Geographic information system and multilevel analysis: gingival status among 12-year-old schoolchildren in São Paulo, Brazil

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ABSTRACT

Objective. *To evaluate gingival and calculus status among schoolchildren 12 years of age using a geographic information system and multilevel analysis.*

Methods. *A total of 1 002 schoolchildren were selected from 18 municipal districts by means of cluster sampling, from among 25 public and private schools in Piracicaba, São Paulo, Brazil, in 2005. Examinations were carried out by a single calibrated examiner utilizing the criteria of the World Health Organization, as well as the Community Periodontal Index. Social, economic, and behavioral variables were recorded with the use of a questionnaire and were used in the individual analysis (first level). The variables "percentage of heads of families without income" and "percentage of illiterate heads of families" were used in the contextual analysis (second level).*

Results. *A geographic information system was constructed for mapping the distribution of gingival bleeding. The variables were visually distinguished in the maps and demonstrated a tendency toward better gingival health in the central areas of the city, which are recognized as more privileged. On the contextual level, only the "percentage of illiterate heads of families" was significantly associated to gingival bleeding.*

Conclusions. *The study confirms better oral health status among schoolchildren from privileged families, but does not confirm the data regarding "income." The individuals from areas in which the heads of family did not have income were not associated to a higher prevalence of gingival problems. This suggests that these individuals are reasonably protected from the impact of social privation due to the actions of public health care services in the municipality.*

Key words Geographic Information Systems; gingivitis; preventive dentistry; oral health; Brazil.

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Studies on oral health have long kept their focus on the evaluation of individual factors in the determination of disease. However, such studies are limited with regard to the comprehension of the

complexity of real-life social processes (1). As our senses are not able to grasp the world in its totality, the construction of models that can explain reality is necessary. Maps constitute explanatory, representative models of the real world—more specifically, real space (2). Moreover, multilevel analysis can be employed to address the interrelationships between the environment and individuals through the simultaneous analysis of individual and contextual variables (3).

Geographic information systems (GIS) are used to aggregate and analyze variables necessary for ecological studies. This type of system recognizes the relationship between the distribution and impact of diseases in the spaces in which they occur. It also helps clarify phenomena that cannot be adequately visualized using data displayed in tables, thus reaffirming the relationship between epidemiology and cartography (4).

Isolated efforts have characterized the recognized centuries-long relationship between geography and human health. In the last 10 years, international interest in this relationship has been renewed in academic and health care management fields. Such interest stresses the positive, progressive impact of the use of spatial analysis in public health care, as well as the pertinence of a prudent, careful way of evaluating results (5).

The aim of the present study was to evaluate gingival status in 12-year-old schoolchildren in the city of Piracicaba using a GIS and multilevel analysis.

MATERIALS AND METHODS

Ethical aspects

This study received approval from the Research Ethics Committee of the Piracicaba Dental School, State University of Campinas (UNICAMP), Piracicaba, São Paulo, Brazil) (protocols #148/2003; #098/2006). Children were given an informed consent form to be taken home for their parent's signature; only those with signed forms were permitted to participate in the study.

Population data

The city of Piracicaba (São Paulo state, Brazil) has a population of 385 287 inhabitants, and a city area of 1 3 78 501 km^2. The Human Development Index (HDI) is 0.785 and monthly income per capita for the urban area population is around R$ 755 (approximately US$ 324) (6).

Questionnaire

Prior to the exams, a questionnaire addressing socioeconomic status and the child's behavioral habits was sent to the parents. The questionnaire consisted of items on monthly household income, number of people living in the household, home ownership, mother's education, father's education, car ownership, toothbrushing habits, and access to oral health care (7).

Sample size

The sample size was calculated based on a prior study (8), considering a statistical power of 0.80, significance level of 0.05, and odds ratio of 1.5. Cluster sampling was employed to select 1 100 student 12 years of age from public and private schools in 18 districts of the municipality of Piracicaba, São Paulo, Brazil, based on geographic location. The proportion between public and private schools in the municipality was taken into account. Twenty-five public and private schools took part in the present study and the sample was made up of 1 002 students (loss < 10%).

