The association between socioeconomic development at the town level and the distribution of dental caries in Brazilian children

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ABSTRACT

Objective. *To investigate the association between dental caries among children in the state of São Paulo, Brazil, and town-level indices of socioeconomic development.*

Methods. *We examined 15 385 oral-examination records from children aged 5 or 6 years old from 129 towns and cities in the state of São Paulo. We studied two outcomes: (1) the mean number of decayed, missing, and filled deciduous teeth (dmft index) and (2) the care index, which is the proportion of decayed teeth that have already been filled. The explanatory variables were the child development index, human development index, illiteracy rate among subjects older than 20 years, household income, Gini coefficient, insufficient income, fluoridated water supply, number of dentists per 10 000 inhabitants, number of dentists in the public service per 10 000 inhabitants, and number of weekly hours of dentist work in the public service per 10 000 inhabitants. Multiple linear regression models were fitted to the two outcome variables (dmft index and care index).*

Results. *The multiple linear regression analysis showed that a higher dmft index was associated with a low child development index, a high illiteracy rate, and an unfluoridated water supply. The child development index was significantly associated with the care index, and the number of dentists in the public service per 10 000 inhabitants showed borderline statistical significance.*

Conclusions. *Our results indicate that town-level indices of socioeconomic status are significantly correlated with caries indices. Our results also emphasize the beneficial effect that fluoridating water has on reducing the prevalence of dental caries and the fact that strategies for treating and preventing oral diseases should be emphasized within the context of overall health promotion for children.*

Key words Dental caries, dental care, socioeconomic factors, Brazil.

There is a well-established relationship between socioeconomic conditions and health. Attempts at a better understanding of this process have been based on at least two different paradigms. One paradigm looks for the causal pathways of behavior and biological aspects that link the social position of individuals to their specific health risks. Another paradigm seeks to understand and explain different patterns of health within and between populations (1, 2). Various studies have explored the impact that socioeconomic standing has on the health status of a community and on the provision of health services (3, 4).

Dental caries is the most common dental disease. As with other chronic

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diseases, a population-level association between socioeconomic development and dental caries has been found in comparisons made between countries and in comparisons within individual countries. Lalloo et al. (5) showed a relationship between a low human development index (a composite measurement assembling indicators of instructional levels, income, and health status of a community) and high levels of dental caries as measured by the DMFT index at 12 years of age in several countries (the upper-case "DMFT" form indicates the measurement of decayed, missing, and filled permanent teeth, while the lower-case "dmft" form is for deciduous teeth).

The same association between dental caries and socioeconomic status has been seen in both developed and developing countries. In the United Kingdom, for example, regional differences have been found in the proportions of 6-year-old children with active tooth decay (6). In Northern Ireland, 64% of the children had dental caries, compared with 59% in Wales, 55% in Scotland, 41% in England, and 44% in the United Kingdom overall. Regional differences in children's dental caries have also been identified within England (7). At most ages, children in North England had the highest number of decayed, missing, or filled teeth of any region of England.

Studies in Brazil have highlighted the role of socioeconomic development in dental caries. Moyses (8) found a significant correlation between low human development index values and high mean DMFT for 12-year-old schoolchildren in 26 Brazilian states. Pattussi et al. (9) investigated the links that social deprivation and social cohesion had with dental caries in schoolchildren 6 to 12 years old in the Federal District of Brazil. They found a strong positive correlation between levels of dental caries and the Gini coefficient. (The Gini coefficient is a measurement used to gauge the concentration of different variables, mainly income, mortality, and the distribution of health services (10, 11). Values of the Gini coefficient range from "0" (uniform distribution) to a theoretic value of "1" (maximum inequality)). In the Federal District, that association between dental caries and the Gini coefficient explained 49% of the dental caries prevalence and 31% of the dental caries severity.

