were not included in the analyses.

Two sensitivity analyses were performed. First, comparisons of untreated caries prevalence and mean DT were carried out with the high HDI cities (>0.73) excluded from the non-fluoridated group of cities (Appendix 3). Second, we compared differences between the three contexts using caries experience as the basis for the outcomes (any caries experience i.e. dmft/DMFT>0, and mean dmft/DMFT) (Appendix 3).

Results

Initial sample sizes were 7,348 (5-year-olds) and 12,773 (12- and 15-19-year-olds). Data were missing for 8.9% of the child and 9.3% of the adolescent sample respectively, therefore analysis samples included 6,696 children (aged 5 years) and 11,585 adolescents (aged 12 and 15-19 years). There were no important differences between the initial and analysis samples for the variables included in regression models (Appendix 2).

The median HDI was 0.66 in non-fluoridated cities and 0.67 in cities with water fluoridation and low HDI. In the fluoridated cities with high-HDI the median HDI was 0.77.

Table 1 shows the distribution of the sample characteristics as a whole, and separately for each context (city group). For both samples, overall levels of untreated caries were lowest in cities with water fluoridation and high HDI. Ethnic inequalities were evident across the three contexts, with White children and adolescents generally having considerably lower levels of untreated decay than Pardo and Black children and adolescents. The pattern of inequalities was not the same across contexts, with more pronounced ethnic inequalities in non-fluoridated cities and fluoridated cities with high development, while in cities with fluoridation and low development differences were evident between White and Black (but not equally between White and Pardo) children.

Tables 2 and 3 show the ethnic inequalities in untreated caries prevalence and mean DT in unadjusted and adjusted multilevel regression models. Among 5 year-old children, there were ethnic differences in caries prevalence and mean DT after adjustment for sex and household income in the non-fluoridated context. Pardo children were 22% more likely to have untreated decay and had a higher number of decayed teeth (RR=1.18; 95% CI: 1.04, 1.34) than their White counterparts. Black children in cities without water fluoridation had more decayed teeth than White children (RR=1.27; 95%CI: 1.01, 1.61) though there was no difference in the overall prevalence of any untreated decay between these ethnic groups. In cities with fluoridation and high HDI, Black children were 42% and Pardo children 20% more likely to have untreated caries than White children, and the same pattern was observed for mean DT. However, no differences between any of the three ethnic groups were observed in the areas with fluoridation and low HDI.

In the non-fluoridated cities, Black adolescents were 67% and Pardos 38% more likely to have untreated caries and also had a higher mean DT (RR=1.25; 95% CI: 1.07, 1.46 for Black, and RR=1.18; 95%CI: 1.08, 1.30 for Pardo) than their White counterparts. Clear ethnic inequalities also existed for adolescents in fluoridated cities with high HDI: Black adolescents were 56% and Pardo adolescents were 48% more likely to have untreated caries, and had more carious teeth, than Whites. Differences between ethnic groups were smaller and not statistically significant in the fluoridated areas with low HDI after adjustment for covariates, however the point estimates suggest that some inequalities existed. After adjustment, Black adolescents in non-fluoridated cities with low HDI had 37% higher odds for untreated caries and a higher number of untreated decayed teeth (RR=1.20; CI: 0.93-1.56) than White adolescents.

In the first sensitivity analysis, excluding cities with high HDI from the group of non-fluoridated cities yielded very similar results and did not substantially change our conclusions (results shown in Appendix 3). In the second sensitivity analysis, using dmft/DMFT as outcome measures resulted in similar findings, i.e., no or smaller ethnic differences in cities with water fluoridation and low HDI than in cities without water fluoridation (Appendix 3).

Discussion

This study explored ethnic inequalities in untreated caries between Brazilian Black and White as well as Pardo and White children and adolescents. Inequalities were evident in non-fluoridated cities and in cities with water fluoridation and high levels of human development. However, in fluoridated cities with low HDI levels no inequalities in untreated caries levels were found among children, and smaller ethnic differences among adolescents, than in cities without water fluoridation.

