STELA MÁRCIA PEREIRA

O USO DOS SISTEMAS DE INFORMAÇÃO GEOGRÁFICA (SIGs) NA ODONTOLOGIA: APLICAÇÃO NO MUNICÍPIO DE PIRACICABA, SP

Tese apresentada à Faculdade de Odontologia de Piracicaba, da Universidade Estadual de Campinas, para a obtenção do Título de Doutor em Odontologia. Área de concentração em Saúde Coletiva.

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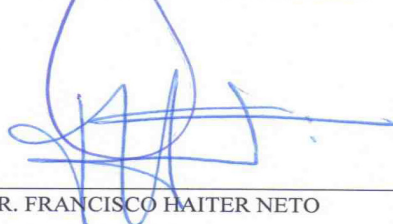
A Comissão Julgadora dos trabalhos de Defesa de Tese de DOUTORADO, em sessão pública realizada em 09 de Dezembro de 2008, considerou a candidata STELA MÁRCIA PEREIRA aprovada.

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Dê sempre o melhor...

E o melhor virá.

Às vezes as pessoas são egocêntricas,

ilógicas e insensatas...

Perdoe-as assim mesmo.

Se você é gentil, as pessoas podem

acusá-lo de egoísta e interesseiro...

Seja gentil assim mesmo.

Se você é um vencedor, terá alguns

falsos amigos e alguns inimigos verdadeiros...

Vença assim mesmo.

Se você é honesto e franco,

as pessoas podem enganá-lo...

Seja honesto e franco assim mesmo.

O que você levou anos para construir,

alguém pode destruir de uma hora para outra...

Construa assim mesmo.

Se você tem paz e é feliz,

as pessoas podem sentir inveja...

Seja feliz assim mesmo.

O bem que você faz hoje

pode ser esquecido amanhã...

Faça o bem assim mesmo.

Dê ao mundo o melhor de você,

Mas isso pode nunca ser o bastante...

Dê o melhor assim mesmo.

E veja você que, no final das contas,

é entre você e Deus...

NUNCA FOI ENTRE VOCÊ E ELES!

Seja Você Mesmo (Madre Tereza de Calcutá)

RESUMO GERAL

O presente estudo é composto por 2 artigos, tendo como principal objetivo avaliar o perfil de distribuição dos principais problemas bucais e suas associações com áreas de privação social em dois níveis, individual e contextual (territorial), por meio de um Sistema de Informação Geográfica (SIG) e análises Multiníveis. A amostra probabilística por conglomerados foi composta por 1002 escolares de 12 anos provenientes de 25 escolas públicas e privadas de Piracicaba, SP, em 2005-2006. Os exames foram realizados por um único examinador previamente calibrado, no pátio das escolas, sob luz natural, com os escolares sentados nas cadeiras e com escovação supervisionada realizada por THD, utilizando-se sonda periodontal (CPI) e espelho bucal plano, seguindo as recomendações da OMS. Um questionário semi-estruturado foi enviado aos pais para a obtenção das informações socioeconômicas e comportamentais individuais (primeiro nível). As variáveis contextuais "porcentagem de chefes de família sem renda e porcentagem de chefes de família analfabetos" foram usadas no nível contextual (segundo nível). Um SIG foi elaborado para a construção de mapas de distribuição das condições bucais, utilizando-se o software ArcView. **Artigo 1:** Os índices CPOD e o Índice de Cuidados (IC) foram considerados como desfechos. No nível individual, escolares com menor renda familiar mensal (OR=1,8;IC=1,0-3,6), maior número de pessoas morando na mesma casa (OR=1,4;IC=1,0-1,8), menos visitas ao dentista (OR=1,8;IC=1,3-2,4), menor nível educacional do pai (OR= 1,67;IC=1-3,33) e da mãe (OR=1,67;IC=1.1-1,25) tiveram mais chance de apresentar um CPOD maior. Indivíduos com maior renda familiar (OR=3.9,IC=0,84-17,9) e com mais visitas ao dentista (OR=4,7;IC=2,9-7,7) apresentaram um melhor IC. No nível contextual, áreas com maior privação social não foram associadas aos índices CPOD e IC, entretanto, é possível visualizar por meio dos mapas que os bairros centrais possuem melhores condições sociais e bucais que os bairros periféricos. No nível individual, as variáveis sociais foram relacionadas a uma maior prevalência da doença, contudo, esta relação não pôde ser observada em nível territorial. **Artigo 2:** Foram avaliadas as lesões iniciais não cavitadas (manchas brancas) e o Índice Periodontal Comunitário foi incluído. Foi possível observar por meio dos dados obtidos nas diferentes análises que as variáveis sociais, econômicas e comportamentais foram associadas aos

níveis dos problemas bucais no primeiro nível, podendo ser visualmente distinguidas nos mapas, apresentando uma melhor tendência de saúde bucal (menores escores de machas brancas e sangramento gengival) nas regiões centrais, consideradas como privilegiadas. Entretanto, no segundo nível (contextual) da análise multinível, somente a porcentagem de chefes de família analfabetos foi significante em ambos desfechos, enquanto a variável renda não foi significativa em relação a estes problemas bucais. O presente estudo confirma um melhor status de saúde bucal para escolares provenientes de famílias privilegiadas, mas não confirma os dados em relação à variável dos bairros renda (chefes de família sem renda). Os indivíduos vindos de áreas de chefes de família sem renda não são associados a uma maior prevalência de problemas bucais, sugerindo que estes estão relativamente protegidos do impacto da privação social, devido às ações de saúde bucal dos serviços públicos do município.

Palavras-Chave: Análise Espacial, Sistemas de Informação Geográfica, Saúde Bucal.

ABSTRACT

The present study was composed by 2 articles which aims were evaluate the distribution profile of oral health problems and its associations with areas of social deprivation at two levels, individual and contextual, by means of Geographic Information Systems (GIS) and multilevel analysis. The cluster sample consisted of 1002 12-year-old schoolchildren attending 25 public and private schools in Piracicaba, SP, Brazil in 2005-06. The examinations were carried out by a single calibrated examiner in outdoor settings, under natural light, using mirror and ball point probe. The examinations were executed after tooth-brushing and followed the recommendations of WHO. A semi-structured questionnaire was sent to the parents to collect information on socioeconomic level and behavior variables related to dental health (first level). The contexts variables "the percentage of heads of families without income" and "the percentage of illiterate heads of families" were used in the contextual level (second level). A GIS was elaborated for mapping the distribution of the oral health condition, using the ArcView software **Article 1:** The DMFT and Care Index (CI) were considered as dependent variables. At individual level, students with lower income (OR=1.8; CI=1.0-3.6), more people living in the household (OR=1.4;CI=1.0-1.8), lower visits to the dentist (OR=1.8;CI=1.3-2.4), lower father's (OR=1.7;CI=1.0-3.3) and mother's (OR=1.7;CI=1.0-3.3) educational level were more likely to present a higher DMFT. The individuals with higher income (OR=3.9; CI=0.8-17.9) and more visits to the dentist (OR=4.7;CI=2.9-7.7) showed best Care Index. At conglomerate level, areas with social deprivation were not associated with the DMFT and the CI indexes, however, by means of the maps, it is possible to visualize that the central districts have the best social and oral conditions than the outlying deprived districts. At individual level, social and economic variables were associated with a higher prevalence of the disease, however, this relationship was not observed at territorial level. **Article 2** Initials lesions and Community Periodontal Index were included. Variables can be visually distinguished in the maps, which show a upward tendency of oral health (less scores of initials lesions and gingival bleeding) in the central regions of the city, that are recognized as a privileged area. However, in the second level (contextual level) of the multilevel analysis, only the percentage of illiterate heads of families was statistically significant

associated to both outcomes, while the variable "income" was not associated to these oral health problems. The individuals from areas where the heads of family do not have income were not associated to a higher prevalence of oral health problems. This fact suggests that these individuals are reasonably protected of the impact of the social deprivation due to the actions of the health public services of the municipality regarding prevention and treatment of the oral health problems.

Key-words: Spatial Analyses, Geographic Information Systems, Oral Health.

SUMÁRIO

INTRODUÇÃO GERAL

É fato constatado em todo o mundo a redução da prevalência da cárie dentária (Vrbic, 2000; Pitts et al., 2002; Pieper & Schulte, 2004). O declínio da prevalência de cárie vem sendo acompanhado por mudanças ocorridas no padrão e na distribuição da doença (Pine et al., 2003). São observadas algumas conseqüências clínicas como a concentração das lesões em alguns dentes e superfícies (Burt, 1998), as mudanças na velocidade de progressão e no padrão da doença (Newbrun, 1992), assim como a formação de grupos de polarização, em que pequenas parcelas da população concentram a maior parte das necessidades de tratamento decorrentes da cárie (Powell, 1998; Tickle, 2002; Bratthall, 2000; Nishi, 2002; Tayanin, 2002).

A distribuição não uniforme da cárie dentária pode ser observada mesmo em países com baixa prevalência de cárie, cujos valores do CPOD são considerados muito baixos pela OMS (CPOD aos 12 anos ≤ 1,2) (Pitts et al., 2002). Adicionalmente, estudos vêm encontrando associações significativas entre variáveis sociais, econômicas, comportamentais e ambientais com a experiência de cárie para indivíduos e áreas privadas socialmente (Campus, 2001; Nicolau, 2005; Bower et al., 2007).

Paralelamente, muito tem sido discutido sobre as estratégias mais adequadas para minimizar a situação descrita acima (Burt et al., 1998; Tickle, 2002; Campus, 2003; Antunes, 2004). Durante muito tempo os estudos em saúde bucal mantiveram seu foco na avaliação dos efeitos de fatores individuais na determinação das doenças, tornando-se limitados quanto à compreensão da complexidade da vida real nos processos sociais (Newton & Bower, 2005).

Os modelos tradicionais de abordagem individual, que envolvem história passada de cárie, morfologia dental, composição da placa, composição salivar, educação e classe social, ainda são amplamente utilizados nos dias atuais. Entretanto, recentemente o resgate do papel do ambiente sociocultural na determinação das doenças tem sido discutido (Carvalho, 2005), mostrando interações entre o ambiente e desfechos em saúde. Batchelor & Sheiham (2002) salientaram que, em uma perspectiva de saúde pública, as estratégias preventivas para a cárie deveriam ser baseadas numa abordagem populacional. Dentro desse contexto, a estratégia populacional ou de área, destaca-se como um método alternativo de estudo. Além disso, é importante a identificação de grupos/áreas de risco de

cárie ou outros problemas bucais que tenham recebido comparativamente menor atenção (Ellwood, 1996), para que sejam alvos de esforços de educação em saúde e do oferecimento de serviços intensivos de saúde bucal (Petridou, 1996).