Context

The city has an Oral Health Program called "Sorria Piracicaba" ("Smile Piracicaba") for children of 0–10 years of age registered in public schools. Four times a year the children brush their teeth under supervision of dental hygienists or dentists from Brazil's Family Health Program, and receive oral hygiene kits with toothpaste, toothbrush, and floss. Furthermore, an educational program in oral health, recreational, theatrical activities, and presentations are provided. During the annual meetings, school teachers are given oral health training and education. The schoolchildren from the present study had received preventive care and oral health education in the years leading up to the study.

Piracicaba has two water treatment stations. Since 1971, the community water supply is fluoridated and the control of the optimum levels (0.6–0.8 ppm F, considering the highest temperature of 37.5°C and the lowest 18°C) are done by continuously monitoring the levels and making necessary adjustments when needed.

Exams

The exams were carried out by a single examiner who followed the criteria recommended by the World Health Organization (WHO) (9). The exams were conducted in an outdoor setting under natural light immediately after tooth brushing and flossing to remove dental biofilm, using a Community Periodontal Index (CPI) probe with a diameter of 0.5 mm (ballpoint). The students received a tooth brushing kit (a regular toothbrush, toothpaste, and floss) and performed the tooth brushing and flossing under the supervision of a dental hygienist.

The examiner was previously trained (calibrated) by a "gold standard" expert epidemiologist. The examiner was calibrated at the beginning of the 12-month study regarding gingival evaluation and dental caries diagnosis (10). The five calibration exercises (baseline 3, 6, 9, and 12 months) were performed during the exam of the schoolchildren, as well as the calculation of the agreement rate and Kappa statistics.

In the present study, approximately 10% of the sample was reexamined in order to determine intra-examiner reproducibility; the mean Kappa value for the periodontal exam was > 0.86.

The gingival status of the students was evaluated using the Community Periodontal Index (CPI) to detect gingival bleeding and dental calculus. Based on WHO criteria for individuals less than 20 years of age, only six index teeth (#16, #11, #26, #36, #31, and #46) were examined. Six sites were evaluated on each tooth. The periodontal pocket was not included in the evaluations due to the age of the individuals. The DMFS index (Decayed, Missing, and Filled surfaces of the tooth index) was used to evaluate dental cavities and the WHO criteria (9) was applied.

Data analysis

The presence or absence of bleeding sites and gingival calculus were used as dependent variables. The chi-square test was used to compare these variables to the dental caries index, socioeconomic, and behavioral variables. Multilevel statistical modeling was performed to identify variables associated with areas of

social privation on two levels—individual and contextual (districts) at a 5% level of significance. The socioeconomic and behavior variables were the independent variables for the individual level; for the contextual level, the following demographic variables were the independent variables: percentage of heads of families without income and percentage of illiterate heads of families. In the present study, areas with heads of family with no income (No. > 4) and percentage of illiterate heads of families (No. > 3) were considered social deprivation areas. The cluster variables were obtained from the Research and Planning Institute of Piracicaba (IPPLAP, Piracicaba, São Paulo, Brazil) (11). Odds ratios and respective 95% confidence intervals (95%CI) were estimated. Associations between the independent variables were evaluated in order to avoid the multicollinearity during the chi-square test. All the statistics were performed using SAS 9.1.2 (SAS Institute Inc., Cary, North Carolina, United States).

Spatial analysis

A GIS was constructed using the entire urban area of the municipality of Piracicaba, including a district 21.8 km from Piracicaba. Eighteen neighborhoods were sampled. The data were georeferenced using thematic maps. The system was constructed to map the data using ArcView 3.1 software (Environmental Systems Research Institute Inc., Redlands, California, United States). First, the districts were drawn with the aid of satellite photographs and maps of the municipality of Piracicaba. A georeferenced database was then created to construct the GIS (system composed of database, variables, themes, and maps). Areas at risk for gingival bleeding were identified and mapped. Due to low frequency of calculus in the present sample, the results were presented only in tables.

RESULTS

Associations were found in the present study between dental caries (DMFS Index) ($P < 0.0001$), monthly household income ($P < 0.0001$), father's education ($P < 0.0001$), mother's education ($P < 0.0001$), car ownership ($P = 0.027$), tooth brushing frequency ($P = 0.0305$), age at first tooth brushing ($P = 0.0046$), and absence or presence of gingival bleeding sites (Table 1).