Better oral health status, including a lower prevalence of dental caries, was found in more cohesive neighborhoods of Curitiba, a large city in southern Brazil, in assessments using both individual and area-based measures (12). The metropolis of São Paulo, which is located in the Brazilian state of the same name, is the country's largest and wealthiest urban area. Antunes et al. (13) applied spatial data analysis in that city to explore hypotheses of ecological association between schoolchildren's indices of dental caries and indicators of socioeconomic development. Those researchers found that schoolchildren living in more affluent districts were less affected by dental caries and had fewer dental treatment needs than did children living in deprived areas. At the spatial level, items that were significantly correlated with variables measuring children's caries experience included average family income, the unemployment rate, household overcrowding, and an index of inequality of income distribution. Several studies support the use of area-based measures to assess health status and to improve the formulation of socially appropriate health policies (14–16).

The purpose of this study was to investigate the association that town-level indices of socioeconomic development had with outcomes for the oral health status of children who were 5 or 6 years old and living in the state of São Paulo. We especially wanted to investigate which dimensions of socioeconomic development best correlated with town-level variations in dental outcomes, in order to help develop information that could guide the planning of socially appropriate dental care programs.

METHODS

From August to December 1998, the São Paulo State Health Secretariat *(Secretaria de Estado da Saúde de São Paulo)* performed an epidemiological survey of oral health in the state of São Paulo, Brazil (17), following international standards established by the World Health Organization (18). A total of 87 918 persons were examined: schoolchildren 5 to 12 years old, youths 18 years old, adults 35 to 44 years old, and elderly people 65 to 74 years old. The examination covered dental caries, treatment needs, dental prostheses, periodontosis, fluorosis, and occlusion disorders. The multistage sampling design was planned to be representative of the entire state and of each of the participating towns for the estimation of caries prevalence in deciduous teeth among schoolchildren 5 or 6 years old and in permanent teeth among schoolchildren 12 years old. The sponsoring institutions made the survey files available for public consultation. We examined 15 385 oral examination records related to 5- or 6-year-old children and assessed their indices of dental caries and restorative dental treatment. We estimated the following indices of oral health status at the town level: (1) the dmft, corresponding to the average number of decayed, missing, and filled deciduous teeth; and (2) the care index, an indicator proposed by Walsh (19) for comparative studies addressing dental programs, which is the ratio between the number of filled teeth and the overall dmft index, and which is scaled as a percentage. The mean dmft index and the care index were the outcomes used in this study. We gathered complementary information on oral health status, including the proportions of caries-free children (i.e., dmft = 0), and of "high-caries" children (i.e., dmft $\geq$ 4).

The survey covered 129 towns and cities: 65 with fewer than 10 000 inhabitants; 39 with a population between 10 000 and 50 000 inhabitants; and 25 with more than 50 000 inhabitants, including the city of São Paulo. The as-

sessment of fluoride in the municipal water supply systems used a dummy variable. That dummy variable differentiated between the 78 towns or cities with optimally fluoridated tap water and the 51 that did not have optimally fluoridated tap water, as reported by local health officials. (Narvai (20) has described the history of water fluoridation in Brazil as well as the quality control procedures that are now used to monitor fluoride levels in water supply systems.)

Brazil's 1991 census provided us with primary information to estimate the following town-level indicators of socioeconomic status: (1) per capita household income, which we calculated using a Brazilian standard for the measurement of income, the "minimum wage"; the minimum wage is set for the entire country (without regional variation) by the national Government, and while varying in recent years, it has generally been lower than US$ 100 per month; (2) "insufficient income," as defined by the Brazilian division of the United Nations Development Program (21), refers to the proportion of the population with a per capita household income less than half the minimum wage level; (3) the Gini coefficient, which we calculated in order to gauge the concentration of income at the town level; and (4) the illiteracy rate among individuals older than 20 years.

