Community Dent Oral Epidemiol 2015; 43; 317–324

Community Dentistry and Oral Epidemiology

Socially unequal improvements in dental caries levels in Brazilian adolescents between 2003 and 2010

Angelo G. Roncalli[1,2], Aubrey Sheiham[2], Georgios Tsakos[2] and Richard G. Watt[2]

[1]Department of Dentistry, Federal University of Rio Grande do Norte Natal, RN, Brazil, [2]Department of Epidemiology and Public Health, University College London London, UK

Roncalli AG, Sheiham A, Tsakos G, Watt RG. Socially unequal improvements in dental caries levels in Brazilian adolescents between 2003 and 2010. Community Dent Oral Epidemiol 2015; 43: 317–324. © 2015 John Wiley & Sons A/S. Published by John Wiley & Sons Ltd.

Abstract – *Objectives:* Although there are numerous reports on socioeconomic inequalities in dental caries, few studies have focused on whether improvements in dental status have been accompanied by changes in socioeconomic inequalities in caries. The objective of this study was to assess whether declines in caries between 2003 and 2010 were associated with reductions in inequalities in dental caries in adolescents. *Methods:* Data on dental caries in adolescents aged 15–19 were used from the Brazilian National Oral Health surveys conducted in 2003 (n = 16 833) and 2010 (n = 5445). The dependent variables were Decayed, Missing and Filled Teeth (DMFT) index and the percentage caries free. Household income and educational level were independent variables. Differences between surveys for DMFT and caries free were calculated, and measurement of inequality was performed using the Slope Index of Inequality (SII) and Relative Index of Inequality (RII). *Results:* Both DMFT and percentage caries free showed significant differences in absolute (SII) and relative (RII) inequalities between the two surveys for both education and income. The SII for DMFT rose from 0.54 to 2.01 and from 1.44 to 3.67 for income and education, respectively. For caries free, these values were 3.64–19.40 and 5.06–22.93. Regarding to RII, a similar trend has been found. *Conclusions:* Despite the overall reduction in DMFT and an increase in caries free, there were increases in both income and education-related inequalities in caries in Brazilian adolescents. The findings on caries differ from those for other health conditions in Brazil, where there have been reductions in inequalities.

Key words: caries; disparities; epidemiology; public health police

Angelo G. Roncalli, Department of Epidemiology and Public Health, University College London, London WC1E 6BT, UK
e-mail: roncalli@terra.com.br

Submitted 19 August 2013
accepted 13 January 2015

Determinants of health inequalities are different from determinants of health (1). The former are about 'the fundamental structures of social hierarchy and the socially determined conditions these create in which people grow, live, work and age' (2), whereas the latter are more related to proximal causes, such as health-compromising behaviours. Therefore, it is important to distinguish between the overall level of health and the social distribution of health determinants, as there can be improvements in overall levels of health but not in levels of inequality. To reduce inequality in health 'requires a rate of health gain that is greatest for the poorest, progressively lower for better-off groups and lowest for those in the most advantaged circumstances' (3).

A number of health conditions have improved in Brazil in the past 30 years. However, the question that needs addressing is, have overall improvements in health been accompanied by reductions in health inequalities? Infant mortality declined by 4.4% per year between 2000 and 2008 (4). Since

doi: 10.1111/cdoe.12156

1975, the overall reduction has been 86% and more pronounced in the poor (5). Nutritional status of children has also improved and there has been a more pronounced decline amongst poorer populations (4). On the other hand, inequalities in the prevalence of some noncommunicable diseases (NCDs) such as diabetes have increased in the last decade in Brazil (6).

Dental caries is a noncommunicable disease (NCD) and its prevalence in children has declined dramatically in most industrialized countries, as well as in Brazil (7, 8). There has been a marked decline in caries levels in Brazilian 12-year-olds between 1986 and 2010. The overall decrease in DMFT was almost 70% between 1986 and 2010, and 25% between 2003 and 2010 (8). Findings from the 2003 and 2010 national surveys indicate that regional differences in the DMFT of 15- to 19-year-olds persisted and did not appear to have changed; the poorest areas of Brazil, namely the north and north-east regions, have the highest DMFT, while the wealthier regions, the Southeast and South, have the lowest levels of caries (8). Regional differences and ethnic inequalities were also found in Brazilian adolescents' oral health (9, 10).