TABLE 1. Bivariate analysis of the association between gingival bleeding sites and gender, socioeconomic characteristics, and behavioral variables related to the individual level (subjects), among students 12 years of age, from Piracicaba, Sao Paulo, Brazil, in 2005

Variable	IPC[a] no bleeding		IPC[a] bleeding		Non-adjusted Odds Ratio (95CI%)	*P*-value
	No.	%	No.	%		
Individual level:						
Gender						
Female	259	44.9	318	55.1	1.00	0.2610
Male	206	48.5	219	51.5	0.86 (0.67–1.11)	
DMFS index[b]						
= 0	338	63.6	194	36.4	1.00	< 0.0001
> 0	126	26.9	343	73.1	4.76 (3.63–6.23)	
People living in the household						
< 4 people	251	48.2	270	51.8	1.00	0.2304
> 4 people	209	44.4	262	55.6	1.16 (0.91–1.50)	
Monthly family income						
≤ 3 times minimum wage[c]	400	44.2	505	55.8	1.00	< 0.0001
> 3 times minumum wage	56	67.5	27	32.5	0.38 (0.24–0.62)	
Father's education						
Completed middle school	174	39.2	270	60.8	1.00	
Completed high school	129	53.8	111	46.2	0.55 (0.40–0.76)	< 0.0001
Completed college	76	58.9	53	41.1	0.45 (0.30–0.67)	
Mother's education						
Completed middle school	238	40.0	357	60.0	1.00	
Completed high school	154	54.0	131	46.0	0.57 (0.43–0.75)	< 0.0001
Completed college	67	59.9	45	40.2	0.45 (0.30–0.68)	
Visits to the dentist						
Never/irregularly	187	43.8	240	56.2	1.00	0.2251
Regularly	267	47.7	293	52.3	0.85 (0.66–1.10)	
Home ownership						
Yes	298	47.2	334	52.8	1.00	0.4982
No	164	44.9	201	55.1	1.09 (0.84–1.42)	
Car ownership						
No car	173	40.8	251	47.4	1.00	0.027
≥ 1	283	50.4	278	49.6	0.68 (0.52–0.87)	
Toothbrushing frequency						
≤ once/day	47	37.3	414	47.6	0.65 (0.45–0.96)	0.0305
≥ twice/day	79	62.7	456	52.4	1.00	
Onset of toothbrushing						
≤ 1 year old	389	48.6	412	51.4	1.00	0.0046
> 1 year old	71	37.2	120	62.8	1.60 (1.15–2.21)	

[a] IPC = Community Periodontal Index.
[b] Decayed, Missing, and Filled surfaces of the tooth index.
[c] Minimum wage at the time of the data collection (2005), approximately US$ 164.

The DMFS index was 1.88 for the overall sample, and 0.63 and 2.05 for private and public schools, respectively. Independent variables with a *P*-value < 0.15 were included in the multilevel model.

On the individual level, the schoolchildren with caries experience (presence of dental caries in the past, i.e., filled or missing teeth, and/or current presence of dental caries DMFS > 0 (Odds Ratio [OR] = 4.68; 95%CI = 3.53–6.20) and those who began tooth brushing at a later age (OR = 1.49; 95%CI = 1.04–2.14) had a greater chance of exhibiting gin-

gival bleeding sites. On the contextual level, only the variable "percentage of illiterate heads of families" was associated to gingival bleeding (Table 2).

There was a significant association between the presence or absence of sites with calculus and the following variables: gender (P = 0.030), visits to the dentist (P = 0.061), car ownership (P = 0.072), and home ownership (P = 0.050) (Table 3). To avoid multicollinearity in this data, an association analysis was performed and a highly significant association was found between car ownership and home ownership. Thus, only the latter was tested in the multivariate model (Table 3).

Calculus was associated to the variables "gender" (OR = 1.64; 95%CI = 1.04–2.58) and "home ownership" (OR = 1.76; 95%CI = 1.11–2.78) on the individual level (P < 0.05), whereas calculus was only associated to the variable "percentage of illiterate heads of families" on the contextual level (Table 4).

