ARTIGO ARTICLE

Dental caries and the nutritional status of preschool children – a spatial analysis

Cárie dental e estado nutricional de pré-escolares – análise espacial

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Abstract ***Objective:** This cross-sectional study sought to conduct a spatially analysis of the distribution of dental caries and the nutritional status (NS) of 5-year-old preschool children of public schools in the city of Araraquara, São Paulo, Brazil. Methods: The sample was selected in a stratified probabilistic manner. A dental examination was conducted to investigate the dmft index. The anthropometric indicators of the weight/ height (W/H), height/age (H/A), weight/age (W/ A) and body mass index (BMI) were calculated to estimate the NS. A descriptive statistical analysis was conducted and a thematic map was created. At the end of the study 491 children had full address codification. A GPS device was used to ascertain the geographic reference points. A pluridirectional semi-variogram was elaborated. Results: It was revealed that both variables presented a pure nugget effect showing the absence of a spatial correlation, in other words the dmft and nutritional status are not regionalized variables, and their values do not reveal direct spatial dependence. Conclusions: Dental caries and nutritional status are health conditions that do not reveal spatial dependence. Ultimately, the combination of these indicators with others can produce spatial dependence effects.*

Key words *Anthropometrics, Dental caries, Geostatistics, Nutritional Status, Spatial Analysis*

Resumo *Objetivo: analisar espacialmente a distribuição da cárie dentária e do estado nutricional (EN) de pré-escolares, de 5 anos de idade do município de Araraquara, SP. Métodos: Trata-se de estudo transversal com delineamento amostral probabilístico estratificado. Realizou-se exame clínico bucal para investigação do Índice ceod. Indicadores de peso para altura (P/A), altura para idade (A/I), peso para idade (P/I) e Índice de Massa Corpórea (IMC) foram calculados para classificação do EN. Realizou-se análise estatística descritiva e confeccionou-se mapa temático. Ao final do estudo 491 crianças possuíam codificação completa de endereço. A captura dos pontos de referencial geográfico foi realizada com o auxílio de aparelho de GPS. Elaborou-se semivariograma omini-direcional. Resultados: Observa-se que ambas variáveis apresentaram efeito pepita puro, ou seja, os valores da semi-variância oscila em torno da variância dos dados. Isso implica que as variáveis não são regionalizadas, sendo assim, seus valores não possuem dependência espacial direta. Conclusão: Cárie dentaria e estado nutricional são condições que não apresentam dependência espacial. Eventualmente a combinação destes indicadores com outros pode produzir efeitos de dependência espacial.*

Palavras-chave *Antropometria, Cárie dentaria, Geoestatística, Estado Nutricional, Análise Espacial*

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Introduction

Knowing the health conditions of several population groups is an indispensable phase in the project's job supply planning and in the impact evaluation of health actions. According to the Health Ministry[1], the epidemiologic focus follows the commitment of integrality, when incorporating as object of actions the person, the environment and the interpersonal behavior. Barcellos and Pina[2] emphasize that the environmental and epidemiologic data analysis can allow not only an association between these phenomenon, but also a better comprehension of the context in which the health social-spatial processes are produced.

Thus, the application of geoprocessing and mapping techniques for health and research has been stimulated[3,4] and the Geographic Information Systems (GIS) stand out as important tools mainly in the analysis involving environmental, epidemiologic factors and their spatial relationships[5,6].

Rojas et al.[6] carried out a survey and map use and analysis, their construction and insertion in the epidemiologic studies to investigate their use in the epidemiology field in Brazil. The results showed that only 11% of the 1174 works evaluated presented maps, with 51% of them used only for illustration purposes (geographic delimitation), 28% were used as data representation (demonstrative), and 20% as mean analysis of health events for the spatial expression (analytic).

Another aspect to be considered in the work by Rojas et al.[6] is that only 7 studies were in accordance with the oral health thematic areas or nutritional evaluation, which can cause a shortage in this area, since they are of great interest to public health due to its magnitude, transcendence and control viability of many pathologies, among which are the dental caries and the alteration in the nutritional status.