Although large socioeconomic and regional inequalities in dental caries have been reported internationally (11–14) and in Brazil (15, 16), few studies have focused on whether the improvements in dental status in children were accompanied by changes in levels of inequalities (17, 18). As there has been a marked decrease in DMFT in 15- to 19-year-old adolescents in Brazil between 1986 and 2010, the objective of this study was to assess whether declines in caries between 2003 and 2010 were associated with reductions in inequalities in dental caries in adolescents. The hypothesis was that there would be declines in inequalities as oral health improved.

Methods

This study involved the secondary analysis of data from the 2003 and 2010 National Oral Health Surveys (General Coordination of Oral Health, Ministry of Health) (19). The SBBrasil Project 2003 and 2010 national surveys used similar methods. Both surveys used the same sample strata in terms of regions (north, north-east, south-east, south and central west), state capitals and municipalities from countryside in each region (250 in 2003 and 150 in 2010). The main oral diseases investigated were dental caries, periodontal condition, malocclusion, prosthetics and fluorosis (20). Further details about the sample design and other information have been reported elsewhere (8, 21).

In this study, data from adolescents aged 15–19 were used. There were 16 833 adolescents examined in 2003 and 5445 in 2010. There are two reasons for using this age group. First, adolescence is a critical period in terms of oral disease development and oral health care and there is a rapid increase in dental caries in the first years of adolescence; the DMFT usually doubles between 12 and 15–19 years (8, 22). Second, socioeconomic information was available at individual level. Furthermore, the outcomes (prevalence and severity of dental caries) have less intragroup variation, which are therefore suitable for performing multiple analyses.

Variables

The dependent clinical variables were the Decayed, Missing and Filled Teeth (DMFT) index and the percentage caries free (DMFT = 0). The independent variables were related to socioeconomic status (income and educational level) obtained by questionnaire in both surveys. Income was measured as total income received by all family members in the month preceding the survey. In 2003, the variable was recorded as the specific value in Brazilian currency (reais = R$) and in 2010 in seven classes (from 'up to R$250' to 'R$9500 and more'). To standardize the measures, the monthly household income was converted into minimum wages, based on the current value at the time of each survey. According to information from the Brazilian government, the minimum wage in 2003 was equivalent to R$210, and in 2010, it was R$510 (23). Therefore, it was possible to establish equivalence between the indexes, through classifying them into four classes of minimum wage (up to 1; 1–2.9; 3–4.9 and 5 and more). For the educational level, the original variable in both surveys was number of years of schooling. It varied from 0 (illiterate) to 16 (undergraduate). However, this variable is affected by age, as it refers to adolescents from 15 to 19 years. For example, if there are proportionally more 18-year-old subjects than 15 years old, the schooling years could be overestimated. Therefore, it was necessary to create a new variable accounting for the age of the participant by calculating the delay in relation to the ideal number of years of schooling in a specific age, known as 'age-grade level' (24). This procedure was based on the recom-

mendation of Brazilian government, which state that the ideal age for starting primary school is 7 years old (24). At age 15, for example, the ideal number of years of schooling is 8 (15–7). Consequently, at age 16, the ideal number is 9 and so forth. If an individual is 17 years old and has only 6 years of schooling, he will be recorded as having a delay of 4 years, because it would be expected he had 10 years of schooling. Then, the greater the number of delayed years, the worse the situation is in relation to educational level. Based on this new variable, the sample was classified into four groups (above, ideal level, 1–2 years of delay and three or more years of delay).

Statistical analysis

The descriptive analysis was based on the average DMFT and the percentage caries free and their respective 95% confidence intervals by socioeconomic groups. They were calculated without considering the design effect as well as the sampling weight, as that information was not available in the 2003 survey. To evaluate inequality in dental caries, we calculated the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII) (25), for each of the outcomes. We also calculated the interaction effect between the two surveys to identify whether there was a change in inequalities between 2003 and 2010 (26).