The maps allow the visualization of a tendency toward better oral health (lower scores of gingival bleeding) in the downtown area of the municipality, which is considered to be a privileged area with the highest percentage of individuals earning a higher income and more years of education (Figure 1). However, on the contextual level of the multilevel analysis, only "percentage of illiterate heads of families" was significantly associated to both outcomes, whereas "income" was not statistically associated to these oral heath problems.

DISCUSSION

Analysis of the social and spatial phenomena involved in the health and disease processes can be done in the more important ecological studies conducted in recent years. These phenomena are complex and methodological refining is needed not to simplify them, but reproduce the static, isolated notion of space (2).

The use of geoprocessing can identify relationships between the distribution of health problems and environmental conditioning factors by aggregating and mapping variables from different sources (4). Determining associations between space and health problems has been investigated in the non-dental literature (12, 13). In dentistry, however, studies on this subject are scarce (14).

A geographic vision is a key aspect in public health. The population and communities tend to have their own characteristics according to their geographical distribution. Factors that influence the health of a community are classified into four groups: inherited conditions; environment (air and water quality, soil characteristics, radiation, and socioeconomic conditions); lifestyle; and health care (15).

GIS provides a broad source of tools for exploring data. These systems can be defined as a set of tools for the acquisition, storage, retrieval, analysis, and interpretation of spatial data (16, 17). The incorporation of mapping revealed inequalities in relation to the oral health status in the municipality studied. This tool is useful for evaluating and easily visualizing the areas that should receive more attention from health care managers. GIS applied to track the oral health of a population has been extremely effective at revealing the distribution of oral health problems and assisting in the planning and evaluation of the effectiveness of tailored health promotion and preventive care in underprivileged areas (14, 18–21).

It should be stressed that oral health actions should be considered, discussed, and carried out by different sectors. Moreover, actions directed at oral health alone are unable to solve problems related to the distribution of disease. The territory is a reflection of the socioeconomic condition of its inhabitants and is influenced by social and political inequalities. Thus, a territory can adversely influence the health status of its inhabitants and perpetuate poverty (2).

In Brazil, as well as the municipality studied here, most of the individuals enrolled in public schools are from underprivileged families that live in areas of social deprivation and do not have financial resources to afford private school (7). These individuals are distinguished by having a greater number of caries and lower access to the health services (7, 21). Although social inequality in Brazil is evident (22, 23), especially the contrast between very wealthy families extremely poor families, and this inequality is visible in the data from the map constructed of the area studied (Figure 1)—this social difference is not always statistically significant from a geographical standpoint, as people with different socioeconomic levels often occupy the same area. It is possible to find rich and poor individuals living in the same geographical space due to fast urban growth, as well as the growth of inequality itself.

This complexity of social factors is related to oral health problems, which means that analysis and actions that respect this complexity are required. Careful analysis is, therefore, important and should unify all the tools that can clearly

TABLE 2. Multilevel model of logistic regression analysis of gingival bleeding sites among schoolchildren 12 years of age, Brazil, 2005

Variable	Estimate	Standard error (SE)	Adjusted odds ratio	95%CI[a]	*P*
Individual level:					
Bleeding					
Bleeding	0.77	0.07	4.68	3.53–6.20	< 0.0001
No bleeding	Reference				
Frequency of tooth brushing:					
≤ once/day	0.20	0.09	1.49	1.04–2.14	0.0303
≥ twice/day	Reference				
–2 loglikelihood (individual level)	1 203.48				
Contextual level:					
% Illiterate/cluster	0.10	0.03	0.11 (β)	0.04 (SE)	0.0081
–2 loglikelihood (full model)	1 157.98				

[a] Confidence interval.