Thus, although currently there has been an increase in the use of maps in the health areas, the Health Departments and Research Centers have not used them very much.

In dentistry, this kind of tool was recently introduced, concentrating the association between the demand and planning of dental services and caries, since no study is available in the Nutrition literature that uses mapping and spatial data analysis according to the nutritional status of the population. It is also important to point out that no other study has tested the spatial dependence of these variables without considering its association with the demographic characteristics, which could be interesting as it would enable to establish the relationship of each variable, alone, and facilitate intervention and tracking.

Considering the lack of studies and the relevance of dental caries and nutritional status in a public health context, this study is an important tool to guide the planning and vigilance actions of the cities, even contributing for the elaboration of a more direct and effective municipal public policy, optimizing resources and spotting fundamental questions for the health management[7].

This paper conducts a spatial study of the dental caries distribution and the nutritional status of 5-year-old preschool children from public schools in Araraquara, SP.

Methods

Sample design

Before the elaboration of this project, the Education Department in the city of Araraquara-SP, Brazil was consulted, it provided us with a list of the city's Primary schools and gave us a written authorization to carry out the data survey in the Education and Recreation Centers.

The city has 32 municipal preschools comprising 2009 children with ages from 5 months to 5 years and 11 months, enrolled in 2006, in both periods: morning and afternoon. The size of the sample was established with the sampling method process for the finite population[8].

The fixed error margin and the variance value were the same adopted by the Brazil Oral Health project for the Southeastern region[9], according to the dmft study for 5 year-old children and by the National Demographic and Health Survey (PNDS)[10] from the classification of the nutritional status of children this age. Under these conditions the minimal sample size was estimated at 515 preschool children. Considering abstention in the order of 20%[11], the size of the sample was established at 644 children and a proportional sharing was done according to the number of children enrolled in each school.

To characterize the sample, an analysis of the educational and economical level of the head of the house was performed according to the criteria proposed by National Association of Research Centers (ANEP)[12]. It must be emphasized that only the children enrolled in the municipal preschools in 2007 participated in the research, and whose parents agreed with the terms of Free Allowance and Clarifying of the Research.

The execution of this work was approved by the Ethics in Research Committee of the Pharmaceutic Faculty - UNESP.

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Dental examination

The children's dental examination was carried out in their own school during regular class, by only one examiner, previously calibrated (κ=0.86), under natural light with the help of disposable wooden spatulas.

The dental examination was in the research of the dmft index (number of decayed, missing and filled deciduous teeth)[13] according to the instructions of the World health Organization[14].

Anthropometric measurements

The anthropometric indicators of the nutritional status were obtained by observing the weight (Kg) and height (cm). The weight was obtained using an anthropometric digital Filizola® scale with precision of 0.1 Kg, the children were barefoot, using minimum clothing. The height was obtained with a measuring tape fixed on a plain wall without baseboard and a T-square above the pre-scholar's head. The child was told to look straight ahead and have his/her feet, buttocks and shoulder touching the measuring tape.

The measures were conducted by only one previously calibrated examiner (ρweight=0.98; ρheight=0.99).

For each individual, the z score was calculated, according to the LMS parameters proposed by Cole[15] and recommended by the National Center of Health Statistics[16]. It is important to add that for the study of malnutrition the z score was calculated by the indicators of weight/age (W/A), height/age (H/A), weight/height (W/H) and body mass index (BMI) and its classification was accomplished according to the recommendation of the World Health Organization[17].

Geoprocessing

Using the SPRING 4.2 program[18] a geo-referenced information basis was elaborated, containing the data regarding the localization of the children's home associated to the anthropometric indicators of the nutritional status and dental caries of the preschool children. As a reference, the digital cartographic base of the city of Araraquara (SP) was used in the scale 1:2000 in the SAD69 projection.

Considering that this cartographic base does not have a complete address codification, it was necessary to use a GPS device model Trex Legend Cx (properly adjusted for the fuse 22, datum SAD 69), to determine the geographic referential of the schools and children participating in the research. This data was collected by a properly trained examiner.