To calculate the SII and RII, the explanatory variables (income and education) were transformed in ridit scores based on the proportion of sample in each class (25). The coefficients and respective exponential values were calculated using generalized linear models (GLM) with Poisson distribution. In general, the SII is the overall rate *difference* and the RII could be interpreted as the overall rate *ratio* between the lower and the higher groups in the socioeconomic hierarchy (26).

To evaluate whether there was a significant change in inequalities between 2003 and 2010, the values of RII and SII over time were assessed by inclusion of the two-way interaction term 'ridit-survey' for each explanatory variable (26).

Results

Data relating to 15- to 19-year-olds were extracted from the 2003 and 2010 databases. In 2003, 310 (1.8%) and 810 (4.8%) adolescents were excluded because of missing data on income and education, respectively. In 2010, these numbers were 310 (5.6%) and 412 (7.5%), respectively.

The highest levels of caries were in adolescents with the worst socioeconomic conditions. In 2003, the mean DMFT was 6.2 (6.1–6.3) for those with lowest level of income and 5.5 (5.2–5.7) for those with highest level (Table 1). In 2010, although an overall reduction in DMFT had occurred, the differences between socioeconomic classes remained. For the poorest adolescents, whose parents earned up to five minimum wages (MW) and who were potentially dependent on the public health system, the reduction in DMFT was 18%, whereas for the richest, the decline in dental caries was 34%.

In relation to education status, the results in terms of the gap between classes were similar, as the mean DMFT ranged from 7.0 (6.8–7.1) to 5.7 (5.5–5.8) in 2003 and from 7.0 (6.5–7.4) to 3.6 (3.3–3.7) in 2010.

Figures 1 and 2 show the gradients in DMFT in both surveys according to the two socioeconomic variables: educational level and household income. There were significant differences in the trend lines for both DMFT and caries free between the two surveys. The Slope Index of Inequality and the RII for DMFT showed significant differences between 2003 and 2010 (Table 2).

The SII value related to income in 2003 was 0.54, which means that the overall difference between the social classes is about a half a DMF tooth. There was a threefold increase in the gap by 2010. In relation to education, the difference was larger. The SII increased from 1.25 in 2003 to 3.47 in 2010. The finding for RII was similar to the SII; the value for income increased by almost 50% (from 1.09 to 1.50), and for education, it almost doubled (from 1.23 to 2.20) indicating that in 2010 those with the lowest educational level had twice the DMFT than those in highest educational level.

The results were similar for the percentage of caries free as for the DMFT. There was a fivefold increase in the SII between 2003 and 2010 for both education and income. There were also significant differences relating to both variables between the two surveys in relative inequality (RII) in DMFT. All the differences showed statistically significant differences between surveys (P-value for trend <0.001), indicating that there were significant increases in inequalities in dental caries related to socioeconomic conditions in Brazilian adolescents between 2003 and 2010.

Table 1. DMFT and prevalence of caries free in adolescents (15–19 years) according to socioeconomic variables and year of survey

		DMFT		Caries free	
	n	Mean	CI (95%)	%	CI (95%)
Household income (minimum wage)					
2003					
Up to 0.9 MW	5796	6.25	6.1–6.3	10.2	9.4–10.9
1–2.9 MW	7156	6.28	6.1–6.3	10.4	9.6–11.1
3–4.9 MW	2278	6.01	5.8–6.2	11.9	10.5–13.2
5 and +	1293	5.51	5.2–5.7	15.5	13.5–17.4
2010					
Up to 0.9 MW	860	5.59	5.2–5.9	15.6	13.1–18.0
1–2.9 MW	2653	5.04	4.8–5.2	19.4	17.8–20.9
3–4.9 MW	928	4.64	4.3–4.9	25.2	22.4–27.9
5 and +	694	3.65	3.3–3.9	34.9	31.3–38.4
Education (age-grade level)					
2003					
3 or + years	4008	6.98	6.8–7.1	9.0	8.1–9.8
1–2 years	3509	6.04	5.8–6.1	9.7	8.7–10.6
Ideal level	5452	5.99	5.8–6.1	11.6	10.7–12.4
Above	3054	5.74	5.5–5.8	12.8	11.6–13.9
2010					
3 or + years	710	6.99	6.5–7.4	11.0	8.6–13.3
1–2 years	873	5.37	5.0–5.7	18.7	16.1–21.2
Ideal level	1973	4.63	4.4–4.8	20.7	18.9–22.4
Above	1477	3.59	3.3–3.7	31.0	28.6–33.3

MW, minimum wage; CI, confidence interval.