TABLE 3. Bivariate analysis of the association between sites with calculus and gender, socioeconomic characteristics, and behavioral variables related to the individual level (subjects), Brazil, 2005

Variable	No calculus		Calculus		Non-adjusted odds ratio (95%CI)	*P*-value
	No.	%	No.	%		
Individual level:						
Gender						
Female	538	93.2	39	6.8	1.00	0.0307
Male	380	89.4	45	10.6	1.63 (1.04–2.56)	
DMFS index[a]						
= 0	487	91.4	46	8.6	1.00	0.7635
> 0	431	91.9	38	8.1	0.93 (0.60–1.46)	
People living in the household						
< 4 people	481	92.3	40	7.7	1.00	0.3471
> 4 people	427	90.7	44	9.3	1.24 (0.79–1.94)	
Monthly household income						
≤ 3 times the minimum wage[b]	825	91.2	80	8.8	1.00	0.2088
> 3 times the minimum wage	79	95.2	4	4.8	0.52 (0.19–1.46)	
Father's education						
Completed middle school	406	91.4	38	8.6	1.00	
Completed high school	220	91.7	20	8.3	0.97 (0.55–1.71)	0.8583
Completed college	119	92.2	10	7.8	0.90 (0.43–1.86)	
Mother's education						
Completed middle school	540	90.8	55	9.2	1.00	
Completed high school	261	91.6	24	8.4	0.90 (0.55–1.49)	0.2492
Completed College	107	95.5	5	4.5	0.46 (0.18–1.17)	
Visits to the dentist						
Never/Irregularly	383	89.7	44	10.3	1.00	
Regularly	521	93.0	39	7.0	0.65 (0.42–1.02)	0.0610
Home ownership						
Yes	587	92.9	45	7.1	1.00	0.0509
No	326	89.3	39	10.7	1.56 (0.99–2.45)	
Car ownership						
No car	381	89.9	43	10.1	1.00	0.0728
≥ 1	522	93.0	39	7.0	0.66 (0.42–1.04)	
Tooth brushing frequency						
≤ once/day	117	92.9	9	7.1	1.00	0.5769
≥ twice/day	795	91.4	75	8.6	1.23 (0.60–2.51)	
Onset of tooth brushing						
≤ 1 year old	736	91.6	65	8.1	1.00	0.5571
> 1 year old	173	90.6	18	9.4	1.17 (0.68–2.04)	

[a] Decayed, Missing, and Filled surfaces of the tooth index.
[b] Minimum wage at the time of the data collection (2005), approximately US$ 164.

explain health and disease processes in different populations. The application of geographical and multilevel analysis can offer more consistency and reliability to epidemiological data. The latest periodontal studies have used Multilevel Modeling (24), which results in a better comprehension of the structure of the complex data found in health, such as the complexity of the progression of periodontal disease and the factors predicting (25, 26) its impact on general health and the importance of surveillance regarding periodontal disease (26, 27).

Further studies that take geographical areas into account are needed in order to enhance the understanding of social inequalities in oral health and lead to the development of interventions for diminishing these inequalities. Progress in understanding the causes of social inequalities will remain limited unless there is a general change in the manner in which health is measured (28). This complexity was first recognized in the 1990s (29) by a study that considered caries to be a complex disease, with a number of social characteristics that may influence its distribution. This suggests that a detailed analysis of the data found in literature is necessary in order to identify groups that are more exposed to disease.

The present study used spatial analysis and statistical model analysis on multiple levels with the purpose of obtaining a better understanding of the data. Bivariate analysis (chi-square test) was used to determine associations between the variables studied (social, economic, and behavioral) and gingival and calculus status. From the data of this first analysis, multilevel models were constructed, in which only the variables that were associated to the outcomes were included. The mapping of the areas at risk for gingival problems was then carried out by means of a GIS.

From the data evaluated in the different analyses, social, economic, and behavioral variables are directly associated to levels of disease (chi-square test, Tables 1 and 3). This can be seen on the map (Figure 1), which shows a tendency toward better oral health in the privileged downtown areas. Regarding multilevel analysis, on the individual level, the experience with caries and age at first tooth brushing were associated to gingival bleeding, whereas gender and home ownership were associated to calculus. However, on the contextual level (districts), only the percentage of illiterate heads of families was statistically significant in both outcomes, and income was not associated with these oral health problems. These results suggest that individuals who live in places in which the percentage of illiterate heads of families is higher will have a greater proneness toward gingival problems (Tables 2 and 4). However, areas in which the income of the head of family is low were not associated to worse oral health status. This result disagrees with a large number of previous studies, which have found

TABLE 4. Multilevel model of logistic regression analysis of sites with dental calculus, Brazil, 2005