A abordagem contextual e de localização espacial dos eventos em saúde e os Sistemas de Informações Geográficas (SIG) vêm se tornando, aos poucos, mais freqüentes na área de saúde pública, apesar das dificuldades de sua implementação devido aos seus métodos e softwares de difícil utilização, além do desconhecimento por parte dos profissionais da área (Carvalho, 2005). Todavia, para um melhor entendimento do processo saúde-doença, é importante explorar as relações existentes entre o espaço e a saúde da comunidade. O espaço geográfico hoje é entendido como um ambiente ativo, receptor dos processos sociais e ativador destes processos (Moreira, 2007).

O uso desta metodologia para as áreas da saúde tem sido observado especialmente na área médica (Werneck et al., 2002; Caiaffa et al., 2005). Na Odontologia, os estudos são escassos, demonstrando resultados importantes para o planejamento em saúde pública (Antunes et al., 2002; Baldani et al., 2002). Adicionalmente, os indicadores geográficos são capazes de discriminar pequenas áreas com privação social (Ellwood, 1996), onde a redução da prevalência da cárie foi menor.

Assim, a complexidade das relações existentes entre fatores sociais, culturais, ambientais e as doenças, exige dos pesquisadores em saúde um maior detalhamento e medidas que reflitam e respeitem tal complexidade, unindo toda a gama de ferramentas que possam explicar de maneira mais clara o complexo processo saúde-doença em diferentes populações. A utilização de ferramentas que possam explicar esses processos, bem como instrumentos que facilitem a percepção e visualização dessas relações, é essencial aos estudos. O emprego de mapas de risco, concomitantemente ao uso de dados mais alinhados, poderiam ser ferramentas de fácil identificação e imediata compreensão das áreas geográficas onde há uma maior ocorrência e severidade dos problemas, servindo de subsídios para o planejamento, organização e o monitoramento dos programas de saúde.

Em relação à referida tecnologia espacial/ mapeamento, destacam-se os SIGs, como um instrumento composto por tecnologia de análise e mapeamento que reserva uma larga quantidade de informações para serem visualizadas e analisadas dentro de um contexto geográfico. Os SIGs são capazes de unir grandes quantidades de dados espaciais

geográficos, bem como associar dados não-geográficos com dados geográficos como, por exemplo, informações geográficas e níveis de exposição ambientais (Vine et al., 1997), abrangendo o desenvolvimento e aplicação de métodos científicos para resolver problemas sociais (Maheswaran & Craglia, 2004).

Outro fator importante a ser abordado e associado ao uso dos Sistemas de Informação Geográfica é o papel das análises de regressão em múltiplos níveis ou multiníveis em estudos recentes (Bower et al., 2007; Turrell et al., 2007). Esta análise traz uma avaliação mais fidedigna das relações entre o ambiente e os indivíduos, não os separando totalmente como as análises mais comuns normalmente o fazem. Leva em consideração os dois níveis considerados, indivíduos e dados contextuais (cluster), combinando-os com o intuito de minimizar as discrepâncias entre variáveis que foram coletadas dos indivíduos (num primeiro nível) e as variáveis de todo o contexto onde esses grupos estão inseridos.

Seguindo estes preceitos, é essencial que os estudos ecológicos passem a utilizar não somente estas ferramentas de alta tecnologia, mas também a analisar os dados de maneira a contemplar o intrincado processo entre indivíduo e ambiente, levando-se em conta a hierarquia de complexidade e as múltiplas interações entre os diferentes níveis estudados, vislumbrando a impossibilidade de se separar o indivíduo de seu território (Moreira, 2007). A utilização dos SIGs juntamente com as análises Multiníveis, que respeitam as interrelações existentes entre o ambiente e os indivíduos, constituem-se de análises detalhadas que reproduzem a complexidade dos processos existentes entre indivíduos e o espaço onde vivem (Moreira, 2007).

Os esforços isolados têm caracterizado secularmente a reconhecida relação entre geografia e saúde humana. Na última década foi renovado o interesse internacional em estudar essas relações, tanto dentro do âmbito acadêmico, como na gestão do setor da saúde, destacando o impacto progressivo positivo do emprego da análise espacial na saúde pública, bem como a pertinência de uma forma prudente e cuidadosa na avaliação dos seus resultados (Rojas & Barcellos, 2003).

Os progressos no sentido de uma total compreensão das causas das desigualdades sociais em saúde serão limitados até uma mudança generalizada na maneira em que a saúde

é medida (Sisson, 2007). Neste contexto, o emprego de tecnologias que possam auxiliar a epidemiologia permitiria um maior avanço desta ciência no enfrentamento das doenças.

PROPOSIÇÃO

O presente estudo foi realizado em formato alternativo conforme deliberação da Comissão Central de Pós-Graduação (CCPG) da Universidade Estadual de Campinas – UNICAMP n°001/98 e foi composto por 2 capítulos, cujos objetivos são:

CAPÍTULO 1**: Geographic Information Systems and Multilevel Analysis in Assessing Dental Health**

Objetivo: avaliar o perfil de distribuição da cárie dentária e suas associações com áreas de privação social em dois níveis, individual e determinantes sociais dos bairros, por meio de um Sistema de Informação Geográfica (SIG);

CAPÍTULO 2: **Gingival Status and Initials Lesions: Geographic Information Systems and Multilevel analysis.**

Objetivo: avaliar as condições gengivais de indivíduos de 12 anos usando um Sistema de Informação Geográfica (SIG) e análise multinível.

Geographic Information Systems and Multilevel Analysis in Assessing Dental Health (submetido ao periódico Journal of Public Health Dentistry)

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ABSTRACT

Objectives: To evaluate the distribution profile of dental caries in 12-year-old schoolchildren and its associations with areas of social deprivation at two levels, individual and social determinants of clusters, by means of Geographic Information Systems. **Methods:** The cluster sample consisted of 1002 12-year-old schoolchildren attending 21 public and private schools in Piracicaba, SP, Brazil in 2005-06. Data on dental caries were collected by a single calibrated examiner, in accordance with the WHO recommendations. The DMFT and Care Index were considered as dependent variables. At contextual level the following variables were studied: percentage of heads of families receiving no income and percentage heads of families that were illiterate. At individual level, socioeconomic and behavioral data were used. The maps were constructed using the ArcView software. **Results:** At individual level, students with lower income (OR=1.8; CI=1.0-3.6), more people living in the household (OR=1.4;CI=1.0-1.8), lower visits to the dentist (OR=1.8;CI=1.3-2.4), lower father's (OR=1.7;CI=1.0-3.3) and mother's (OR=1.7;CI=1.0-3.3) educational level were more likely to present a higher DMFT. The individuals with higher income (OR=3.9; CI=0.8-17.9) and more visits to the dentist (OR=4.7;CI=2.9-7.7) showed best Care Index. At conglomerate level, areas with social deprivation were not associated with the DMFT and the Care Indexes, however, by means of the maps, it is possible to visualize that the central districts have the best social and oral conditions than the outlying deprived districts. **Conclusions:** At individual level, social and economic variables were associated with a higher prevalence of the disease, however, this relationship was not observed at territorial level.

Key-words: Spatial Analyses, Geographic Information Systems, Dental Caries.

INTRODUCTION

For a better understanding of the oral health-disease process, it becomes interesting to explore the relationships established between space and Community Health. Today, geographic space is understood as an active environment, receptor of social processes and activator of these processes (1). Detailed analysis of the pattern of inequality and spatial distribution of oral diseases is fundamental for the allocation of resources to areas with the greatest social privation, leading to greater efforts to address the problems (2).

Within this new approach, Geoprocessing tools have appeared, among them the Geographic Information Systems (GIS) are outstanding as valuable technology in the exploration of these relationships, contributing to a better understanding between the environment and health (3), at the same time in which they provide health services with rapid understanding of the locations where the problems occur with greater frequency, facilitating the continuous process of planning, monitoring and evaluating the oral health services.

There has been a great deal of discussion about the most adequate strategies for evaluating and intervening in the process of inequality in the distribution of oral diseases observed all over the world (4-6), with emphasis on the populational approach, whose fundamental principle is to rescue the role of the sociocultural environment in the distribution and determination of diseases; and approach that has generated great interest among researchers (7). Recent studies have shown the importance of the use of Geographic Information Systems (GIS) in this type of strategy, as a method increasingly accepted and used in epidemiological studies, bringing important information as regards analysis of the geographic distribution of diseases, their associations with social, economic and

environmental factors, and pathogenic agents, as well as elucidating the mechanisms of diseases (8,9). GISs are still a method infrequently used in public health, and even more rarely in dental studies, however, the method has attained an outstanding place among professionals in the area due to the innovative information it can offer as regards understanding, planning, monitoring and allocation of resources in health.

According to these precepts, it becomes important for these studies to begin to use not only these high technology tools, but also to analyze the data in order to contemplate the intricate process between the individual and the environment, taking into account the hierarchy of complexity and multiple interactions among the different levels studied, conjecturing the impossibility of separating the individual from its territory (1).

Thus the aim of this study was to evaluate the distribution profile of dental caries and its associations with areas of social deprivation at two levels, individual and social determinants of clusters, by means of Geographic Information Systems.

METHODS

Ethical Aspects

This study was approved by the Research Ethics Committee of the Piracicaba Dental School, State University of Campinas/ UNICAMP (protocol: 098/2006).

Sample

To calculate the sample size the data of a previous study conducted in the municipality (10) were considered, admitting a sampling error of 7%, level of confidence of 95% and design error equal to 2. The schools were selected by means of probabilistic

sampling by cluster. The sample was composed of 1002 schoolchildren aged 12 years, enrolled at 21 public and private schools in the municipality, distributed throughout 18 districts.

Exams

All exams were carried out by only one previously calibrated examiner (Kappa>0.89). The entire examiner calibration process was conducted by a standard examiner (Gold Standard) experienced in epidemiological surveys, and the theoretical-practical activities of the training exercises consisted of a total of 7 periods of 4 hours. Ten percent of the sample was reexamined to calculate the intra-examiner error in the second calibration period after the interval of one day.