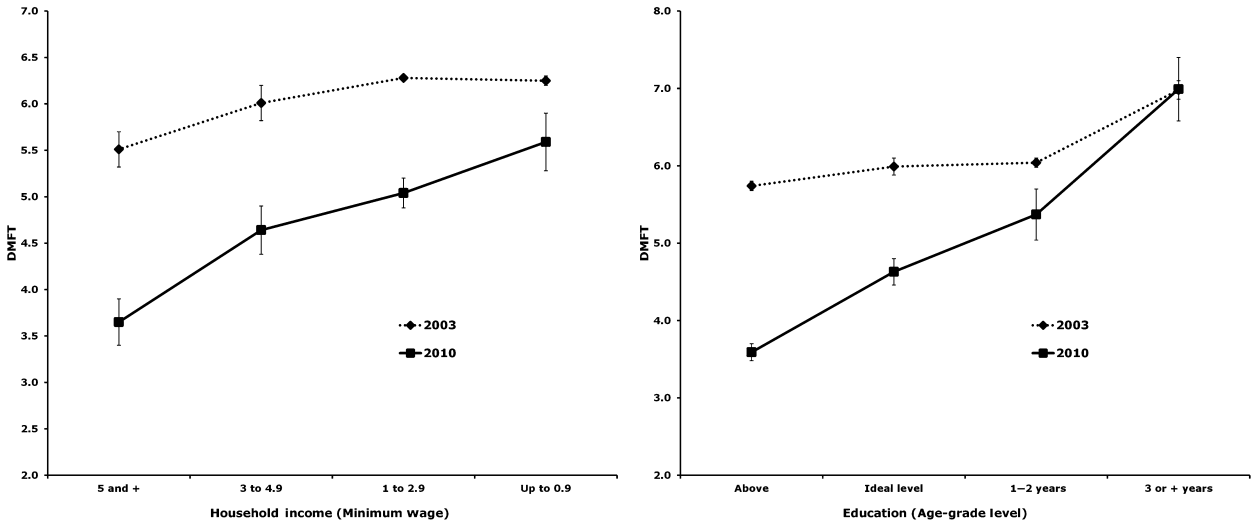

Fig. 1. DMFT in adolescents (15–19 years), by socioeconomic status and year of survey in Brazil. Household income on the left and education on the right. Bars indicate the confidence interval (95%).

Discussion

Despite the overall recent marked reduction in caries, there was a significant increase in inequality in dental caries status related to socioeconomic position in Brazilian adolescents between 2003 and 2010. The indices for absolute and relative inequality indicated significant differences between these two periods for both socioeconomic variables, income and education, and for both outcomes, DMFT and caries free. The absolute inequality for education, for example, showed that the overall difference increased from a little more than a DMF tooth to about 3.5 DMF teeth between 2003 and 2010. This means that in 2010, there were 3.5 more teeth affected by caries

Table 2. Slope Index of Inequality (SII) and Relative Index of Inequality (RII) for DMFT and prevalence of caries free. The *P*-value for trend indicates the significance between surveys

	SII (CI 95%)			RII (CI 95%)		
	2003	2010	*P* for trend	2003	2010	*P* for trend
DMFT						
Household income (minimum wage)	0.54 (0.39–0.68)	2.01 (1.79–2.24)	<0.001	1.09 (1.04–1.14)	1.50 (1.35–1.67)	<0.001
Education (age-grade level)	1.44 (1.31–1.58)	3.67 (3.45–3.88)	<0.001	1.27 (1.21–1.32)	2.20 (1.99–2.45)	<0.001
Caries free (%)						
Household income (minimum wage)	3.64 (1.92–5.36)	19.40 (15.38–23.42)	<0.001	1.43 (1.20–1.69)	2.56 (2.13–3.13)	<0.001
Education (age-grade level)	5.06 (3.35–6.77)	22.93 (18.98–26.88)	<0.001	1.61 (1.37–1.89)	2.94 (2.44–3.57)	<0.001