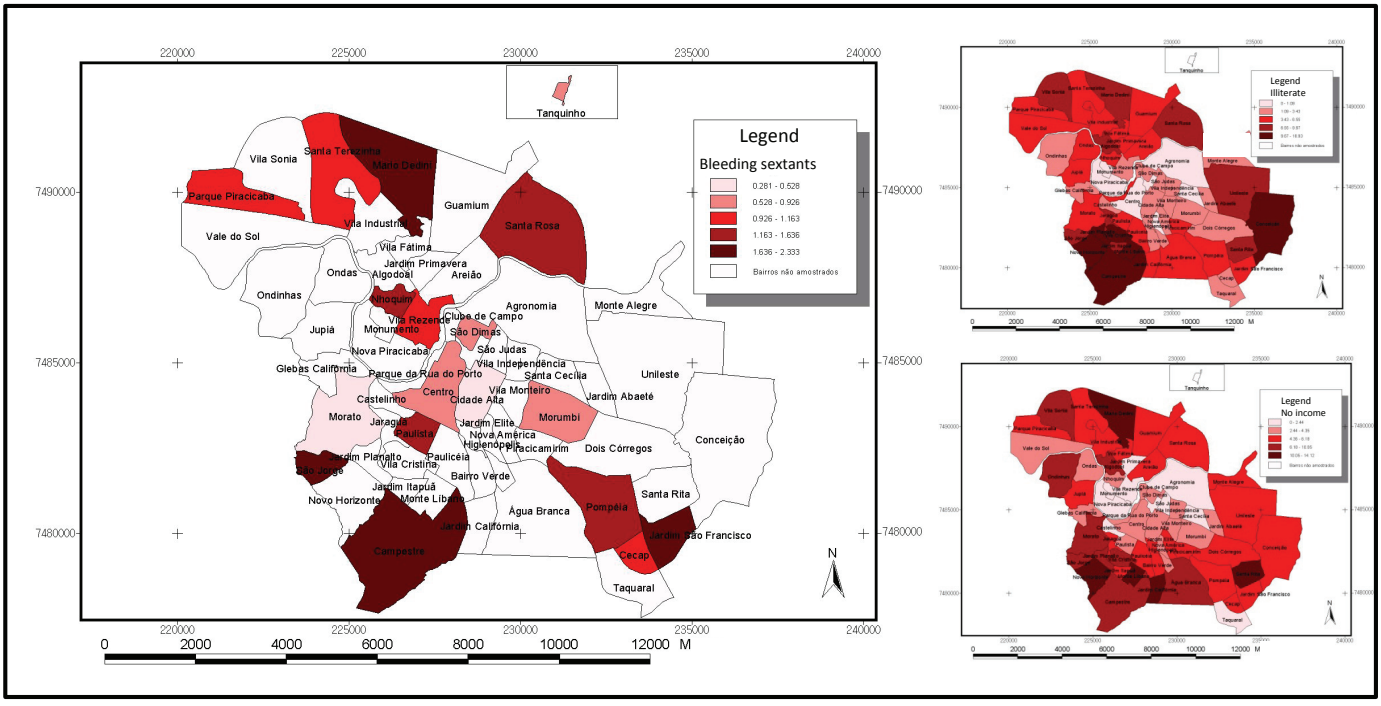
Variable	Estimate	Standard error (SE)	Adjusted odds ratio	95%CI[a]	*P*
Individual level:					
Gender					
Female	0.25	0.12	1.64	1.04-2.58	0.0387
Male	Reference				
Home ownership					
No	0.28	0.12	1.76	1.11-2.78	0.0264
Yes	Reference				
–2 loglikelihood (full model)	568.25				
Contextual level:					
% Illiterate/cluster	0.08	0.04	0.008 (β)	0.008 (SE)	0.3639
–2 loglikelihood (full model)	559.13				

[a] Confidence interval.

income to be a major factor of social deprivation and strongly associated to oral health problems, especially in Brazil (30–33). However, income alone is insufficient to test materialist theories regarding health inequalities (28).