The exams were conducted in accordance with the recommendations of the World Health Organization for the codes and criteria (11). All schoolchildren received a brush kit, containing toothbrush, toothpaste and dental floss, and were instructed during tooth brushing by a Dental Hygienist. Exams were performed in outdoor setting, with individuals seated on chairs, under natural light, use of a ball point probe, oral mirror, and with aid of air-drying using a portable mini-compressor.

Indexes and variables used

The DMFT Index (number of decayed, missing and filled teeth) was used for dental caries, and the Care Index, to measure access to dental services, by the equation: (FT/DMFT) x 100 (12). The following were considered as independent variables at the first individual level: monthly family income, people living in the household, home ownership, Car ownership, father's and mother's educational levels, oral hygiene habits and visits to

the dentist, obtained by means of a previously validated semi-structured questionnaire (10). The variables percentage of heads of families without income, and percentage of illiterate heads of families, were used as variables of the clusters.

Data Analysis

Univariate analysis was used to verify the influence of the socio-economic and behavioral variables on oral health using the Chi-square test ($\chi2$) at 5% level of significance. The goal of multilevel regression analysis was to identify variables that would be associated with areas of social privation at two levels, individual and contextual (Districts). In this analysis, the "DMFT Index" and "Care Index" were considered as response-variables; as demographic variables of the cluster "the percentage of heads of families without income" and "the percentage of illiterate heads of families" were considered, and as variable of individuals, the socio-economic and behavioral information was used. The purpose of the multilevel analysis was to minimize the discrepancies between the variables of the individuals (at the first level) using the residue of this first level to evaluate contextual variables (of the districts). By means of the multilevel regression model, the odds ratios and their respective intervals of confidence of 95% were estimated. The DMFT Index (dependent variable) was dichotomized according to the median (Med=0) and the Care Index was dichotomized according to the tercile. In addition, a Spearman Correlation was performed between income (level of subjects) and the variables of the clusters. All statistical tests were performed using the SAS software.

For spatial analysis the Geographic Information Systems were set up, the thematic maps being constructed with the aid of ArcView 3.1 Software.

RESULTS

The results of the present study, by means of analysis of the DMFT Index, demonstrated that the lower the illiteracy indexes, the lower the rates of "percentage heads of families receiving no income" the less was the severity of caries disease (Table 1).

In Table 2, gender, income, people living in the household, father's and mother's educational level, visits to the dentist and car ownership variables presented association with the DMFT Index (p<0.15) and were tested in the multilevel model. As regards the analysis of the dependant variable Care Index (Table 2), the following variables were significantly associated: income, people living in the household, father's and mother's educational level, visits to the dentist, home ownership, tooth brushing frequency, car ownership and onset of tooth brushing (p<0.15). These variables were tested in the respective multilevel analyses.

In the Multilevel Regression Analysis, at "individual level", students with lower income (OR=1.8; CI=1.0-3.6), more people living in the household (OR=1.4; CI=1.0-1.8), lower number of visits to the dentist (OR=1.8; CI=1.3-2.4), father's (OR=1.7; CI=1.0-3.3) and mother's (OR=1.7; CI=1.1-1.3) lower educational level were more likely to present a higher DMFT (Table 3). The individuals with higher income (OR=3.9; CI=0.8-17.9) and more visits to the dentist (OR=4.7; CI=2.9-7.7) showed the best Care Index (table 4). At conglomerate level, areas with social deprivation were not associated with the DMFT and the Care Indexes (Tables 3 and 4). In addition, a Spearman Correlation was performed between income (individual level) and the variables that characterized the clusters. Correlation was observed between the percentage of heads of families receiving no income

and percentage of heads of families that were illiterate ($p < 0.0001$), whereas with regard to income (variable of subjects) this correlation could not be observed ($p = 1.0000$).

In Figure 1, which presents the maps related to the DMFT Index (larger map), and in relation to the variables percentage of heads of families receiving no income and percentage of heads of families that were illiterate, presented in the smaller maps, it is possible to observe that the central districts have better social and oral conditions, however, it is important to point out that this difference was not significant in the Multilevel analysis. In a similar manner, Figure 2 presents the maps related to the Care Index (larger map), and the variables of the clusters percentage of heads of families receiving no income and percentage of heads of families that were illiterate (smaller maps), and it is possible to note a similar trend, in which the best conditions are visualized in the central areas, however, this condition was also not significant. The smaller maps containing the information related to the social context (variables of the clusters) were included in the figures that contain the maps with information about oral health with the purpose of facilitating understanding and comparison of the two levels studied (contextual and individual).

DISCUSSION

The spatial location approach to events in health and the Geographic Information Systems have become increasingly frequent in the public health area, in spite of the difficulties of implementing them, due to their methods and software being difficult to use being unknown to the professionals in the area (7). Initially, it is important to define the basic terminology more commonly used, in order to understand it better. Data Geoprocessing involves the entire process, starting with data collection through to making

the maps. Whereas, a Geographic Information System can be defined as a computational system provided with four groups of aptitudes to work with georeferenced data input, management, manipulation and analysis, and output (13).

The use of spatial methodology for health areas has been observed especially in the medical area (14-17). In Dentistry, studies are recent and have demonstrated important results for public health planning (2,18). Furthermore, geographic indicators are capable of discriminating small areas of social privation (19), in which the reduction of caries prevalence was lower.

The distribution of dental caries in the municipality, by means of maps, follows the same distribution trend as the social and economic variables previously observed. (Fig.1). The more central districts have better oral health conditions, which can be observed both for the DMFT Index (Fig 1.), and the Care Index (Fig. 2). Although this information is capable of being observed in the maps, the multilevel analysis did not show that there was any significant association between oral conditions and the characteristics of the clusters in the present study.

In the dentistry literature studies that use spatial analysis are scarce, nevertheless, the findings of the present study corroborate the study of Antunes (6) conducted in the city of São Paulo, which found high levels of dental caries in areas of social privation (outlying deprived areas), while the individuals that were at lower risk occupied the central portion of the municipality, and the same occurred as regards the treatment requirements, in which the greatest necessities were verified in the (outlying) deprived areas. Nevertheless, it is important to point out that the study Antunes (6) was developed in São Paulo, which is the largest city in Brazil, concentrating around 11 million inhabitants, while Piracicaba has

around 360 thousand resident inhabitants (20). The differences as regards the number of inhabitants and extent of the municipalities are discrepant, however, the non-uniform distribution profile of the disease observed all over the world (21) occurs in a similar manner. These findings support the discussions related to heterogeneity of the oral manifestations and support the planning of actions in other municipalities.

Another important aspect is the role of Multilevel Regression analysis in recent studies (22, 23). This analysis provides a more faithful analysis of the relationships between the environment and individuals, not separating them completely as the commoner analyses normally do. The analysis referred to takes into consideration the two levels considered: individuals and contextual data (cluster), combining them with the purpose of minimizing the discrepancies among the variables that were collected from the individuals (at a first level) and the variables of the entire context in which these groups are included.

Concomitantly with the reduction in the prevalence of dental caries, the growing social inequality of the distribution of the disease has become clearer (24). This process is known as "polarization" of the disease, in which small portions of the population concentrate the greater part of the disease, which is normally recognized as socially deprived population groups.

Studies directed towards delimitation of the areas of greater risk for diseases and treatment needs involving, in addition to clinical variables, socio-economic, behavioral and geographic characteristics, would be extremely important to public health services, in order to optimize the allocation of financial and human resources. In addition to the importance of mapping to analyze the distribution of diseases and their possible associations with environmental variables, the risk map would be a tool enabling easy identification and

immediate understanding of the geographical areas where there is greater and more severe occurrence of health problems, and it would also be valuable to the public health services for obtaining subsidies to organize health programs.

In this sense, in "spatialization" of the oral health-disease process, the Public Health Services could find a relationship between occurrences and determinants, and adopt epidemiology as a privileged referential in the study of this relationship (1).

The limitation of the present study is that in some areas, the physical environment of the municipality does not present a clear division between the different social strata, therefore, it runs into situations and realities that are common in present times, in which disorderly expansion of urban areas gives space to a mixture of realities. Luxury condominiums can easily be seen among areas of social privation. In Brazil, this is an increasingly common scenario. As regards the municipality of Piracicaba, this panorama is still being molded, however, it can already be seen as a limitation of this study, since some of the elite areas studied were mixed in with outlying deprived areas of the municipality, there being no distinction between their boundaries. In other words, the contextual data attributed to an elite cluster by the municipal authorities (25), also includes individuals of an inferior socio-economic level. The non-association between socially private areas and the oral health conditions can be a reflection of this situation.

The findings demonstrated a univariate association between socio-economic variables and the educational level of the parents and oral health, but did not demonstrate association between the private areas and the oral conditions in the multilevel model. In a similar manner, a study conducted in Scottish adults (22) did not find a significant association between the deprivation area and the oral health of adults, suggesting further

multilevel research exploring the relationship between deprivation area and oral health using a much higher number of participants and geographic areas in a prospective longitudinal design.

Seeking to explore and understand these relationships a little better, a correlation analysis was performed between the variables of the clusters and the variable of the first level (subjects) income. It was verified that the variables correlated with the clusters - percentage of heads of families receiving no income and percentage of heads of families that were illiterate – were statistically association, whereas with regard to income (subject variable) this correlation could not be observed. These data reinforce the hypothesis that the variables of the districts are not statistically related to the oral health conditions in the municipality, in spite of visualization of the maps showing differences between areas with social privation and those without social privation. On the other hand, the variable income (subject level) was shown to be a strong indicator of risk for dental caries, which evidences the previous discussion, demonstrating that today, various realities occupy the same space, and consequently, families from different income levels live in the same districts. By means of the present study, it is possible to conclude that at individual level, social and economic variables were associated with a higher prevalence of the disease; however, this relationship was not observed at territorial level.

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Table 1. Frequency of the DMFT Index and Care Index (mean, standard deviation and median) as a function of the type of school and districts.