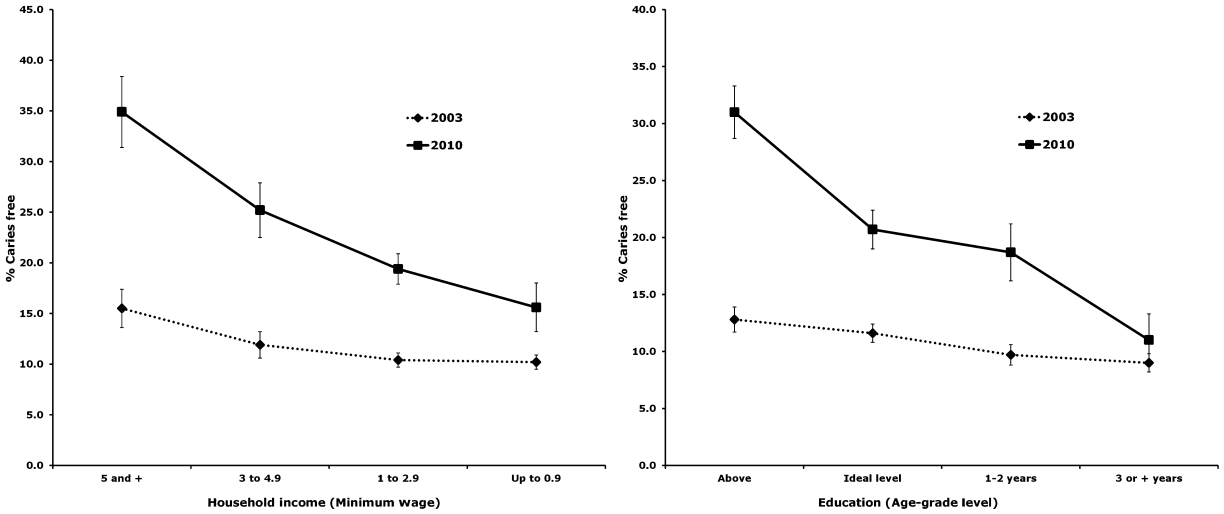

Fig. 2. Prevalence of caries free in adolescents (15–19 years), by socioeconomic status and year of survey in Brazil. Household income on the left and education on the right. Bars indicate the confidence interval (95%).

in the worst educational level, about three times the 2003 value. In terms of the ratio between the extreme socioeconomic groups, in 2003, the worst educational level had a DMFT 23% higher than the better-off group. This value almost doubled in 2010, meaning that the worst educational level had more than twice as likely of developing tooth decay. The reasons for this increase in inequalities are not clear, as the general health of children had improved in Brazil during the study period (4, 5, 8).

Although there are numerous publications reporting inequalities in oral health, studies on inequalities over time are rare. Moreover, the results varied by the outcome evaluated, the age group, the period and the country studied. Do et al. (17) reported that there was an increase in inequalities in caries in the primary teeth, but not in permanent teeth of Australian children between 1993 and 2003. In older people, Jagger et al. (27) reported an increase in economic-related inequalities in edentulism in Scottish adults. Different results were reported by Cunha-Cruz et al. (28) when analysing data from United States; differences in prevalence of edentulism remained stable between high and low socioeconomic groups. Updating these results and including data from Canada, Elani et al. (29) found that oral health outcomes had improved in both countries and the improvement was accompanied by a decline in absolute socioeconomic inequality. Similar results using the same outcome were reported by Holst in Norway (30). However, when considering functional dentition as an outcome amongst elderly people, there was more inequality in 2002. In German adults despite an overall improvement measured by the increase in functioning teeth, oral health was less equally distributed in 2005

compared with previous surveys, in terms of educational level (31).

The reasons for the above-mentioned findings have not been explained. To aid interpretation of our results, we took into account the particular situation in Brazil, and from a theoretical perspective, the conceptual framework proposed by the Commission on Social Determinants of Health (CSDH) (32). According to the CSDH framework, the interaction amongst social determinants occurs through three hierarchically distributed levels: the socioeconomic and political context, the social position and the material circumstances. In this study, our explanatory variables (education and income) are in the second level and have some important determinants related to the material circumstances and to the healthcare system.