We also obtained from the Brazilian divisions of the United Nations Development Program and the United Nations Children's Fund information about the human development index (HDI) (21) and the child development index (CDI) (22). Both these indices were calculated by these agencies with primary information provided by the census and by Governmental health services agencies. The CDI is a composite measurement summarizing information about income, educational level, and child health. Both the HDI and the CDI range theoretically from 0 to 1, with higher values indicating better conditions.

Official data for 1997 from the Information System on Ambulatory Data of the Unified Health System of Brazil *(Sistema de Informações Ambulatoriais do Sistema Único de Saúde)* (23) provided us quantitative information to estimate the effectiveness of community dental health initiatives. This town-level information made it possible to estimate the number of dentists in the public service per 10 000 inhabitants as well as the number of weekly hours of dentist work in the public dental service per 10 000 inhabitants. We also estimated the total number of dentists per 10 000 inhabitants in each town, according to information for 1998 supplied by the Brazilian Federal Dentistry Council *(Conselho Federal de Odontologia)*.

We performed the statistical analysis using SPSS 8.0 software (SPSS Inc., Chicago, Illinois, United States of America) (24). For this study we used space as an organizing frame to explore variations in dental health status in the different towns. Our aim was to express single general relationships between aggregate information for the dental health outcomes (the dmft index and the care index) and socioeconomic characteristics. The aggregation of variables at the town level complied with the methodology described by Bailey and Gatrell (25) for the analysis of area data. For the classification of oral health indices we applied K-means cluster analysis (26). We also used ordinary least squares regression analysis (27) to appraise the association that figures of oral health (the dmft index and the care index) had with the provision of dental care (the total number of dentists per 10 000 inhabitants, the number of dentists in the public service and their number of weekly hours of work per 10 000 inhabitants) and with socioeconomic status.

Prior to the regression analysis, we performed the following control of variables: (1) the Kolmogorov-Smirnov test (28) to determine whether the distribution of the variables could be considered normal, (2) the Kendall-Stuart and Goldfeld-Quandt tests (29) to estimate heteroscedasticity in the distribution of these variables, and (3) the Box-Cox power transformations (26) to correct heteroscedasticity and nonnormality of distribution of the variables, which could prevent the application of regression analysis.

In addition, multiple regression models were fitted to the two outcome variables (dmft index and the care index) and explanatory variables related to municipal socioeconomic development indicators (CDI, HDI, illiteracy rate among individuals older than 20 years, household income, Gini coefficient, insufficient income), fluoridated water supply, and the provision of dental services (the total number of dentists per 10 000 inhabitants and the number of dentists in the public service and their number of weekly hours of work per 10 000 inhabitants).

Theoretically, we assumed two levels of determinants for the outcomes studied. The first is the macrosocial level, represented by indicators of socioeconomic development. The second level consists of variables relating to the provision of dental services and the supply of fluoridated water. Addressing the influence of the first level on the second level, the multiple linear regression analysis used a forward stepwise procedure to include or exclude explanatory variables in the fitting of models. Explanatory variables presenting a P value ≤ 0.20 in the assessment of correlation with each outcome were included in the fitting of the model. Explanatory variables were selected for the final models only if they had a P value ≤ 0.05 after adjustment for variables from the same or prior levels of determinants.

RESULTS

Table 1 summarizes the K-means cluster analysis of the dmft index. We identified four clusters of increasing values of caries prevalence in deciduous teeth. The dmft index presented a significant negative town-level correlation with the proportion of caries-free children and a positive town-level correlation with the proportion of children with four or more teeth affected by caries. In general, towns or cities

TABLE 1. K-means cluster analysis of the decayed, missing, and filled deciduous teeth (dmft index) for 5- and 6-year-old schoolchildren in towns and cities in the state of São Paulo, Brazil, 1998