School	District	% No income	% Illiterate	DMFT Mean (SD)	Median	Care Index Mean (SD)	Median
Private	V.Rezende	2.15	2.06	0.12 (0.33)	0.00	100.00 (0.00)	100.00
	Alto	2.95	1.64	0.48 (0.75)	0.00	85.71 (37.80)	100.00
	S. Dimas	2.77	2.21	0.94 (1.32)	0.00	100.00 (0.00)	100.00
	Morato	7.54	5.95	0.47 (1.02)	0.00	100.00 (0.00)	100.00
	Centro	3.29	0.75	0.55 (0.69)	0.00	80.00 (44.72)	100.00
Public	S.Francisco	5.73	5.63	1.09 (1.59)	0.00	67.65 (40.06)	90.00
	S.Rosa	5.81	7.69	1.67 (1.96)	1.00	67.94 (38.98)	80.00
	V.Rezende	2.15	2.06	1.17 (2.06)	0.00	79.29 (35.38)	100.00
	Alto	2.95	1.64	1.28 (1.68)	0.00	75.36 (37.35)	100.00
	CECAP	5.42	3.05	1.19 (1.62	1.00	68.94 (42.50)	100.00
	Nho Quim	4.08	4.06	1.43 (1.60)	1.00	68.44 (44.36)	100.00
	Morumbi	4.24	2.92	1.09 (1.51)	0.00	64.44 (43.01)	75.00
	S.Jorge	7.76	9.66	1.09 (1.89)	0.00	47.03 (47.31)	45.00
	S.Dimas	2.77	2.21	0.91 (1.47)	0.00	88.63 (26.53)	100.00
	B.Lenheiro	13.55	7.77	1.00 (1.50)	0.00	59.71 (46.79)	80.00
	Tanquinho	-	-	2.33 (1.69)	2.00	88.26 (29.95)	100.00
	Campestre	8.47	11.62	1.96 (1.70)	2.00	86.38 (32.26)	100.00
	S.Terezinha	6.18	6.55	1.29 (1.53)	1.00	84.14 (28.82)	100.00
	Paulista	3.14	4.72	1.46 (1.76)	1.00	82.73 (36.68)	100.00
	Pompéia	5.72	4.80	2.78 (3.32)	2.00	77.97 (37.40)	100.00
	P.Piracicaba	6.04	5.42	1.26 (1.91)	0.00	65.29 (44.15)	100.00

Table 2. Univariate analysis of the association between DMFT (dichotomization by the median) and gender, socio-economic characteristics and behavioral variables related to DMFT and Care Index at the first level (subjects).

Variable	DMFT=0 n (%)	DMFT>0 n(%)	p-value	CI# ≤75% n (%)	CI# >75% n (%)	p-value
First level: subjects						
Gender						
Female	289 (50.09%)	288 (49.91%)	0,0216	88 (30,56)	200 (69,44)	0,6427
Male	244 (57.41)	181 (42.59%)		59 (32,60)	122 (67,40)	
Monthly family icome						
up to 3 minimum wages*	463 (51,16%)	442 (48,84%)	0,0002	144 (32,58)	298 (67,42)	0,0495
> 3 minimum wages	60 (72.29%)	23 (27.71%)		3 (13.04)	20 (86.96)	
People living in the household						
≤ 4 people	291 (55.85%)	230 (44.15%)	0.0700	61 (26.52)	169 (73.48)	0.0195
> 4 people	236 (50.11%)	235 (49.89%)		86 (36.60)	149 (63.40)	
Father's education						
Complete middle-school	200 (45.05%)	244 (54.95%)	<0.0001	84 (34.43)	160 (65.57)	0.0503
Complete high school	143 (59.58%)	97 (40.42%)		23 (23.71)	74 (76.29)	
Complete undergraduate	89 (68.99%)	40 (31.01%)		8 (20.00)	32 (80.00)	
Mother's education						
Complete middle-school	283 (47.56%)	312 (52.44%)	<0.0001	108 (34.62)	204(65.38)	0.0172
Complete high school	175 (61.40%)	110 (38.60%)		31 (28.18)	79(71.82)	
Complete undergraduate	69 (61.61%)	43 (38.39%)		6 (13.95)	37(86.05)	
Visits to the dentist						
Never/Irregularly	246 (57.75%)	180 (42.25%)	0.0060	91 (50.56)	89 (49.44)	<0.0001
Regularly	274 (48.93%)	286 (51.07%)		55 (19.23)	231 (80.77)	
Home ownership						
Yes	345 (54.59%)	287 (45.41%)	0.2341	83 (28.92)	204 (71.08)	0.1329
No	185 (50.68%)	180 (49.32%)		64 (35.56)	116 (64.44)	
Car ownership						
No car	202 (47.64%)	222 (52.36%)	0.0034	81 (36.49)	141 (63.51)	0.0214
≥ 1	320 (57.04%)	241 (42.96%)		64 (26.56)	177 (73.44)	
Toothbrushing frequency						
≤ once/day	65 (51.59%)	61 (48.41%)	0,7136	26 (42,62)	355 (57,38)	0,0401
> twice/day	464 (53.33%)	406 (46.67%)		120(29.56)	286 (70.44)	
Onset of toothbrushing						
≤ 1 year old	432 (53.93%)	369 (46.07%)	0.2966	107 (29.00)	262 (71.00)	0.0174
>1 year old	95 (49.74%)	96 (50.26%)		40 (41.67)	56 (58.33)	

* Minimum wage at the time of the data collection, approximately US$163.55
Care Index

Table 3. Multilevel logistic regression model with DMFT as dependent variable

	Estimate	SE	Adjusted OR	95%CI	p
First level: subjects					
Monthly family icome:					
up to 3 minimum wages	0.3229	0.1602	1.8	1.0-3.6	0.0313
> 3 minimum wages	Reference				
People living in the household:					
> 4 people	0.1547	0.0756	1.4	1.0-1.8	0.0344
≤ 4 people	Reference				
Father's education :					
Complete middle-school	-0.3410	0.1924	0.7	0.5-1.05	0.0763
Complete high school	-0.5466	0.2824	0.6	0.3-1.0	0.0532
Complete undergraduate	Reference				
Mother's education:					
Complete middle-school	-0.4706	0.1947	0.6	0.4-0.9	0.0157
Complete high school	-0.1688	0.2899	0.8	0.5-1.4	0.5604
Complete undergraduate	Reference				
Visits to the dentist:					
Never/Irregularly	0.2860	0.0792	1.8	1.3-2.4	0.0003
Regularly	Reference				
-2 loglikelihood (first level)	1015.528				

	Estimate	SE	β	p	
Second level: districts					
% No income/cluster	0.00876	0.0516	-0.0580	0.8651	
% Illiterate/cluster	-0.0445	0.0504	0.1259	0.2027	
-2 loglikelihood (full model)	1044.459				

Table 4. Multilevel logistic regression model with Care Index as dependent variable

	Estimate	SE	Adjusted OR (IC>75%)	95%CI	P
First level: subjects					
Monthly family icome					
up to 3 minimum wages	Reference				
> 3 minimum wages	0.6799	0.3902	3.9	0.84-17.9	0.0601
Visits to dentist:					
Never/Irregularly	Reference				
Regularly	0.7794	0.1229	4.7	2.9-7.7	<0.0001
-2 loglikelihood (first level)	577.178				

	Estimate	SE	β	P	
Second level: clusters					
% No income/cluster	-0.3049	0.1705	-2.0138	0.0960	
% Illiterate/cluster	0.1606	0.1705	-0.2533	0.3492	
-2 loglikelihood (full model)	554.191				