The Brazilian socioeconomic and health indicators have significantly improved in the last two decades. The minimum wage has steadily increased in terms of real purchasing value in the last 10 years, with a more egalitarian distribution, as this increase was higher in the poorest quintile. This situation had an important effect in some inequality indicators such as Gini index, which has decreased since 2003 (23).

With regard to the public health services, there was a significant expansion in the public health services in the last decade. At the same period, the population covered by oral health teams in primary care increased in the whole country with a positive discrimination towards the poorest. In terms of the behavioural risk factors, the average consumption of sugars, candies and other confectionery and soft drinks was higher in high-income families (33) and there has been an increase in the consumption of oral hygiene products in the last decade. However, there were inequalities in the purchasing capacity for those products (34). The average expenditure on hygiene and personal care products that included toothpaste, mouthrinses and toothbrushes showed a typical gradient in relation to household income (34). Thus, except for the consumption of oral hygiene products, the aforementioned data reveal a presumed paradox: Why was there an increase in inequalities if policies and income trends favoured a reduction in inequalities?

A possible explanation for the increase in inequalities is the length of time between the two surveys. Although for some socioeconomic conditions and even for some health indicators, the period studied was sufficient for a reduction in inequalities (35), this probably does not equally apply to oral disease, particularly taking into account the nonreversible and cumulative nature of the relevant outcome measures – dental caries. Alternatively, it has been argued that some effective population-based interventions, which focus on the improvement of overall population health, may also increase health inequalities. This uneven effect occurs because the frequency distribution of disease, despite the reduction in the mean effect, does not shift the frequency distribution to the left (36). Hence, there is an increase in the variability and a concentration at the ends of the distribution. Amongst those at low risk, there is a greater positive effect, resulting in a concentration of benefits in that group, whereas in populations at high risk, there is a concentration of risks (36).

That explanation has already been proposed for oral health by Batchelor and Sheiham (37). Roberts-Thompson (38) also showed how some oral health interventions, even those using a population approach, may increase inequalities, despite substantial overall improvements in oral health. The author highlights that this cannot be applied for all population interventions, as some of them such as water fluoridation and immunization both improve health and reduce inequalities. More vulnerable people are less able to move towards the healthier state because their level of caries at a young age was already high and caries levels track as children grow older (39).

In the present study, it is important to also consider the potential effect of the age group under consideration and the time period, 7 years, between the surveys. For example, a 15-year-old teenager in 2010 was aged 8 years in 2003. The caries level in 2003 was already set and that caries level will track into adolescence (39). As it was higher in those in lower socioeconomic positions, the socioeconomic gap is unlikely to decrease. In addition, the concentration of risk in the lower socioeconomic groups also precludes a significant reduction when compared to those in high socioeconomic position. In the higher socioeconomic children, the risks are less and the harmful effects on oral health would be less severe. Additionally, the concentration of benefits permits a more significant reduction. In other words, the initial effect of an overall reduction in oral disease could result in different levels of reduction amongst

socioeconomic groups, leading to an increase of inequality. For example, in the case of DMFT related to educational level (Fig. 1), people in the worst socioeconomic position had no improvement in their oral health between 2003 and 2010.

All aspects discussed so far have important implications for the implementation of public health policies, especially for Brazil and other developing countries. As stressed by Watt (11), future strategies to tackle the social gradient and reduce inequalities in oral health may be very different from previous strategies that have improved overall oral health. These strategies require integrated interventions, such as structural changes in the environment, legislative and regulatory controls, improving accessibility of services, reorientation of health services and fundamental in the case of Brazil, to prioritize disadvantaged groups. All these changes need sufficient time to manifest their effects (11).

This study has some strengths and limitations. The comprehensiveness of both surveys enabled the use of representative data, an important aspect considering the regional disparities in Brazil. The sample size and the number of primary sample units are a further strength. On the other hand, although income and education might be considered as proxy of socioeconomic position, in our data they were self-reported, so that some bias may occur. As the income information was obtained for the entire family, it was not possible to evaluate the effect of the difference in family size and composition. The DMFT and the prevalence of caries free were calculated without considering the design effect, as this information was not available in 2003 data set. This could affect the results for the population estimates, especially in terms of the confidence intervals. However, this study is focused on the comparison between socioeconomic groups, in such manner that the overall difference and the ratio between them were not affected.