Data analysis

The data referring to the gender, economic level and educational level of the household head, the dmft and nutritional status of the preschool children was organized and obtained using the STATA 9.0 program.

The localization data of the preschool children and their respective dmft and nutritional status were incorporated in a GIS project. For this, two numeric information plan models of the area were prepared, with the coordinate values x and y the localization of the children's home, and to the value of the z quota, the value of the dmft and the final classification of the pre-scholar's nutritional status were associated.

The first step to study the spatial dependence of dental caries and nutritional condition was to analyze if these variables are regionalized, that is, if their value is influenced by their spatial position, then, the experimental semivariograms were elaborated. The semivariograms were obtained for the increase and continuous space values (h) between the sample spots, with the application of coordinates xi and z value of the expression of semi-variant that follows[19-21]:

$$\gamma(\boldsymbol{h}) = \frac{1}{2\boldsymbol{n}_h} \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}_h} \left\{ [\boldsymbol{Z}(\boldsymbol{x}_{i+h}) - \boldsymbol{Z}(\boldsymbol{x}_i)]^2 \right\}$$

That is:

$\boldsymbol{n}_h$: number of pair values separated by na h spacing.

Considering that the sample was collected in an irregular pattern, an omni-directional semivariogram was elaborated to identify the existence of a spatial dependence in the considered variables. The graphic of the surface for each variable was also elaborated.

The usual geostatistic analysis process will be carried out for the variable considered regionalized, with the semivariogram modeling, for the identification of the theoretical representation model of the experimental semivariogram, this model should be used in the interpoling process of the Krigagem data.

Results

In this study we had the participation of 602 preschool children, 52.66% females, however there was a loss of 6.52%.

Among the children participating in the research, only 491 presented a complete address codification. They are represented in Figure 1.

Table 1 shows the economical status and educational level of the household head.

Most of the families presented low economical level. The prevailing school level of the household head was "complete high school or incomplete university".

The demographic characteristics (genre, social and scholastic level) found in the sample are similar to the ones found for the population of Araraquara.

It was noticed that children coming from all regions of the city participated in the research (Figure 1), that when added to the representation of the socio-economical variables, was able to guarantee the external validity of the study.

The average dmft of the children was of 1.22 with standard deviation of 2.23 and values varying from 0 to 14. the high prevalence of children with a dmft equal to zero (63.54%) was observed.

Table 2 illustrates the final classification of the preschool children's nutritional status.

The high prevalence of overweight and obesity and the coexistence of malnutrition in this population are quite remarkable.

To identify the existence of a spatial dependence in the dmft variant and nutritional status, the following experimental semivariograms and surface graphics were elaborated (Figures 2 and 3).

As previously shown, the experimental semivariogram analyzes the degree of spatial dependence among the samples within a region, while the surface chart indicates the pattern of variability in the different geographic locations (north, south, east, west). It can be observed that both the dmft index and the nutritional status presented the pure nugget effect, that is, there is a total lack of correlation between the spotted sites.

Figure 1. Distribution of preschool children with complete address codification. Araraquara, 2007.

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Table 1. Economic Status and Educational Level of the Head of Household of Preschool Children. Araraquara, 2007.

Socio-demographic characteristics	n	%
Economical status (MW*/month)		
25 ├ +	7	1.43
10 ├ 25	93	18.94
4 ├ 10	239	48.68
0 ├ 4	152	30.96
Educational level		
Illiterate or incomplete elementary school	54	11.00
Complete elementary school or incomplete middle school	120	24.44
Complete middle school or incomplete high school	100	20.37
Complete high school or incomplete university	191	38.90
Complete university	26	5.30
Total	491	100.00

*MW/month: minimum wage per month, where: 1MW ≅ U$275.00

Table 2. Nutritional Status of Preschool Children. Araraquara, 2007.