Our study has a number of strengths. The analysis utilized data from a national epidemiological survey (SBBrazil 2010), which is probably the best available Brazilian data on oral health that accurately reflects the country's characteristics as a whole, also considering the complexity involved in ethnic/racial classification in Brazil[6]. Water fluoridation levels were determined using different data sources, thereby improving their reliability. Multilevel analysis took the clustered nature of the data into account and stratification by water fluoridation status and Human Development Index allowed us to examine the influence of contextual factors on ethnic inequalities. On the other hand, the study had several limitations. As these were observational data, no causal inferences can be made. Because the vast majority of cities with high levels of human development were fluoridated, it was not possible to examine the role of water fluoridation on ethnic inequalities in caries levels in a high HDI context. Furthermore, we did not have data on sugar intake or other oral health behaviours from participants, including other sources of individual fluoride exposure. However, as the selected households were located in urban areas covered by the public water supply network, we can infer that participants had access to fluoridated water in cities with water fluoridation. Also, participants in all three contexts were likely to be exposed to fluoridated toothpaste[37]. Other unobserved factors potentially influencing levels of untreated caries include the availability and accessibility of dental services.

Among the three contexts considered in this study, two had similarly low levels of development but contrasting exposure to water fluoridation. Our findings showed clear and extensive ethnic inequalities in cities with low HDI and without fluoridated water; however, much more modest (if any at all) inequalities were found in cities with similarly low HDI but with fluoridated water supply. This suggests that water fluoridation may help to reduce ethnic inequalities in levels of untreated caries among children and adolescents living in more disadvantaged areas in Brazil. However, for more affluent cities the role of water fluoridation on oral health inequalities could not be ascertained.

Caries prevalence and mean DT were lower for all ethnic groups in the areas with water fluoridation and high HDI, endorsing the important role of fluoridation and favorable socioeconomic area-level conditions as structural determinants of dental caries[13-15,23-26]. At the same time, clear and extensive ethnic inequalities in caries were evident in this context. Potential explanations could relate to a wider variation in affluence and higher levels of racial discrimination in more affluent cities. For example, it is possible that within cities with higher HDI, ethnic differences in levels of affluence are more excessive, with more Blacks and Pardos living in extreme poverty and Whites living in more affluent neighborhoods. However, this could not be investigated in this study due to lack of available relevant data at neighborhood level. Although we did adjust for self-reported income, this is not sufficient to support or refute the aforementioned explanation.

Comparing to the relevant literature, water fluoridation did not eliminate ethnic inequalities in caries-free levels between Māori and non-Māori children in New Zealand[4] or in untreated dental caries in Brazil[6], but did reduce the gap in racial inequalities. However, unlike our investigation, these studies did not take the human development context into account, therefore direct comparisons are not straightforward even when referring to Brazilian data.

Overall, the same pattern of results was observed irrespective of whether the outcome was the prevalence of untreated decay or the number of decayed teeth. This indicates that ethnic inequalities affect the caries distribution in its totality, rather than being relevant only for different levels of caries severity. From a public health policy perspective, our results highlight the relevance of water fluoridation as one potential pathway to address ethnic inequalities among children and adolescents living in more deprived areas in Brazil. There are other important factors that can potentially influence ethnic inequalities that were not assessed here, such as oral health policies and access to dental services, but also health behaviors and broader neighborhood conditions.

Furthermore, these factors do not directly address the fundamental causes of ethnic inequalities and the interplay between socioeconomic position and racial discrimination. Higher SES was a protective factor for dental caries in all three contexts of this study, corroborating other findings[1-3,6,15]. Some disadvantaged Brazilian racial groups live in deprived neighbourhoods[8], reflecting a complex and long-standing social process shaped by slavery, class, and gender oppression[38,39]. While it is essential to focus on the social inequalities in oral health, ethnic inequalities may not be eliminated simply by addressing only the mechanisms that link SES to health[40]. Future research should use longitudinal approaches to further explore the conditions that contribute to ethnic inequalities in oral health, including but not limited to exposure to fluoridated water supplies.

In conclusion, ethnic inequalities in untreated caries among children and adolescents were evident in Brazilian cities with high development and also in those with low development that did not benefit from water fluoridation, while no such inequalities existed in low development cities that had water fluoridation. Water fluoridation could reduce inequalities related to dental caries in more disadvantaged settings.

Figure Legends

Fig 1. Geographical distribution of the three groups of cities. SBBrazil 2010

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Table 1. Caries prevalence and severity (weighted proportions) in Brazilian children and adolescents, by explanatory variables and by context. SBBrazil 2010.