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	City-level correlation coefficient	*P* value
dmft index						
Mean	2.13	3.05	4.21	5.63	NA[a]	NA
Standard deviation	0.28	0.29	0.36	0.60	NA	NA
Number of towns	33	44	34	18	NA	NA
City-level mean figures for oral health status						
care index	37.9%	28.4%	27.6%	19.4%	–0.323	< 0.001
Proportion of caries-free children	46.2%	34.8%	23.2%	15.2%	–0.929	< 0.001
High-caries children	25.9%	37.8%	51.1%	63.9%	0.975	< 0.001
City-level mean figures for the dental service profile						
Dentists per 10 000 inhabitants	12.62	8.53	6.73	6.12	–0.334	< 0.001
Dentists in the public service per 10 000 inhabitants	3.10	4.67	3.94	5.39	0.192	0.052
Weekly hours of dentist work in the public service per 10 000 inhabitants	74.55	118.42	109.08	119.35	0.149	0.103
City-level mean figures of socioeconomic development indicators						
Illiteracy rate (above 20 yr old)	13.8%	18.8%	20.9%	22.1%	0.433	< 0.001
Human development index	0.757	0.668	0.556	0.395	–0.473	< 0.001
Child development index	0.646	0.601	0.560	0.525	–0.494	< 0.001
Household income (number of "minimum wages" per capita)	1.60	1.31	1.20	0.96	–0.378	< 0.001
Gini coefficient	0.572	0.597	0.572	0.613	0.147	0.131
Insufficient income	23.5%	33.4%	30.6%	47.8%	0.368	< 0.001

[a] NA = not applicable.

with higher levels of caries prevalence also had higher figures for insufficient income and illiteracy in adults, lower household income, a lower HDI, and a lower CDI. The dmft was not associated with the Gini coefficient. As the number of dentists per 10 000 inhabitants in the private sector tends to be higher in towns with better socioeconomic status, this indicator correlated negatively with the dmft index at the town level. Therefore, towns with lower caries prevalence tended to have a higher proportion of dental care provided by private dentists. In contrast, there were mild positive correlations between the dmft index and both measures assessing dental work in the public service. These results indicate some effectiveness in the reform of Brazil's public health system during the 1990s, which set up the public dental service in the country and then promoted initiatives on oral health education and also increased the provision of free dental care and preventive dental treatment.

Table 2 presents the results of simple and multiple linear regression analysis for the dmft and the covariates that assess socioeconomic development and the profile of water and dental services. All the indices of socioeconomic development except the Gini coefficient were significantly associated with the dmft index in the unadjusted analysis. Among the second set of variables, water fluoridation and the number of dentists per 10 000 inhabitants were significantly associated with the dmft, while dentists in the public service showed a borderline association ($P = 0.06$). Most of the socioeconomic variables were excluded from the multivariate analysis after adjustment for the remaining variables at the first level of determination (indices of socioeconomic development), with only the CDI and the illiteracy rate among persons older than 20 years continuing to be associated with the dmft index. The CDI and the illiteracy rate among individuals older than 20 years explained 49% of the town-level dmft variation.

Table 3 summarizes the K-means cluster analysis for the care index. We found a better profile of restorative dental treatment in towns with lower levels of caries prevalence as measured by the dmft, the proportion of caries-free children, and the proportion of children with 4 or more teeth affected by caries ("high-caries children"). These towns also had higher income levels, higher HDI values, higher CDI values, less illiteracy among adults, and lower levels of insufficient income. The care index was not associated with the Gini coefficient at the town level. As the number of dentists per 10 000 inhabitants in the

TABLE 2. Simple and multiple regression analysis of municipal socioeconomic development indicators and water and dental services profile for 5- and 6-year-old schoolchildren's decayed, missing, and filled deciduous teeth (dmft index) in towns and cities in the state of São Paulo, Brazil, 1998