In conclusion, despite a significant reduction in the overall prevalence and severity of dental caries in Brazilian adolescents, income and education-related inequalities persist and have worsened in the last decade. These results differ from the trends in other socioeconomic and health indicators in Brazil.

In public health terms, it is necessary to ensure that the decline in adolescents' dental caries is more equitable. To implement the principle of equity, it is crucial to tackle these inequalities by considering both the socioeconomic and political contexts of dental public health policies.

Funding

This work was supported by CAPES Foundation, Ministry of Education of Brazil (Grant Number BEX 10246/12-6).

References

1. Graham H, Kelly MP. *Health inequalities: concepts, frameworks and policy*. NHS and Health Development Agency, briefing paper; 2004; available at: http://www.nice.org.uk/niceMedia/documents [accessed on 2 March 2013].
2. Marmot M; For the Commission on Social Determinants of Health. Achieving health equity: from root causes to fair outcomes. Lancet 2007;370:1153–63.
3. Graham H. Health inequalities, social determinants and public health policy. Policy Polit 2009;37:463–79.
4. Victora C, Aquino EML, Leal MC, Monteiro CA, Barros FC, Szwarcwald CL. Maternal and child health in Brazil: progress and challenges. Lancet 2011;377:1863–76.
5. Paim J, Travassos C, Almeida C, Bahia L, Macinko J. The Brazilian health system: history, advances, and challenges. Lancet 2011;377:1778–97.
6. Schmidt MA, Duncan BB, Azevedo e Silva G, Menezes AM, Monteiro CA, Barreto SM et al. Chronic non-communicable diseases in Brazil: burden and current challenges. Lancet 2011;377:1949–61.
7. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. Bull World Health Organ 2005;83:661–9.
8. Roncalli AG, Souza GCA. Fundamentos de epidemiologia para a vigilância em saúde bucal. Pro-Odonto Prevenção 2013;6:9–38.
9. Barbato PR, Peres MA. Perdas dentárias em adolescentes brasileiros e fatores associados: estudo de base populacional. Rev Saúde Pública 2009;43:13–25.
10. Bastos JL, Antunes JLF, Frias AC, Souza MLR, Peres KG, Peres MA. Color/race inequalities in oral health among Brazilian adolescents. Rev Bras Epidemiol 2009;12:313–24.
11. Watt RG. Social determinants of oral health inequalities: implications for action. Community Dent Oral Epidemiol 2012;40(Suppl. 2):44–8.
12. Pitts N, Amaechi B, Niederman R, Acevedo AM, Vianna R, Ganss C et al. Global oral health inequalities: dental caries task group–research agenda. Adv Dent Res 2011;23:211–20.
13. Petersen PE, Kwan S. Equity, social determinants and public health programmes – the case of oral health. Community Dent Oral Epidemiol 2011;39:481–7.
14. Sheiham A, Alexander D, Cohen L, Marinho V, Moysés S, Petersen PE et al. Global oral health inequalities: task group—implementation and delivery of oral health strategies. Adv Dent Res 2011;23:259–67.
15. Narvai PC, Frazão O, Roncalli AG, Antunes JFF. Cárie dentária no Brasil: declínio, iniquidade e exclusão social. Rev Panam Salud Publica 2006;19:385–93.