Individual variables	n	%	Caries Prevalence	Decayed Teeth	n	%	Caries Prevalence	Decayed Teeth
			% (95%CI)	mean (95%CI)			% (95%CI)	mean (95%CI)
	Children (n=6,696)				Adolescents (n=11,585)			
Ethnic Group								
Whites	3,073	49.1	45.2 (37.0-53.5)	1.70 (1.22-2.17)	4,780	46.8	39.5 (32.9-53.5)	1.28 (0.84-1.73)
Pardos	3,064	41.6	53.7 (47.4-59.8)	2.33 (1.77-2.96)	5,576	41.9	53.3 (42.7-62.7)	1.90 (1.20-2.59)
Blacks	559	9.3	55.8 (43.8-67.2)	2.73 (2.20-3.27)	1,229	11.3	51.2 (42.5-59.9)	1.92 (1.22-2.61)
Sex								
Female	3,368	48.9	48.9 (41.4-56.4)	1.96 (1.49-2.43)	5,578	51.5	48.6 (42.0-52.2)	1.65 (1.24-2.06)
Male	3,328	51.1	50.5 (45.5-56.5)	2.18 (1.69-2.67)	6,007	48.5	44.5 (34.4-55.2)	1.57 (0.81-2.32)
Income								
Below minimum wage	4,271	61.9	56.6 (49.6-63.4)	2.53 (2.02-3.05)	6,967	56.2	55.3 (47.1-63.2)	2.08 (1.41-2.74)
At or above minimum wage	2,425	38.1	38.3 (33.7-43.4)	1.31 (1.01-1.62)	4,618	43.8	35.5 (28.6-43.1)	1.01 (0.62-1.41)
Context: No WF	2,607	23.8	61.5 (51.6-70.6)	3.00 (2.32-3.68)	4,250	19.4	62.2 (52.7-70.2)	2.83 (2.24-3.40)
Ethnic Group								
Whites	1,008	44.4	55.6 (40.9-69.5)	2.27 (1.39-3.14)	1,355	38.8	54.6 (44.6-64.3)	2.45 (1.74-3.16)
Pardos	1,481	45.9	65.8 (58.5-72.3)	3.43 (2.66-4.20)	2,528	53.3	67.1 (57.7-75.3)	3.04 (2.49-3.60)
Blacks	118	9.6	68.6 (63.8-73.0)	4.33 (3.58-5.09)	367	7.8	66.5 (51.1-79.0)	3.19 (1.54-4.85)
Context: WF and Low HDI	571	17.6	58.2 (47.2-68.5)	2.50 (1.73-3.27)	1,003	18.9	58.0 (51.1-64.7)	2.11 (1.39-2.83)
Ethnic Group								
Whites	265	42.7	57.9 (42.5-72.0)	2.52 (1.67-3.36)	386	34.9	52.4 (44.0-60.7)	1.91 (1.18-2.64)
Pardos	270	45.1	55.6 (44.9-65.8)	2.34 (1.28-3.39)	470	46.6	57.6 (50.4-64.6)	2.00 (1.28-3.39)
Blacks	70	12.2	68.9 (65.3-72.3)	3.06 (2.56-3.56)	147	18.5	69.7 (55.8-80.8)	2.79 (1.73-3.83)

Context: WF and High HDI	3,518	58.6	42.3 (38.3-46.3)	1.57 (1.44-1.70)	6,332	61.7	38.2 (31.8-44.6)	1.08 (0.81-1.35)
Ethnic Group								
Whites	1,800	53.0	38.5 (35.9-41.1)	1.31 (1.20-1.42)	3,039	53.0	33.4 (27.1-40.4)	0.89 (0.59-1.19)
Pardos	1,410	38.7	47.2 (42.2-52.0)	1.86 (1.63-2.08)	2,578	36.9	45.4 (40.4-50.4)	1.34 (1.08-1.60)
Blacks	308	8.3	44.1 (26.9-59.7)	1.83 (1.44-2.22)	715	10.1	37.2 (21.1-56.7)	1.12 (0.57-1.68)

Table 2. Results of multilevel logistic regression models predicting odds of having untreated dental caries in the three contexts. SBBrazil 2010.