Variable	Unadjusted regression coefficient (95% CI)[a]	*P*	R^{2b}	Adjusted regression coefficient (95% CI)	*P*	R^2
Socioeconomic development indicators						0.49
Child development index	–7.08 (–9.26, –4.90)	< 0.01	0.25	–4.22 (–7.21, –1.23)	< 0.01	
Illiteracy rate	0.08 (0.05, 0.11)	< 0.01	0.19	0.04 (0.00, 0.08)	0.03	
Human development index	–5.92 (–8.45, –3.40)	< 0.01	0.17	EXCL[c]		
Household income	–0.81 (–1.19, –0.44)	< 0.01	0.14	EXCL		
Gini coefficient	4.09 (–1.18, 9.36)	0.127	0.02	EXCL		
Insufficient income	0.03 (0.01, 0.04)	< 0.01	0.14	EXCL		
Water and dental services profile						0.64[d]
Fluoridated water supply	–1.27 (–1.64, –0.90)	< 0.01	0.27	–0.97 (–1.32, –0.62)	< 0.01	
Dentists per 10 000 inhabitants	–0.06 (–0.09, –0.03)	< 0.01	0.11	EXCL		
Dentists in the public service per 10 000 inhabitants	0.84 (–0.02, 1.70)	0.06	0.04	EXCL		
Weekly hours of dentist work in the public service per 10 000 inhabitants	0.57 (–0.01, 1.24)	0.10	0.02	EXCL		

[a] 95% CI = 95% confidence interval.
[b] R^2 = coefficient of determination.
[c] EXCL = excluded because showed $P > 0.05$ in the multiple regression analysis.
[d] Multivariate model including child development index, illiteracy rate, and fluoridated water supply.

TABLE 3. K-means cluster analysis of the care index for 5- and 6-year-old schoolchildren in towns and cities in the state of São Paulo, Brazil, 1998

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	City-level correlation coefficient	*P* value
Care index						
Mean	11.6%	27.0%	46.1%	67.8%	NA[a]	NA
Standard deviation	5.18%	5.56%	5.36%	8.90%	NA	NA
Number of towns	41	49	30	9	NA	NA
City-level mean figures for oral health status						
dmft index[b]	3.96	3.43	3.02	3.08	–0.323	< 0.001
Proportion of caries-free children	27.0%	31.9%	37.0%	37.6%	0.356	< 0.001
High-caries children	46.9%	41.3%	37.1%	38.7%	–0.270	0.002
City-level mean figures for the dental services profile						
Dentists per 10 000 inhabitants	5.60	9.56	11.40	11.94	0.427	< 0.001
Dentists in the public service per 10 000 inhabitants	3.63	4.19	4.46	5.26	0.168	0.091
Weekly hours of dentist work in the public service per 10 000 inhabitants	94.64	107.50	96.96	129.31	0.043	0.637
City-level mean figures of socioeconomic development indicators						
Illiteracy rate (above 20 yr old)	21.0%	18.4%	15.2%	15.9%	–0.417	< 0.001
Human development index	0.516	0.644	0.726	0.660	0.313	< 0.001
Child development index	0.533	0.598	0.642	0.646	0.563	< 0.001
Household income (number of "minimum wages" per capita)	1.09	1.37	1.52	1.37	0.320	0.001
Gini coefficient	0.587	0.583	0.584	0.592	–0.054	0.571
Insufficient income	38.9%	30.3%	25.8%	26.0%	–0.373	< 0.001

[a] NA = not applicable.
[b] dmft index = decayed, missing, and filled deciduous teeth.

TABLE 4. Simple and multiple regression analysis of municipal socioeconomic development indicators and water and dental services profile for 5- and 6-year-old schoolchildren's care index, in towns and cities in the state of São Paulo, Brazil, 1998