Fig1. Distribution of the DMFT Index in the sampled districts. Smaller maps containing the demographic data of percentage of heads of families receiving no income and percentage of heads of families that was illiterate in the districts (IPPLAP – Research and Planning Institute of Piracicaba)
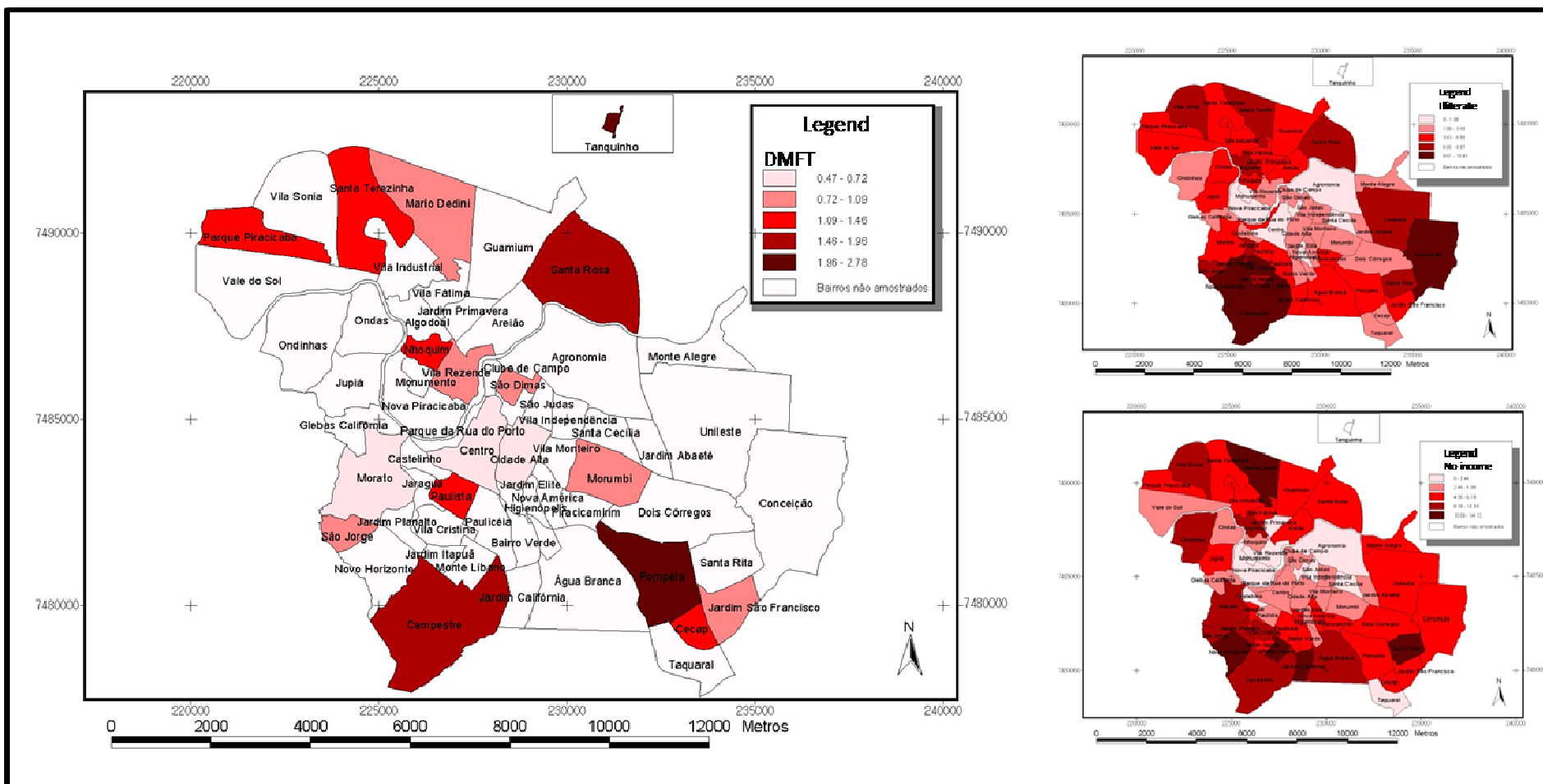
Fig2. Distribution of the Care Index in the sampled districts. Smaller maps containing the demographic data of percentage of heads of families receiving no income and percentage of heads of families that was illiterate in the districts (IPPLAP – Research and Planning Institute of Piracicaba)
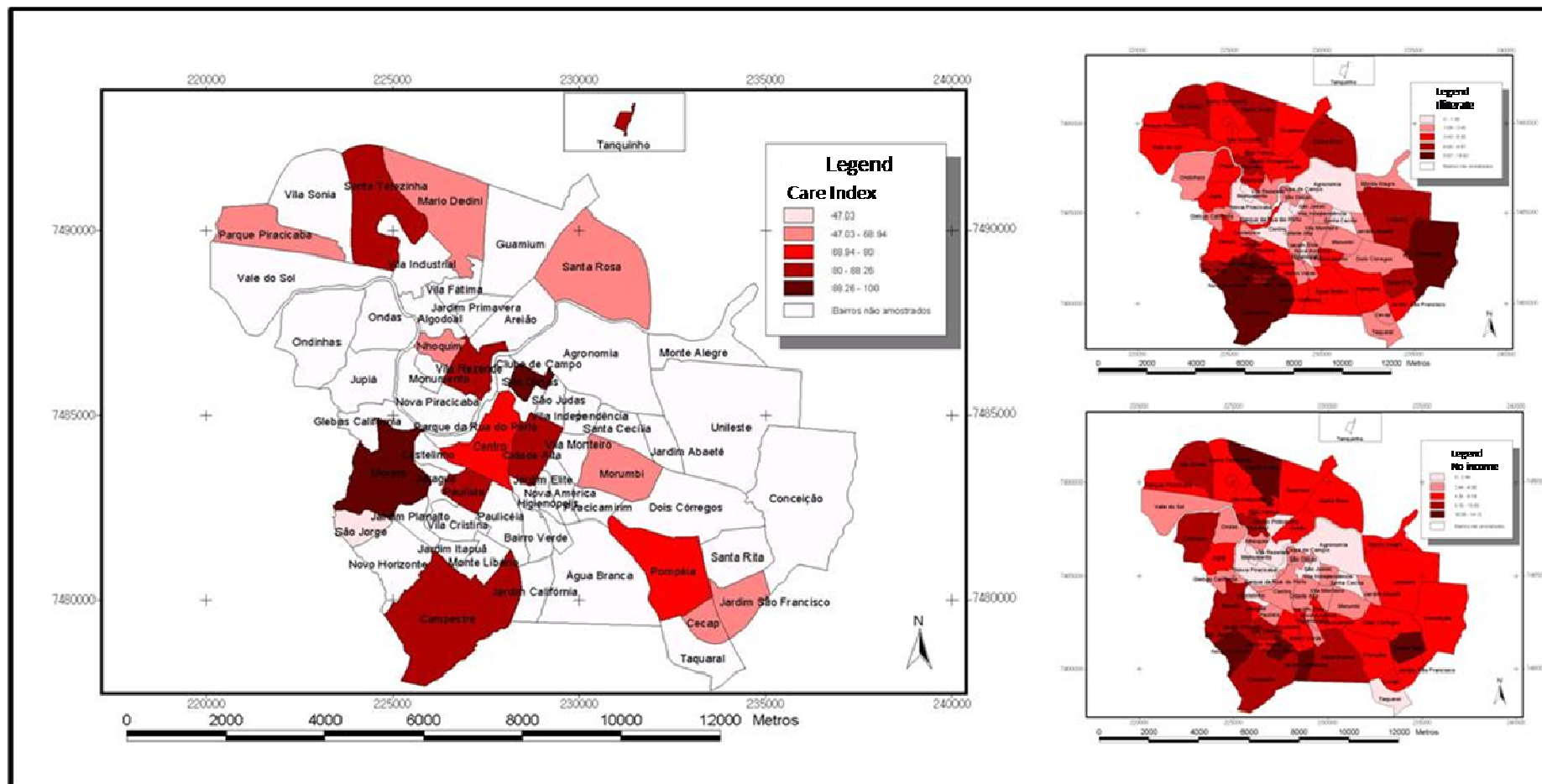
Geographic Information Systems and Multilevel analysis: Gingival Status in 12-year-old schoolchildren

(artigo submetido ao periódico Journal of Periodontology)

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ABSTRACT

The aim of the present study was to evaluate the gingival status in 12-year-old schoolchildren using Geographic Information Systems (GIS) and multilevel analysis. One thousand and two individuals were selected from 18 districts by means of cluster sample. The cluster sample consisted of 1002 12-year-old schoolchildren attending 25 public and private schools in Piracicaba, SP, Brazil in 2005. The exams were conducted according to the WHO criteria. Community Periodontal Index were included. Social, economic and behavior variables were recorded using a questionnaire and were used in the individual multilevel analysis (first level). The contexts variables "the percentage of heads of families without income" and "the percentage of illiterate heads of families" were used in the contextual level (second level). A Geographic Information System was elaborated for mapping the distribution of the gingival status. These variables can be visually distinguished in the maps, which show a upward tendency of oral health (less scores of gingival bleeding) in the central regions of the city, that are recognized as a privileged area. However, in the second level (contextual level) of the multilevel analysis, only the percentage of illiterate heads of families was statistically significant associated to gingival bleeding, while the variable "income" was not associated to outcome. The present study confirms a better oral health status to the schoolchildren from privileged families, but it does not confirm the data regarding to the cluster "income" (heads of family without income). The individuals from areas where the heads of family do not have income were not associated to a higher prevalence of gingival problems. This fact suggests that these individuals are reasonably protected of the impact of the social deprivation due to the

actions of the health public services of the municipality regarding prevention and treatment of the oral health problems.

Key-words: Geographic Information Systems, Gingival Status and Schoolchildren.

INTRODUCTION

During a long time the studies related to oral health have kept their focus in the evaluation of the individual factors in the determination of diseases. These studies became limited to the comprehension of the complexity of the real life social processes (Newton & Bower, 2005).

Our senses are not be able to realize the world in its totality, it is necessary the construction of models that can explain the reality. The maps constitute explanatory and representative models of the real world, more specifically to the real space (Moreira et al., 2007) and together to Multilevel Analysis, that obey the existents interrelationship between the environment and the individuals, because they involve a simultaneous analysis of the individual and contextual variables (Bower et al., 2007).

The Geographic Information Systems is a unifiable and analyzable tool of necessary variables to ecological studies. This tool recognize the existent relation between the distribution and the impact of the diseases in the space that they occur, as well as the verification of the phenomena that are not be able to visualize by data presented in tables. This fact reaffirms the relationship between epidemiology and cartography (Lopes & Ribeiro, 2006).

The isolated efforts have characterized the recognized centurylong relationship between the geography and the human health. In the last decade, the international interest was updated for studying these relationships both in the academic area and in the management of health sector. It makes the positive and progressive impact of the use of spacial analysis in public health stand out, as well as the pertinency of a prudent and careful way in the evaluation of the results regarding this subject (Rojas & Barcellos, 2003).

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In this way, the present study aimed to evaluate the gingival status of 12-year-old individuals using a Geographic Information System (GIS) and the Multilevel Analysis.

Material and Method

Ethical aspects

This study was approved by Research Ethics Committee of Piracicaba Dental School, State University of Campinas/ UNICAMP (protocols #148/2003; #098/2006). Children were given an informed consent form to take home for parental permission.

Questionnaire

Previously to exams, a questionnaire regarding to socioeconomic status and the child's behavioral habits was sent to parents. The questionnaire consisted of questions on monthly family income, number of people living in the household, home ownership, mother's and father's education, car ownership, toothbrushing habits, and access to oral health care (Pereira et al., 2007).

Sample size

The sample size was calculated according to Demidenko (2008), considering a statistical power of test of 0.80, significance level of 0.05 and odds ratio of 1.5.

The 1100 12-year-old students were selected by the cluster sampling methods from public and private schools that belong of 18 sections of the municipality of Piracicaba, São Paulo, Brazil, according to geographical localization. It was considered the proportion between public and private schools of the municipality. Twenty five public and private

schools took part of the present study and the sample was composed by 1002 students (less than 10% of missing).

Exams

The exams were carried out by a single examiner who followed the criteria of World Health Organization (WHO, 1997). The exams were conducted in an outdoor setting, under natural light, after previous dental brushing, using CPI probe with a diameter of 0.5 mm ("ball point"). The students receive a dental brushing kit (tooth brush, dentifrice and floss) and performed the tooth brushing on supervision of a dental hygienist.

The examiner was previously calibrated. This calibrations phase was composed by an initial training phase (theoretical and clinical) and five calibration exercises (baseline, 3, 6, 9 and 12 months). Approximately 10% of the sample was reexamined in order to verify intra-examiner reproducibility. The mean Kappa to periodontal exam was > 0.86.

The gingival conditions of the students were evaluated using the Community Periodontal Index (CPI) to detect gingival bleeding and dental calculus. In accordance with the WHO criteria, for individuals under the age of 20 years, only six index teeth – 16, 11, 26, 36, 31, and 46 – were examined, in each teeth was evaluated six sites and periodontal pocket was not included in the evaluations because of the age of the individuals.

Data Analysis

The presence and absence of bleeding sextants and gingival calculus were used as dependent variables and Chi-square Test was applied to compare these variables to the socio-economic and behavioral variables on oral health. A multilevel modeling statistical was performed to identify variables that would be associated with areas of social privation

at two levels, individual and contextual (districts) at 5% level of significance. The independent variables in the first level were socioeconomic and behavior variables (first level) and as demographic variables of the cluster "the percentage of heads of families without income" and "the percentage of illiterate heads of families" were considered (second level). The cluster variables were obtained from the Research and Planning Institute of Piracicaba (IPPLAP, in Portuguese abbreviation). The odds ratio and their respective intervals of confidence of 95% were estimated. In addition, the association between the independent variables was evaluates to avoid the multicolinearity during the Chi-square test.