	No Fluoridation		**WF and low-HDI**		**WF and high-HDI**	
	Unadjusted	**Adjusted[1]**	**Unadjusted**	**Adjusted[1]**	**Unadjusted**	**Adjusted[1]**
Children	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**
Ethnic Group						
White	1	1	1	1	1	1
Pardos	1.36 (1.14-1.62)	1.22 (1.02-1.46)	0.94 (0.63-1.41)	0.85 (0.56-1.29)	1.33 (1.14-1.55)	1.20 (1.02-1.40)
Blacks	1.13 (0.80-1.59)	1.02 (0.72-1.44)	1.21 (0.65-2.27)	1.08 (0.57-2.05)	1.61 (1.25-2.07)	1.42 (1.10-1.84)
Per capita Income						
<1 MW	1	1	1	1	1	1
≥ 1MW	0.43 (0.36-0.52)	0.44 (0.37-0.53)	0.57 (0.38-0.83)	0.54 (0.36-0.81)	0.44 (0.38-0.51)	0.47 (0.41-0.55)
VPC	14.80%	11.60%	8.40%	9.80%	3.20%	2.90%
Adolescents						
Ethnic Group						
White	1	1	1	1	1	1
Pardos	1.49 (1.29-1.72)	1.38 (1.19-1.60)	1.20 (0.88-1.64)	1.15 (0.84-1.59)	1.57 (1.40-1.77)	1.48 (1.31-1.67)
Blacks	1.81 (1.41-2.34)	1.67 (1.29-2.15)	1.61 (1.03-2.52)	1.37 (0.87-2.16)	1.77 (1.49-2.11)	1.56 (1.31-1.87)
Per capita Income						
<1 MW	1	1	1	1	1	1
≥ 1MW	0.52 (0.46-0.60)	0.52 (0.45-0.60)	0.57 (0.43-0.76)	0.54 (0.40-0.73)	0.54 (0.48-0.60)	0.51 (0.46-0.57)
VPC	12.70%	11.10%	11.60%	8.40%	5.50%	5.20%

[1]Adjusted for gender, income, age. MW - minimum wage. VPC - Variance Partition Coefficient (% of variance due to differences at the municipality level)

Table 3. Results of multilevel negative binomial regression models estimating rate ratio for the mean number of untreated decayed teeth in the three contexts. SBBrazil 2010

	No Fluoridation		WF and low-HDI		WF and high-HDI	
	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]
	RR (95%CI)	RR (95%CI)	RR (95%CI)	RR (95%CI)	RR (95%CI)	RR (95%CI)
Children						
Ethnic group						
White	1	1	1	1	1	1
Pardos	1.29 (1.14-1.47)	1.18 (1.04-1.34)	0.99 (0.75-1.30)	0.95 (0.72-1.25)	1.25 (1.09-1.44)	1.13 (0.99-1.31)
Blacks	1.38 (1.09-1.76)	1.27 (1.01-1.61)	1.01 (0.66-1.54)	1.01 (0.65-1.51)	1.66 (1.31-2.08)	1.59 (1.27-1.99)
Per capita Income						
< MW	1	1	1	1	1	1
≥ 1MW	0.48 (0.42-0.55)	0.50 (0.44-0.57)	0.50(0.44-0.57)	0.67 (0.51-0.89)	0.50 (0.44-0.57)	0.50 (0.44-0.57)
Adolescents						
Ethnic group						
White	1	1	1	1	1	1
Pardos	1.25 (1.14-1.38)	1.18 (1.08-1.30)	1.13 (0.92-1.38)	1.12 (0.92-1.36)	1.38 (1.25-1.53)	1.34 (1.21-1.48)
Blacks	1.32 (1.13-1.57)	1.25 (1.07-1.46)	1.36 (1.04-1.76)	1.20 (0.93-1.56)	1.61 (1.39-1.88)	1.47 (1.26-1.70)
Per capita income						
< MW	1	1	1	1	1	1
≥ 1MW	0.67 (0.62-0.74)	0.66 (0.60-0.72)	0.62 (0.56-0.67)	0.60 (0.50-0.73)	0.62 (0.56-0.67)	0.61 (0.56-0.67)

*Adjusted for gender, income, age (only permanent dentition); RR - rate ratios; MW - minimum wage