Variable	Unadjusted regression coefficient (95% CI)[a]	*P*	R^{2}[b]	Adjusted regression coefficient (95% CI)	*P*	R^{2}
Socioeconomic development indicators						0.32
Child development index	115.4 (85.4, 145.4)	< 0.01	0.32	115.4 (85.4, 145.4)	< 0.01	
Illiteracy rate	–1.16 (–1.64, –0.68)	< 0.01	0.17	EXCL[c]		
Human development Index	88.8 (49.6, 127.9)	< 0.01	0.16	EXCL		
Household income	10.41 (4.48, 16.33)	< 0.01	0.10	EXCL		
Gini coefficient	–20.85 (–102.87, 6.17)	0.62	0.00	EXCL		
Insufficient income	–0.39 (–0.58, –0.21)	< 0.01	0.14	EXCL		
Water and dental services profile						0.33[d]
Fluoridated water supply	3.56 (–2.68, 9.79)	0.261	0.01	EXCL		
Dentists per 10 000 inhabitants	1.15 (0.66, 1.63)	< 0.01	0.18	EXCL		
Dentists in the public service per 10 000 inhabitants	9.92 (–2.24, 22.08)	0.11	0.03	9.92 (–0.22, 20.05)	0.06	
Weekly hours of dentist work in the public service per 10 000 inhabitants	2.60 (–7.48, 12.68)	0.61	0.00	EXCL		

[a] 95% CI = 95% confidence interval.
[b] R^2 = coefficient of determination.
[c] EXCL = Excluded because showed $P < 0.05$ in the multiple regression analysis.
[d] Multivariate model including child development index and dentists in the public services per 10 000 inhabitants.

private sector tends to be collinear with town-level indicators of socioeconomic status, this variable was also positively associated with the care index at the town level. The mild positive correlation ($P = 0.09$) between the care index and the number of dentists in the public service per 10 000 inhabitants is another indication of some effectiveness in the reform of the public health system in Brazil.

The results of the multiple linear regression analysis fitting the care index to town-level indices of socioeconomic development and the profile of water and dental services are shown in Table 4. The profile of correlations between the care index and variables in the first level of determinants (socioeconomic development) was similar to the pattern described for the dmft (Table 2). In the second level of determinants (provision of dental services), only the number of dentists was associated with the care index. We included the number of dentists in the public service in the multiple regression analysis because its association with the care index had a P value < 0.20. After adjustment for the remaining first-level variables, the CDI was the only explanatory variable assessing socioeconomic status that was associated with the care index. The CDI explained 32% of the variation observed for this outcome. In the second level, the number of dentists was excluded from the model after adjusting for the higher-level variable (CDI). The opposite occurred with the number of dentists in the public services, which showed a borderline significant association with the care index ($P = 0.06$) after the adjustment. As the CDI was the only remaining variable in the first level of determinants in both multivariate models (for the dmft index and for the care index), we considered it to be the most useful town-level socioeconomic variable for assessing the children's caries risk and their restorative dental treatment.

Using the dmft index, we found a significantly higher prevalence of caries in the towns that had not added fluoride compounds to their tap water (Table 5). On average, towns without fluoridated tap water presented an excess of 127 deciduous teeth affected by caries per each 100 schoolchildren aged 5 or 6 years old. We also found an association between the dmft index and the proportion of households linked to the water supply network in both groups of towns. As this proportion is a proxy for socioeconomic development, even in towns where fluoride is not added to the tap water, lower caries prevalence accompanied higher proportions of households linked to the water supply system.

DISCUSSION

The total gross national product of Brazil places the country among the 10 most powerful economies in the world. Nevertheless, inequality continues to be symptomatic of the country, with millions of poor people receiving less than an equal portion of benefit from that large economy. This picture is particularly dramatic and ethically unacceptable when figures for health and quality of life of Brazilian children are appraised. Infant mortality rates in Brazil in 1998–1999 ranged from 72 per 1 000 live births in the northeastern state of Alagoas to 19 per 1 000 births in the southern state of Rio Grande do Sul. At the high end of the scale, these rates are comparable

TABLE 5. Prevalence of dental caries in deciduous teeth in schoolchildren aged 5 or 6 years old in the state of São Paulo, according to the fluoride status of tap water in the towns and cities, 1998

dmft index[a]	Nonfluoridated	Fluoridated
Mean	4.25	2.98
Standard deviation	1.17	0.94
Number of towns	51	78
Correlation between the dmft index and the proportion of households linked to the water supply network	$r = -0.349$	$r = -0.516$
Level of significance	$P = 0.046$	$P < 0.001$