16. Roncalli AG, Cortes MIS, Peres KG. Perfis epidemiológicos de saúde bucal no Brasil e os modelos de vigilância. Cad Saúde Pública 2012;28(Suppl.):S58–68.
17. Do LG, Spencer AJ, Slade GD, Ha DH, Roberts-Thomson KF, Liu P. Trend of income-related inequality of child oral health in Australia. J Dent Res 2010;89:959–64.
18. Do LG. Distribution of caries in children: variations between and within populations. J Dent Res 2012;91:536–43.
19. Brasil, Ministério da Saúde, Coordenação Geral de Saúde Bucal. *Banco de dados da Pesquisa Nacional de Saúde Bucal – Projeto SBBrasil 2010*; available at: www.saude.gov.br/bucal [accessed on 1 April 2012].
20. World Health Organization – WHO. Oral Health Surveys: Basic Methods, 4th edn. Geneva: ORH/EPID; 1997.
21. Roncalli AG, Silva NN, Nascimento AC, Freitas CHS, Casotti E, Peres KG et al. Relevant methodological issues from the SBBrasil 2010 Project for national health surveys. Cad Saúde Pública 2012;28 (Suppl.):S40–57.
22. Lu HX, Wong MCM, Lo ECM, McGrath C. Trends in oral health from childhood to early adulthood: a life course approach. Community Dent Oral Epidemiol 2011;39:352–60.
23. Brasil, Ministério da Fazenda. Economia Brasileira Em Perspectiva, 17th edn. Brasília: Ministério da Fazenda; 2012.
24. Brasil, Ministério da Educação, Instituto Nacional de Estudos e Pesquisas Educacionais. *Glossário de termos, variáveis e indicadores educacionais. DudataBrasil – Sistema de Estatísticas Educacionais*; 2012; available at: www.inep.gov.br [accessed on 13 May 2012].
25. Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. Soc Sci Med 1997;44:757–71.
26. Ernstsen L, Strand BH, Nilsen SM, Espnes GA, Krokstad S et al. Trends in absolute and relative educational inequalities in four modifiable ischaemic heart disease risk factors: repeated cross-sectional surveys from the Nord-Trøndelag Health Study (HUNT) 1984–2008. BMC Public Health 2012;12:266.
27. Jagger DC, Sherriff A, Macpherson LM. Measuring socio-economic inequalities in edentate Scottish adults – cross-sectional analyses using Scottish Health Surveys 1995–2008/09. Community Dent Oral Epidemiol 2013;41:499–508 doi: 10.1111/cdoe.12040.
28. Cunha-Cruz J, Hujoel PP, Nadanovsky P. Secular trends in socio-economic disparities in edentulism: USA, 1972–2001. J Dent Res 2007;86:131–6.
29. Elani HW, Harper S, Alisson PJ, Bedos C, Kaufman JS. Socio-economic inequalities and oral health in Canada and the United States. J Dent Res 2012;91:865–70.
30. Holst D. Oral health equality during 30 years in Norway. Community Dent Oral Epidemiol 2008;36:326–34.
31. Holtfreter B, Berg MH, Kocher T, Schiffner U, Hoffmann T, Micheelis W. Change in FS-T index in adults in the German national oral health surveys between 1989 and 2005. Community Dent Oral Epidemiol 2013;41:251–60.
32. CSDH. Closing the Gap in a Generation: Health Equity Through Action on the Social Determinants of Health. Final Report of the Commission on Social Determinants of Health. Geneva: World Health Organization; 2008.
33. Brasil, Ministério do Planejamento, Orçamento e Gestão, Instituto Brasileiro de Geografia e Estatística – IBGE. Pesquisa de Orçamentos Familiares 2008–2009 – Análise do Consumo Alimentar Pessoal no Brasil. Rio de Janeiro: IBGE; 2011.
34. Brasil, Ministério do Planejamento, Orçamento e Gestão, Instituto Brasileiro de Geografia e Estatística – IBGE. Pesquisa de Orçamentos Familiares 2008–2009 – Perfil das Despesas no Brasil, Indicadores Selecionados. Rio de Janeiro: IBGE; 2012.
35. Rasella D, Aquino R, Barreto ML. Impact of income inequality on life expectancy in a highly unequal developing country: the case of Brazil. J Epidemiol Community Health 2013;67:661–6 doi:10.1136/jech-2012-201426.
36. Frohlich KL, Potvin L. Transcending the known in public health practice: the inequality paradox: the population approach and vulnerable populations. Am J Public Health 2008;98:216–21.
37. Batchelor P, Sheiham A. The limitations of a 'high-risk' approach for the prevention of dental caries. Community Dent Oral Epidemiol 2002;30:302–12.
38. Roberts-Thomson K. Targeting in a population health approach. Community Dent Oral Epidemiol 2012;40(Suppl. 2):22–7.
39. Broadbent JM, Thomson WM, Poulton R. Trajectory patterns of dental caries experience in the permanent dentition to the fourth decade of life. J Dent Res 2008;87:69–72.