Spatial Analysis

It was constructed a Geographic Information System using the whole urban area of the municipality of Piracicaba, including a district far 21.8 km from Piracicaba. Eighteen neighborhoods was sampled. The data was geo-referenced using thematic maps.

A Geographic Information System was elaborated to map the data using the ArcView 3.1 Software. First, with the help of satellite photographs and maps of the municipality of Piracicaba, the districts were drawn. Later, a geo-referenced database was created to elaborate a Geographic Information System (system composed by database, variables, themes and maps). Risk areas to gingival bleeding were identified and mapped.

RESULTS

It was observed in the present study an association between the caries experience (DMFS) ($p<0.0001$) to monthly family income ($p<0.0001$), father's education ($p<0.0001$) and mother's education ($p<0.0001$), car ownership ($p=0.027$), toothbrushing frequency

(p=0.0305), onset of toothbrushing (p=0.0046) and absence or presence of gingival bleeding sextants (Table 1).

From these results, an association analysis between the independent variables, with the intention of avoiding the multicolinearity was performed. A highly significant association between the variables monthly family income, father's education, mother's education was verified (Table 1). In this way, just the variable "income" was tested in the multilevel model (Table 2).

There was a significant association between the absence and presence of sextants with calculus and 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 the multicolinearity in this data, an association analysis was performed and a highly significant association was verified between car ownership and home ownership. The latter was tested in the multivariate model (Table 3). The DMFS index that was verified for all sample was 1.88 and the DMFS index to private and public school, respectively, was 0.63 and 2.05.

The independent variables that showed a significant association at $p < 0.15$ were selected and included in the multilevel model.

In the level subjects (first level), the individuals with caries experience (DMFS > 0) (OR=4.76; CI=3.63-6.23) and whose started to tooth brushing later (OR=1.49; CI=1.04-2.14) had more chance to present sextants with gingival bleeding. In the contextual level (second level) just the variable "the percentage of illiterate heads of families" was associated to gingival bleeding. Regarding to the analysis to calculus, in the first level, the variables gender (OR=1.64; CI=1.04-2.58) and home ownership (OR=1.76; CI=1.11-2.78) were associated to calculus presence at $p < 0.05$. In the second level, similarly to gingival

bleeding, just the variable "the percentage of illiterate heads of families" was associated (Table 2).

Through the maps is possible to visualize a better tendency to oral health (lower scores of gingival bleeding) in the downtown region of the municipality that is considered privileged and with the best percentage of individuals with high income and more years of study (Figures 1 and 2). However, in the second level (contextual) of the multilevel analysis, just the "the percentage of illiterate heads of families" was statistically significant associated in both outcomes. Regarding these oral problems, the variable "income" was not statistically significant associated.

DISCUSSION

The recent valorization of the ecological studies opens a field to analyze the social and spatial phenomena that are involved to the process health and disease. However, methodological refining is need but it can not simplify the complexity of these phenomena, actually it should reproduce the static and isolated notion of the space (Moreira, 2007). The geoprocessing technology use possibilities to identify relations between distribution of health injuries and environmental conditioning factors, adds and maps variables from different sources (Lopes & Ribeiro, 2006). Frequently, the verifying of an association between space and health injuries has been investigated in the non-dental literature (Tiwari et al, 2006; Harris et al., 2008). However, in Dentistry the studies about this subject are scarce (Antunes et al., 2002).

The geographic vision is a key aspect to the public health. The population and the communities are geographically distributed and they tend to have their own characteristics. The factors that influence the health of a community are classified in 4 groups: inherited

conditions; environmental (quality of the air and water, characteristics of the soil, radiation and socioeconomic conditions); lifestyle and healthcare (Maheswaran & Craglia, 2004).

Geographic Information Systems provide a broad source of tools for exploring data. These systems can be defined as a set of tools for acquisition, storage, recovering, analysis and interpretation of spatial data (Graham et al., 2004; Ruankaew, 2005).

The embodiment of mapping in the studies reflects the condition of inequalities in relation to the oral health condition of the municipality. This tool is useful to evaluate and to visualize in an easily way the areas that should receive more attention from the managers of health service. Geographic Information Systems applied to follow the oral health of a population has been extremely effective to show the disease distribution and to help the planning of procedures focus in the areas more deprivated.

It is important to highlight that actions in oral health should be thought, argued and done by different sectors. Besides, actions just orientated to oral health are unable to solve the problems related to disease distribution. The territory is a reflex of the economical condition from its habitants and it suffers influence from social and politics inequalities. Thus the territory could influence contrarily the health condition of their habitants and create a sustainable poorness (Moreira et al., 2007).

In Brazil and in the present municipality studied, most of the individuals enrolled in public schools are from underprivileged families which live in social deprivation areas and that do not have financial resources to pay a private school (Pereira et al., 2007). These individuals distinguish themselves because they present the higher caries experience. Although be evident the social inequality in Brazil (Antunes et al., 2006), because there are very wealthy families in contrast to extremely poor families. This inequality is visible in the studied region data through the map constructed (Figure 1). Sometimes this social

difference present is not statistical significant, since the different realities are happening often in the same area. Not rarely it is possible to verify rich and poor individuals who live in the same geographical space due to the quick urban growth of the cities, as well as the growth of the inequality present.

This complexity of the social factors is related to the oral health problems what means that analysis and actions that respect this complexity are required. So careful analysis are important and it should unify all the tools that can be explain clearly the health and disease process in different populations. The application of geographical and multilevel analysis can bring more consistency and reliability to the epidemiological data. The latest periodontal studies have used the Multilevel Modeling (Tu et al., 2004) what results in a better comprehension about the structure of the complex data existents in health, for instance the complexity of the progression of the periodontal disease (Gilthorpe et al., 2001), its impact in the general health of the individuals and the importance of the surveillance for periodontal diseases (Tomar, 2007). More studies to evaluate the geographical area are need to increase the understanding about the social inequalities in oral health and to lead for a development of interventions to decrease them. The progress in totally comprising the causes of social inequalities will be limited so far a general change in the manner of the health be measured (Sisson, 2007). This complexity is recognized since 90's through the study of Ellwood & O'Mullane (1996) considering that the caries diseases are complex and several social characteristics may influence its distribution in a population, what suggests a detailed analysis of data found in literature is necessary in order to identify the group most exposed to disease.

The present study used both tools spatial analysis and statistical model analysis in multiple levels with the purpose to better comprehension of the data. Univariate analysis

(Chi-square test) were applied to verify the associations between the variables studied (social, economic and behavior) and the gingival condition. Later, from the data of this first analysis, it was elaborated the multilevel models in which just the variables that were associated to the proposed outcomes were included. At last, the mapping of the risk areas to gingival problems was done by means of the elaboration of a GIS.

It is possible to verify by means of the data evaluated in the different analysis that social, economic and behavior variables are directly associated to levels of disease (Chi-square test, Table 1 and 3). This can be visualized in the map (Figure 1) that show a better tendency in oral health in downtown areas, which are considered privileged. Regarding to Multilevel analysis, at individual level, the caries experience and onset of tooth brushing were associated to gingival bleeding, while gender and home ownership were associated to calculus. However, at the second level (contextual), just the percentage of illiterate heads of families was statistically significant in both outcomes and the variable "income" was not associated with these oral health problems. These results suggest that individuals who live in places where the percentage of illiterate heads of families is higher will have a higher propensity to present gingival problems (Table 2 and 4). Nevertheless, regions where the income of the head of family is so low was not associated to worse oral health conditions. This result disagree of a lot of other studies that verified income as a main factor of social deprivation and strongly associated to oral health problems, mainly in the Brazilian context (Peres et al., 2000; Pattussi et al., 2001; Cortellazzi et al., 2008; Antunes et al., 2008). However, only the income is not enough to test the materialists theories of health inequalities (Sisson, 2007).

It is important, in the present study to relate the efforts of the public health services of the municipality studied. There is a oral health program developed and directed to the

scholars and involve a partnership with the Dental School, a local company, city hall and the state dentistry association. Treatment, preventive and educative measures are orientated to 5,000 students from the public schools administered by the Local Department of Education of Piracicaba, SP. These procedures reach the less supported and minimize the impact of the social and environmental factors on individuals, what decrease the existent differences regarding oral health between the schoolchildren from low and high income, that suggests that these individuals are reasonably protected by the impact of the social deprivation due to the actions of the health public services of the municipality regarding prevention and treatment of the oral health problems. This approach brings the comprehension and the hypothesis that the socioeconomic inequalities could be solved by means of oral healthcare programs that achieve all the individual socialy deprivated.

The results of the present study could be better explained through the long-term prospective ecological studies, in which there is a higher number of groups and individuals (Bower et al., 2007). An authentic causal relationship just could be confirmed by randomized, controlled, prospective studies (Tu et al., 2004) that test the predictive value of variables associated to gingival disease and beginning of lesions with the aim to find viable mechanisms to disease surveillance (Tomar, 2007). The distribution of disease are commonly done by means of three pillars: person, time and space (Werneck & Struchiner, 1997; Maheswaran & Craglia, 2004).

The Geographical Information Systems are tools that offer a large source of information which are not explored by public health yet. These systems are arousing interest of professionals from other areas, as Dentistry, however, this is a method not so much applied, although it has vast advantages.

The present study confirms a better status of oral health in the schoolchildren from privileged families, but it does not confirm the data regarding the socioeconomic variable of clusters, income. The individuals, whom head of family does not have any income, were not associated to a higher prevalence of gingival problems. By means of the present study, it is possible to conclude that at individual level, social and economic variables were associated with a higher prevalence of the bleeding sextants and calculus, however, this relationship was not observed at multilevel model. By means of multilevel analysis and GIS application was possible to evaluate better the oral health conditions and construct a panorama of this condition in a small area.

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Table 1. Univariate analysis of the association between bleeding sextants and gender, socio-economic characteristics and behavioral variables related to at the first level (subjects).