[a] dmft index = decayed, missing, and filled deciduous teeth.

to those for Bolivia (64/1 000) and Ghana (63/1 000). At the low end of the scale, they are similar to those for Argentina (19/1 000) and Saudi Arabia (20/1 000) (30). Inequalities in health, including in the distribution of dental caries, occur throughout Brazil and also within individual states and municipalities. It is worth emphasizing that this study was conducted in the state of São Paulo, which is the wealthiest state in Brazil and whose indices of socioeconomic development rank among the highest in the country.

Since this was an ecological study, we cannot infer the results at the individual level. The association between dental caries and CDI does not necessarily mean that children whose families have lower educational attainments (one of the dimensions included in the CDI) will have higher dental caries indices. In spite of the special care needed in interpreting aggregate data, other studies have judged the ecologic assessment of health information as an appropriate resource to compare different populations and their specific socioeconomic characteristics and to investigate structural effects of human behavior on ill health (1, 31).

There was a chronological difference between the outcome and explanatory variables in our study, which requires some comment. For our socioeconomic indicators, we used 1991 census data (21), while the outcome indicators were based on a survey carried out in 1998 (17). This chronological difference is unusual in ecological studies, and it could be viewed as a potential source of bias in assessing the associations between the variables. However, the development of dental caries requires a length of time, and socioeconomic conditions do not change appreciably within a limited time span. The dental exams carried out in 1998 detected the cumulative harmful effects of dental caries produced after 1991. As a chronic cumulative disease, dental caries needs some time to demonstrate clinical effects. The children whom we studied in 1998 had been born in 1992 or 1993. Therefore, they were exposed during their early years of life, when their first primary teeth erupted, to the town-level socioeconomic condition measured by the census performed in 1991. These early years of life are considered to be among the most risky in terms of developing dental caries in childhood.

Another potential source of bias in this study was the timing of water fluoridation. We only differentiated between towns with fluoridated tap water in 1998 and those that did not have that resource in 1998. However, the effect of water fluoridation on dental caries prevalence and severity takes some time to produce its maximum benefit, and we did not gather information about when each town began adding fluoride to its water supply. These considerations add to the need for caution in interpreting the cross-sectional data in our ecological study.

Notwithstanding the chronological differences between the outcome and explanatory variables in our study, we believe the associations in our study are useful information for planning socially appropriate dental health programs. We found associations between indices of dental caries and socioeconomic indicators at the town level. Among the several town-level indicators of socioeconomic development that we used, the CDI was the variable showing the best fit in the association with the dmft for children aged 5 or 6 years: the lower the CDI, the higher the prevalence of caries. A similar pattern was seen when the care index was the outcome analyzed: towns with a lower CDI had a lower level of dental restorative treatment. The illiteracy rate was also associated with the dmft: towns with higher illiteracy levels tended to have higher caries prevalence. These associations were independent of the supply of fluoridated tap water in the town.

Our findings of higher indices of caries in towns with poorer figures of socioeconomic development indicate differential levels of exposure to risk factors for dental caries. There is increasing evidence associating low-income individuals and communities in Brazil with the intake of high levels of carbohydrates, including sweets (32–34); with more frequent poor medical conditions requiring sweetened medications (35); and with limited use of fluoridated toothpaste and inadequate dental treatment (36). In addition, studies have indicated the impact on oral and overall health of a harmful socioeconomic environment occurring very early in life such as from low levels of maternal education (37), low birthweight (35), malnutrition (38–40), and a high proportion of children not attending a day-care center (40). These phenomena appear to increase the risk for dental caries and are more prevalent in deprived areas. It has been suggested that social and biological risks accumulated since childhood have consequences for the subsequent health status of adults (41). Furthermore, young children with dental caries have a higher probability of having dental caries in their permanent dentition (42, 43).