Nutritional State	n (%)
Underweight	46 (9.37)
Normal weight	292 (59.47)
Overweight	86 (17.52)
Obesity	67 (13.65)
Total	491 (100.00)

In this case, groupings cannot be identified, thus, the samples cannot be distinguished only for their location in space. This means that the dmft and nutritional status are not regionalized variables, thus, their values do not have direct spatial dependence, a fact observed by the constant variability characteristic indicated by the semivariogram and the even spreading toward the different cardinal points seen in the surface chart.

Discussion

The results of the spatial analysis of the dmft index and the nutritional status of preschool children in Araraquara, SP were presented in this study. The purpose of this analysis, for the first time in the literature, was to characterize the diffusion pattern of the dmft index and the spatial nutritional status.

It is important to mention that the total number of children with complete address codification (n=491) was sufficient for the application of the geostatistic methods, once they were properly distributed spatially, assuring the external validity of the study.

The spatial studies performed are justified when considering the assumption that space has an accumulation of historical, environmental and social situations that produce individual conditions of the health-disease process, hence adding a territorial logic to the health analysis of a population, based on the fact that the closest spatial elements share similar socio-environmental conditions.

By means of Geographic Information Systems (GIS) and by incorporating addresses in health records and/or use of Global Positioning Systems (GPS), there is an opportunity to present and analyze health events on local scale maps, which enables to aggregate the data in different ways, thereby searching for the construction of indicators for different spatial units according to the interests in question.

According to Barcellos and Ramalho[22] , spatial analysis and its tools should be directed to solving specific problems, since the structure and spatial dynamics of the population is the first step toward characterizing health situations, which will enable the planning of control actions and the allocation of resources in a more directed and effective manner.

Despite the increased use of maps in the health area currently, such use has been implemented by few Research Centers and Health Departments, especially due to the difficulty in obtaining human resources with interdisciplinary knowledge, trained for geographic data acquisition, construction of indicators, data georeferencing, spatial analysis and the use of specific computer programs for this purpose.

There are few studies in the literature in the dental area that use geospatial data technologies. In the works of Susi and Mascarenhas[23] and Krause et al.[24], the authors used GIS to map the distribution of dentists in the cities of Ohio and Mississippi, respectively, without, however, examining other health variables that could be of interest to the results found.

In the area of nutrition, Liu et al.[25] al conducted spatial analysis to study the relationship between environmental and social factors with children's obesity and used the geographic information system (GIS) to discuss the findings. The