Variable	CPI Bleeding= 0 n (%)	CPI Bleeding > 0 n (%)	OR non-adjusted (IC95%)	p-value
First level: subjects				
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				
= 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 icome				
up to 3 minimum wages*	400(44.2)	505(55.8)	1.00	<0.0001
> 3 minimum wages	56(67.5)	27(32.5)	0.38 (0.24-0.62)	
Father's education				
Complete middle-school	174(39.2)	270(60.8)	1.00	
Complete high school	129(53.8)	111(46.2)	0.55(0.40-0.76)	<0.0001
Complete undergraduate	76(58.9)	53(41.1)	0.45 (0.30-0.67)	
Mother's education				
Complete middle-school	238(40.0)	357(60.0)	1.00	
Complete high school	154(54.0)	131(46.0)	0.57(0.43-0.75)	<0.0001
Complete undergraduate	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)	

* Minimum wage at the time of the data collection, approximately US$163.55

Table 2. Multilevel model of logistic regression analysis to Bleeding Sextants.

	Estimate	SE	Adjusted OR	95%CI	p
First level: subjects					
DMFS					
DMFS:>0	0.77	0.07	4.68	3.53-6.20	<0.0001
DMFS:<0	Reference				
Onset of toothbrushing:					
≤ once/day	0.20	0.09	1.49	1.04-2.14	0.0303
≥ twice/day					
-2 loglikelihood (first level)	1203.48				
	Estimate	SE	B	SE	p
Second level:					
% Illiterate/cluster	0.10	0.03	0.11	0.04	0.0081
-2 loglikelihood (full model)	1157.98				

Table 3- Univariate analysis of the association between sextants with calculus and gender, socio-economic characteristics and behavioral variables related to at the first level (subjects).

Variable	Calculus = 0 n (%)	Calculus > 0 n (%)	OR non-adjusted(IC95%)	p-value
First level: subjects				
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				
=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 family icome				
up to 3 minimum wages*	825(91.2)	80(8.8)	1.00	0.2088
> 3 minimum wages	79(95.2)	4(4.8)	0.52 (0.19-1.46)	
Father's education				
Complete middle-school	406(91.4)	38(8.6)	1.00	
Complete high school	220(91.7)	20(8.3)	0.97(0.55-1.71)	0.8583
Complete undergraduate	119(92.2)	10(7.8)	0.90 (0.43-1.86)	
Mother's education				
Complete middle-school	540(90.8)	55(9.2)	1.00	
Complete high school	261(91.6)	24(8.4)	0.90(0.55-1.49)	0.2492
Complete undergraduate	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	0.0610
Regularly	521(93.0)	39(7.0)	0.65 (0.42-1.02)	
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)	
Toothbrushing 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 toothbrushing				
≤ 1 year old	736(91.9)	65(8.1)	1.00	0.5571
>1 year old	173(90.6)	18(9.4)	1.17 (0.68-2.04)	

* Minimum wage at the time of the data collection, approximately US$163.55

Table 4. Multilevel model of logistic regression analysis to sextants with dental calculus.

	Estimate	SE	Adjusted OR	95%CI	p
First level: subjects					
Gender					
Female	0.25	0.12	1.64	1.04-2.58	0.00387
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				
			β	SE	p
Second level:					
% Illiterate/cluster	0.08	0.04	0.008	0.008	0.3639
-2 loglikelihood (full model	559.13				
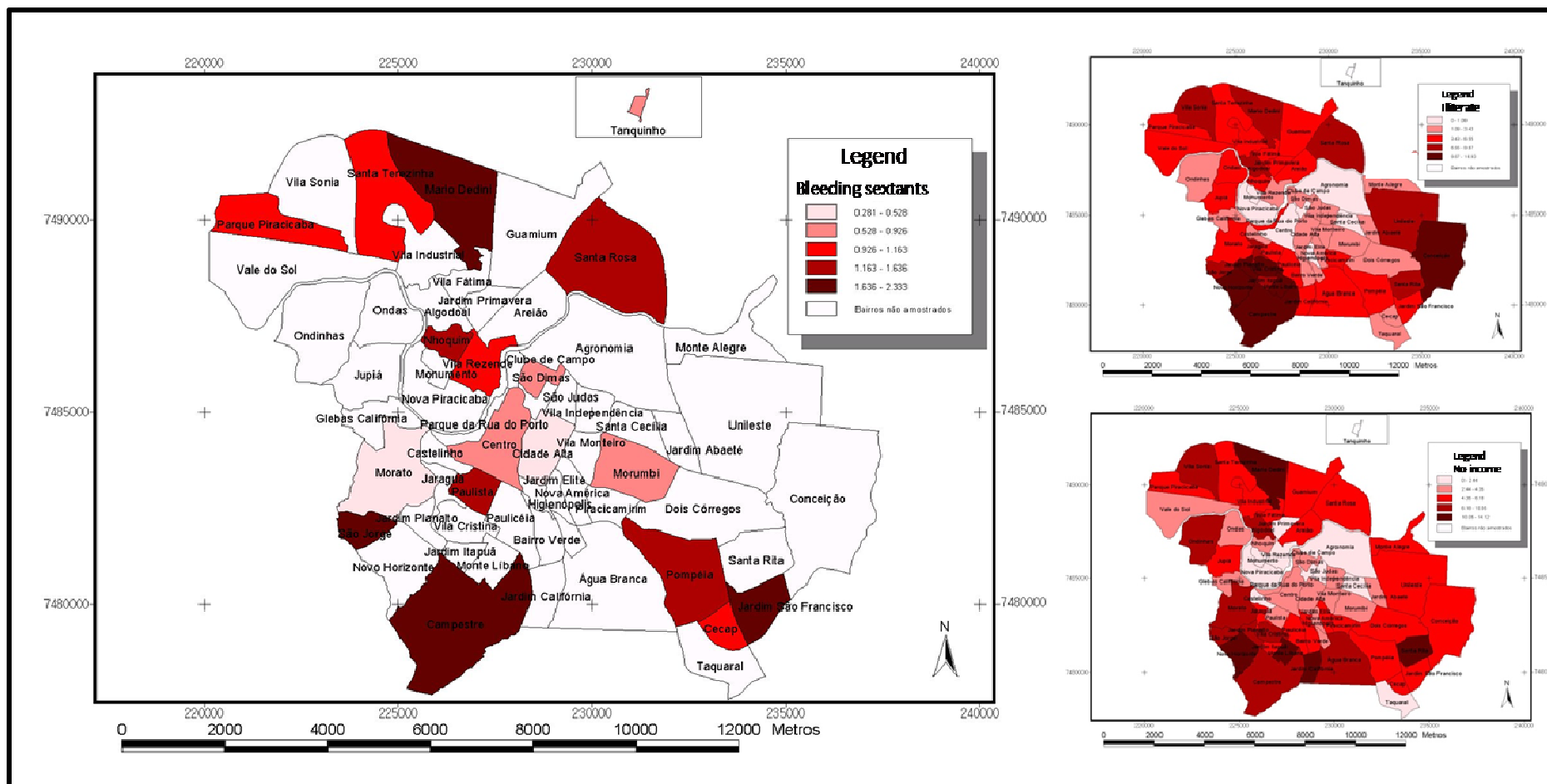
Figure 1. Distribution of the Bleeding Sextants in the sampled districts. Smaller maps containing the demographic data of percentage of heads of families receiving no income and percentage of heads of families that was illiterate in the districts (IPPLAP – Research and Planning Institute of Piracicaba).

CONSIDERAÇÕES FINAIS

Estudos direcionados a delimitação de áreas de maior risco de doenças e de necessidades de tratamento envolvendo além de variáveis clínicas, características socioeconômicas, comportamentais e demográficas, seriam de extrema importância aos serviços de saúde pública de modo a otimizar a alocação dos recursos humanos e financeiros.

Além da importância do mapeamento para a análise da distribuição das doenças e suas possíveis associações com variáveis ambientais, o mapa de risco seria uma ferramenta de fácil identificação e imediata compreensão das áreas geográficas onde os problemas de saúde são de maior ocorrência e severidade, sendo também valioso na obtenção de subsídios para o planejamento, execução e monitoramento dos programas de saúde pelos serviços públicos. Dentro deste contexto, os sistemas de informação geográfica são ferramentas que podem oferecer uma extensa fonte de informações ainda não exploradas pela saúde pública e vêm despertando o interesse de profissionais de outras áreas, por exemplo, da odontologia. Entretanto, verifica-se que este é um método ainda pouco utilizado frente às suas extensas vantagens.

CONCLUSÃO

O presente estudo confirma um melhor status de saúde bucal para escolares provenientes de famílias privilegiadas por meio de avaliação visual dos mapas, mas não confirma os dados em relação às variáveis contextuais no modelo multinível, onde indivíduos não privilegiados não foram associados a uma maior prevalência de problemas bucais. Por meio dos achados, sugere-se que estes indivíduos estão relativamente protegidos do impacto da privação social devido às ações de saúde bucal dos serviços públicos. As análises multiníveis e os Sistemas de Informação Geográfica permitiram uma melhor avaliação das condições de saúde bucal e a construção de um panorama da situação em uma pequena área.

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53

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ANEXOS

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Submission Confirmation

Thank you for submitting your manuscript to *Journal of Public Health Dentistry*.

Manuscript ID:	JPHD-OA-08-08-0106
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Authors:	Pereira, Stela Cortellazzi, Karine Ambrosano, Gláucia Vettorazzi, Carlos Ferraz, Silvio Meneghim, Marcelo Pereira, Antonio
Date Submitted:	11-Aug-2008

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Termo de Consentimento Livre e Esclarecido

Aos diretores das escolas

Ilmo (a). Coordenador (a)/ Diretor (a)

Prof. (ª). _____

Escola _____– SP

Nós, Stela Márcia Pereira e Antonio Carlos Pereira, do Programa de Pós-Graduação da FOP/UNICAMP, solicitamos através deste, a permissão para a realização da pesquisa intitulada: "Análise Espacial da distribuição da cárie dentária em escolares de 12 anos em Piracicaba, SP" nas dependências deste estabelecimento de ensino. Para tanto, necessitaremos da lista dos alunos regularmente matriculados na faixa etária de 12 anos, sendo que os exames bucais a serem realizados, ocorrerão no pátio, dentro do horário de funcionamento da escola. A participação de sua escola nesta pesquisa será deveras relevante para a elucidação das condições da saúde oral das crianças desta cidade, bem como, em específico à de cada uma das participantes da pesquisa.