Our multivariate model assessing the variation in the dmft index excluded indices of the provision of dental services (Table 2). This finding is consistent with the hypothesis that dental care has a minor influence on dental caries prevalence, as previously stated by Nadanovsky and Sheiham (44).

Our findings supplied additional evidence for the role of water fluoridation in reducing the prevalence of dental caries (Table 5), as earlier described by McDonagh et al. (45). In the state of Paraná, Brazil, Baldani et al. (46) found a significantly lower DMFT index in 12-year-old schoolchildren in towns with a fluoridated water supply. Therefore, both our research and the study by Baldani et al. point to water fluoridation as an effective public health measure for preventing dental caries. The Centers for Disease Control and Prevention of the United States has labeled water fluoridation as one of the main public health achievements in that country during the twentieth century (47, 48).

Ecological studies on oral health aim at clarifying the socioeconomic and environmental determinants of oral health and at providing information on how to reduce preventable pain and suffering associated with dental diseases. The association between socioeconomic status and the risk of caries has already been extensively reported in the literature. However, our study evaluated several explanatory variables in order to select indices of socioeconomic development and of the provision of dental services that better fit the variation of dental outcomes (the dmft index and the care index). This strategy was undertaken with the intention of guiding health services in the planning of socially appropriate programs of oral health promotion.

We found that the CDI was the most useful index for assessing caries risk and dental treatment at the town level. This observation suggests that the dmft index and the care index share common covariates of the overall health status of children, which the CDI assesses. Therefore, strategies for treating and preventing oral diseases should be emphasized within the context of approaches aimed at overall health promotion for children (49).

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RESUMEN

La asociación entre el desarrollo socioeconómico local y la distribución de caries dental en niños brasileños

Objetivo. Investigar la asociación entre la caries dental en niños del estado de São Paulo, Brasil, y los índices de desarrollo socioeconómico en el nivel local.

Métodos. Examinamos 15 385 registros con los resultados de exámenes bucales de niños de 5 y 6 años de edad provenientes de 129 pueblos y ciudades del estado de São Paulo. Fueron dos los resultados examinados: 1) el número medio de dientes cariados, perdidos y obturados en la dentadura decídua (índice CPOD) y 2) el índice de atención, que es la proporción de dientes deteriorados que han sido empastados. Las variables explicativas fueron el índice de desarrollo infantil, el índice de desarrollo humano, la tasa de analfabetismo entre personas mayores de 20 años, el ingreso domiciliario, el coeficiente de Gini, la escasez de ingresos, el abastecimiento con agua fluorurada, el número de dentistas por 10 000 habitantes, el número de dentistas en el sistema público de atención por 10 000 habitantes y el número de horas semanales dedicadas a trabajos de tipo dental en el sistema público de atención por 10 000 habitantes. Se ajustaron modelos de regresión lineal múltiple a las dos variables dependientes de interés (el índice CPOD y el índice de atención).

Resultados. El análisis de regresión lineal múltiple mostró que un índice CPOD más elevado se asocia con un índice bajo de desarrollo infantil, un índice elevado de analfabetismo y la ausencia de un abastecimiento de agua fluorurada. El índice de desarrollo infantil mostró una asociación significativa con el índice de atención, y el número de dentistas en el servicio público de atención por 10 000 habitantes mostró una asociación marginalmente significativa con ese mismo índice.

Conclusiones. Nuestros resultados indican que los indicadores de nivel socioeconómico aplicables en el nivel local se correlacionan en grado significativo con los índices de caries dental. También resaltan el efecto beneficioso de la fluoruración del agua en lo que respecta a la reducción de la prevalencia de caries dental y el hecho de que las estrategias encaminadas a tratar y prevenir las afecciones bucales deben ser objeto de especial atención en el contexto de la promoción de la salud infantil.