This disagreement can be related to the presence of an oral health program directed at schoolchildren that involves a partnership between the dental school, a local company, city hall, and the state dentistry association. Treatment, along with preventive and educative measures, is offered to 5 000 students from the public schools administered by the local Board of Education of Piracicaba, São Paulo. The schoolchildren examined in the present study were enrolled in preventive and educational oral health programs during the years preceding this study. In addition, the community water supply has been treated with fluoride since 1971. These procedures reach the less privileged and minimize the impact of social and environmental factors on individuals. They help to reduce the existing differences regarding oral health between schoolchildren from low-income and high-income families. The study suggests that these individuals are reasonably protected from the impact of social deprivation by the municipality's public health care services and actions regarding the oral health prevention and treatment. The approach taken in the study reveals an understanding that certain socioeconomic inequalities may be sidestepped by means of oral health care programs that reach

FIGURE 1. Distribution of gingival bleeding among schoolchildren 12 years of age in the districts sampled; smaller maps contain demographic data of percentage of heads of families with no income and percentage of illiterate heads of families in the districts, Piracicaba, São Paulo, Brazil, 2005



Source: Research and Planning Institute of Piracicaba, Brazil.

the socially underprivileged. It is important to report the efforts of the public health care services in the municipality studied.

Study limitations

The results of the present study could be better explained by long-term prospective ecological studies in which there are a greater number of groups and individuals (3). An authentic causal relationship could only be confirmed by randomized, controlled, prospective studies (24) that test the predictive value of variables associated to gum disease and onset of lesions with the aim of finding viable mechanisms of disease surveillance (27). The distribution of disease is commonly determined by three pillars: person, time, and space (15, 34).

Another study limitation is that in some areas, the physical environment of the municipality does not present a clear division between the different social strata. Disorderly expansion of urban areas gives rise to areas where luxury condominiums coexist with areas of social deprivation. This panorama is still evolving; however, it can already be seen as a limitation of this study.

Conclusions

The present study confirms better oral health status among schoolchildren from privileged families, but it does not confirm data regarding the socioeconomic cluster variable "income." Individuals whose head of family had no income were not associated to a higher prevalence of gingival problems. From the findings of the present study, it is possible to conclude that, on the individual level, socioeconomic variables were associated with a higher prevalence of the gingival bleeding and calculus, but this relationship was not observed in the multilevel model. By means of multilevel analysis and the use of a geographic information system, it was possible to better evaluate oral health status and construct a panorama of this condition in a small area.

Conflict of interests. None.

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RESUMEN

Sistema de información geográfica y análisis de niveles múltiples: estado gingival en escolares de 12 años de edad en São Paulo, Brasil

Objetivo. Evaluar el estado gingival y la presencia de sarro en escolares de 12 años de edad mediante el empleo de un sistema de información geográfica y análisis de niveles múltiples.

Métodos. En el año 2005, se seleccionó a un total de 1 002 escolares de 18 distritos municipales mediante muestreo por grupos, con la participación de 25 escuelas públicas y privadas de Piracicaba, en el estado de São Paulo, Brasil. Un único examinador calibrado, que utilizó los criterios de la Organización Mundial de la Salud, así como el Índice Periodontal Comunitario, llevó a cabo los exámenes. Mediante un cuestionario, se registraron las variables sociales, económicas y conductuales, y estas se emplearon en el análisis individual (primer nivel). En el análisis contextual (segundo nivel), se utilizaron las variables "porcentaje de cabezas de familia sin ingresos" y "porcentaje de cabezas de familia analfabetas".

Resultados. Se construyó un sistema de información geográfica para elaborar mapas de la distribución de la hemorragia gingival. Los mapas, donde se pueden distinguir visualmente las variables, demostraron una tendencia hacia una mejor salud gingival en las zonas del centro de la ciudad, consideradas como privilegiadas. En el nivel contextual, únicamente el "porcentaje de cabezas de familia analfabetas" se asoció significativamente con el sangrado gingival.

Conclusiones. El presente estudio confirma una mejor salud bucodental en los escolares pertenecientes a familias privilegiadas, pero no confirma los datos en cuanto a "ingresos". Las personas residentes en zonas donde las cabezas de familia no tenían ingresos no presentaron una mayor prevalencia de problemas gingivales. Esto indica que estas personas, como consecuencia de las actividades de los servicios de atención de salud pública del municipio, están razonablemente protegidas de la repercusión de la privación social.

Palabras clave Sistemas de información geográfica; gingivitis; odontología preventiva; salud bucal; Brasil.