Certos de sua compreensão, desde já, nos colocamos à sua disposição para eventuais esclarecimentos que se fizerem necessários, seguindo em anexo, cópia do certificado de aprovação da referida pesquisa, expedido pelo Comitê de Ética em Pesquisa da FOP/UNICAMP.

Atenciosamente,

- Stela Márcia Pereira - Pós-Graduanda da FOP/UNICAMP
- Antonio Carlos Pereira - Prof. Dr. da FOP/UNICAMP

_____

Diretor (a)/ Coordenador (a)

Aos pais/ responsáveis pelos escolares

Solicitamos aos pais ou responsável pelo aluno

_____

autorização para a participação dele (a), na pesquisa intitulada: "Análise Espacial da distribuição da cárie dentária em escolares de 12 anos em Piracicaba, SP", de responsabilidade dos pesquisadores: Stela Márcia Pereira e Prof. Dr. Antonio Carlos Pereira. Salientamos que seu filho (a) será submetido a um exame clínico bucal, no pátio da escola, no qual será feita uma avaliação de suas condições de saúde bucal. Se for verificada a presença de cárie, as crianças terão os pais ou responsáveis avisados e serão encaminhadas para o tratamento odontológico gratuito no prédio central da Odontologia em Piracicaba, SP.

Declaramos também, que seu filho (a) não será submetido (a) a nenhum desconforto ou risco, sendo que a participação dele (a) nesta pesquisa será muito importante para a determinação das condições de saúde bucal da população desta cidade, bem como a avaliação de sua distribuição. A participação dele (a) é voluntária, podendo ser retirada a qualquer momento da execução da pesquisa, sem prejuízo algum para ele (a). Os dados coletados ficarão guardados em sigilo, não sendo divulgado o nome dele (a) em hipótese alguma, estando disponíveis ao senhor (a) a qualquer momento. Maiores informações poderão ser conseguidas no telefone abaixo, bem como, dúvidas sanadas junto ao Comitê de Ética em Pesquisa da FOP/UNICAMP, o qual aprovou esta pesquisa em sua íntegra.

Diante do exposto, permito a realização dos exames de cárie dentária em meu filho (a).

_____   _____
Nome legível do responsável   ASS: Assinatura do responsável

INFORMAÇÕES SOBRE A PESQUISA

TÍTULO DA PESQUISA: "Análise Espacial da distribuição da cárie dentária em escolares de 12 anos em Piracicaba, SP".

PESQUISADORES: Prof. Dr. Antonio Carlos Pereira e Stela Márcia Pereira.

LOCAL: Escolas da rede pública e privada de ensino da cidade de Piracicaba-SP

1. INTRODUÇÃO: Por favor, leia este termo cuidadosamente, pois as informações a seguir irão descrever esta pesquisa e sua função nela como participante. Caso tenha qualquer dúvida sobre este estudo ou termo, você deverá esclarecê-la com os pesquisadores responsáveis pelo trabalho.

2. PROPÓSITO: Participar de uma pesquisa epidemiológica cujo objetivo é avaliar o perfil de distribuição das condições de saúde bucal em dois níveis, individual e contextual (bairros), por meio de análise Multinível e da elaboração de um Sistema de Informação Geográfica.

3. DESCRIÇÃO DO ESTUDO: Irão participar deste estudo escolares de 12 anos de idade provenientes de escolas da rede pública e privada de ensino da cidade de Piracicaba, sendo que serão examinadas ao todo 1000 crianças. Os pacientes que concordarem em participar da pesquisa serão examinados por um único cirurgião dentista. Em caso de necessidade de tratamento, entraremos em contato com os pais ou responsáveis, além de encaminhar estas crianças para tratamento gratuito.

4. DESCONFORTOS E RISCOS: Declaramos que seu filho não será submetido a nenhum desconforto ou risco, os métodos utilizados para avaliação são atraumáticos, não invasivos e o tratamento odontológico integral não serão prejudicados pela pesquisa.

5. BENEFÍCIOS ESPERADOS: O paciente receberá, através da pesquisa, avaliação para verificação das condições bucais em relação à cárie, possibilitando o diagnóstico precoce de possíveis problemas existentes, sendo que as crianças que apresentarem problemas serão encaminhadas para tratamento gratuito. Os dados coletados estarão disponíveis ao responsável do escolar, a qualquer momento.

6. INFORMAÇOES: Os voluntários e seus pais ou responsável têm garantia de que receberão respostas a qualquer pergunta ou esclarecimento acerca dos procedimentos, benefícios e aspectos pertinentes à pesquisa.

7. RETIRADA DE CONSENTIMENTO: Os voluntários e seus pais ou responsável têm a liberdade de retirar seu consentimento a qualquer momento e deixar de participar do estudo.

8. GARANTIA DE SIGILO: Os dados coletados de seu (sua) filho (a) têm finalidade exclusivamente científica, sendo guardados em sigilo, não sendo divulgado o nome dele (dela), em hipótese alguma, estando disponíveis ao responsável do aluno (a), a qualquer momento. Os resultados deste projeto de pesquisa poderão ser apresentados em congressos ou publicados em revista científica, porém a identidade do voluntário não será divulgada nessas apresentações.

9. RESSARCIMENTO: Não há gasto previsto em decorrência da participação dos voluntários na pesquisa uma vez que os exames serão realizados no pátio das escolas.

12. ASPECTO LEGAL: Maiores informações poderão ser conseguidas no endereço abaixo, bem como dúvidas sanadas junto ao Comitê de Ética em Pesquisa da FOP/UNICAMP, o qual aprovou esta pesquisa em sua íntegra. Endereço- Av. Limeira, 901 CEP/FOP 13414-903- Piracicaba-SP.

Havendo alguma dúvida, entrar em contato com os responsáveis pela pesquisa:

 Pesquisador: Stela Márcia Pereira
 Orientador: Prof. Dr.Antonio Carlos Pereira
Faculdade de Odontologia de Piracicaba - FOP – UNICAMP
Av. Limeira, 901 CEP. 13414-903
Telefone de contato FOP-UNICAMP / 2106-5209

Questionário socioeconômico enviado aos pais

* Solicitamos PREENCHER COM "X" A LETRA CORRESPONDENTE A SUA RESPOSTA EM CADA QUESTÃO do presente questionário, sendo que os dados coletados serão tratados de forma estritamente confidencial, não sendo identificados em hipótese alguma.

1. SITUAÇÃO ECONÔMICA DA FAMÍLIA (Renda familiar mensal)

A.　　( ) até R$ 520,00

B.　　( ) de R$ 521,00 a R$ 1040,00

C.　　( ) de R$ 1041,00 a R$ 1560,00

D.　( ) de R$ 1561,00 a R$ 2600,00

E.　( ) de R$ 2601,00 a R$ 3900,00

F.　( ) de R$ 3901,00 a R$ 5200,00

G.　　( ) Acima de R$ 5200,00

2. NÚMERO DE PESSOAS NA FAMÍLIA (Residentes na mesma casa)

A.( ) até 2 pessoas C.( )4 pessoas E.( )6 pessoas B.( )3 pessoas D.( )5 pessoas F. ( )acima de 6 pessoas

3. GRAU DE INSTRUÇÃO DOS PAIS OU RESPONSÁVEIS

　PAI ou RESPONSÀVEL　　　MÃE

A.　　( )　　　　　　　( )　　Não alfabetizado

B.　　( )　　　　　　　( )　　Alfabetizado

C.　　( )　　　　　　　( )　　1ª a 4ª série incompleta (antigo Primário)

D.　　( )　　　　　　　( )　　1ª a 4ª série completa (antigo Primário)

E.　　( )　　　　　　　( )　　5ª a 8ª série incompleta (antigo Ginasial)

F.　　( )　　　　　　　( )　　5ª a 8ª série completa (antigo Ginasial)

G.　　( )　　　　　　　( )　　2º Grau incompleto (antigo Colegial)

H.　　( )　　　　　　　( )　　2º Grau completo (antigo Colegial)

I.　　( )　　　　　　　( )　　Superior incompleto

J.　　( )　　　　　　　( )　　Superior completo

4. HABITAÇÃO (Moradia)

A.( ) Residência própria quitada

B.( ) Residência própria com financiamento a pagar

C.( ) Residência cedida pelos pais ou parentes morar

D.( ) Residência cedida em troca de trabalho

E.( ) Residência alugada

F.( ) Residência cedida por não ter onde

5. POSSE DE AUTOMÓVEL:

　( ) Não possui　　　　　　　( ) Possui um automóvel　　　　　　　( ) Possui 2 ou mais automóveis

6. PROFISSÃO DO CHEFE DA FAMÍLIA (Mencionar mesmo que desempregado)

- Profissão_____

7. SEU FILHO JÁ FOI AO DENTISTA ALGUMA VEZ?

A.( )Nunca foi ao dentista B. ( )Não vai regularmente C.( )6 em 6 meses D.( )1 vez por ano

E.( )2 em 2 anos

8. QUANTAS VEZES SEU FILHO ESCOVA OS DENTES POR DIA?

A.( ) Escova 1 vez por dia　　B. ( ) Duas vezes por dia　　C. ( ) 3 vezes ou mais

　( )Não possui escova

9. DESDE QUE IDADE SEU FILHO ESCOVA OS DENTES?

A.( ) antes de um ano　　B. ( ) 1 ano　　C. ( ) 2 anos　　D. ( ) 3 anos　　E. ( ) 4 anos

　F. ( ) 5 anos ou mais

Ficha Clínica utilizada

COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "Análise espacial da distribuição da cárie dentária em escolares de 12 anos em Piracicaba/SP", protocolo n° 098/2006, dos pesquisadores STELA MÁRCIA PEREIRA e ANTONIO CARLOS PEREIRA, satisfaz as exigências do Conselho Nacional de Saúde – Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 09/08/2006.

The Research Ethics Committee of the School of Dentistry of Piracicaba - State University of Campinas, certify that project "Spatial analysis of dental caries distribution in 12-year-old schoolchildren in Piracicaba/SP", register number 098/2006, of STELA MÁRCIA PEREIRA and ANTONIO CARLOS PEREIRA, comply with the recommendations of the National Health Council – Ministry of Health of Brazil for researching in human subjects and was approved by this committee at 09/08/2006.

Profa. Cecília Gatti Guirado
Secretária
CEP/FOP/UNICAMP

Prof. Jacks Jorge Júnior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.
Notice: The title of the project appears as provided by the authors, without editing.

61