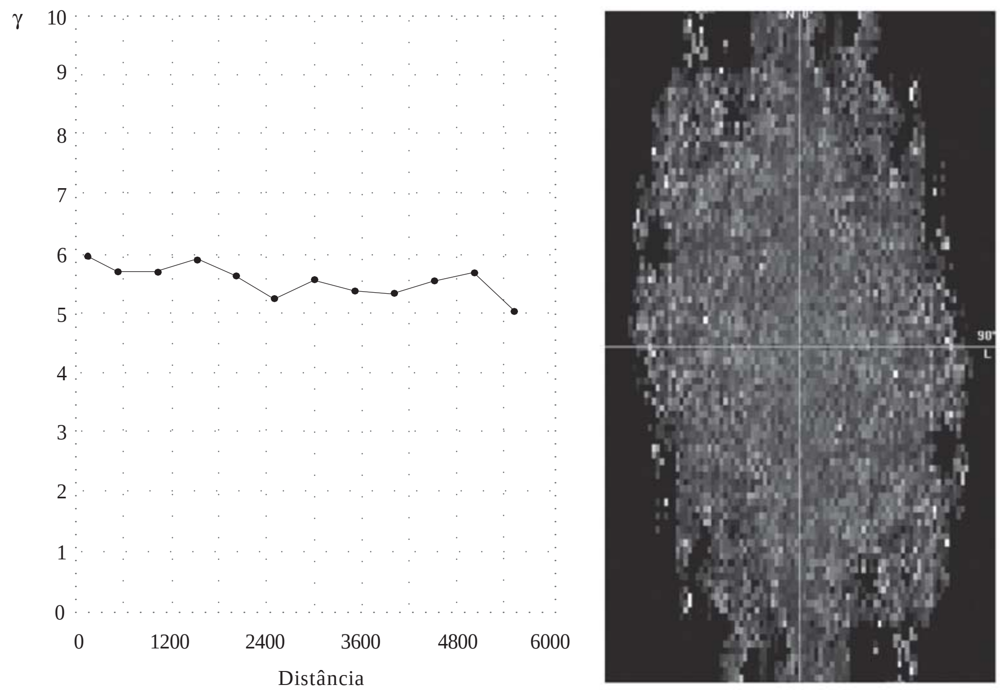

Figure 2. Experimental semi-variograms and graphic of the surface to dmft índex. Araraquara, 2007.

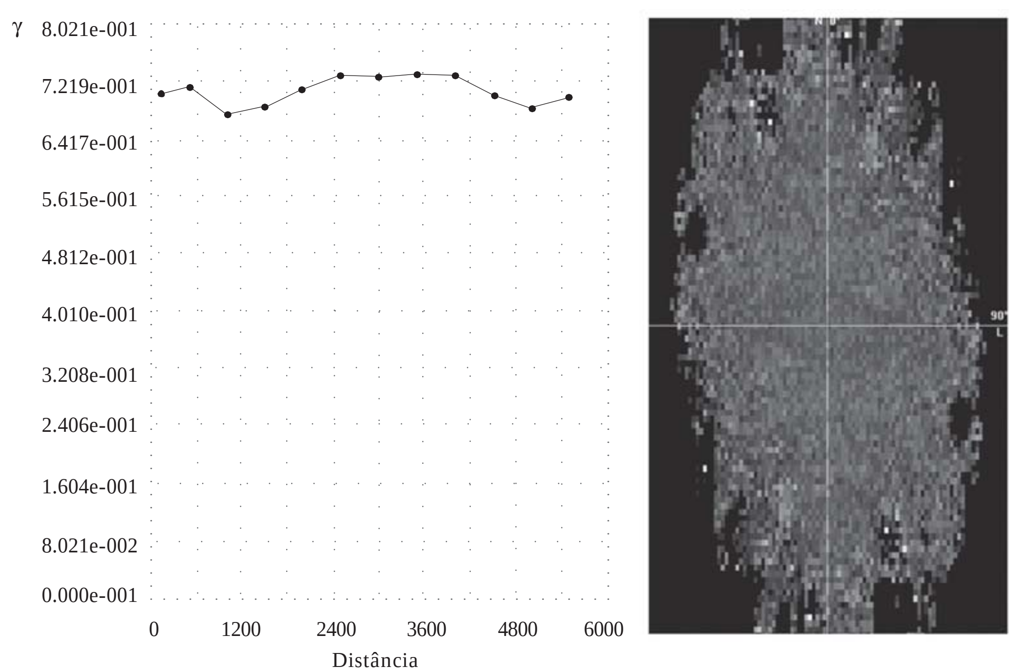

Figure 3. Experimental semi-variograms and graphic of the surface to nutritional status. Araraquara, 2007.

Center for Disease Control and Prevention[26], mapped the prevalence of obesity in adults in the American states. Drewnowski et al.[27] applied GIS and geostatistics techniques for the data analysis of the prevalence of obesity in adults in a city in the State of Washington, USA and Lebel et al.[28]

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used the same procedures for adult residents in Quebec, Canada.

Thus, it is believed that GIS studies in these areas and the divulgation of this type of methodology among health professionals, can persuade and encourage the expansion of studies by adding to the classic methodology, the spatial component, hence empowering the possibilities for analysis and performance.

The dental caries represent a substantial public health problem in Brazil and efforts have been made to minimize its consequences and occurrence[4]. Significant reductions in the prevalence of caries has been observed both in developed and developing countries, which can be attributed to the generalized use of fluorides, access to odontologic services and increased promotion actions and education in oral health[29]. The average dmft found in this study (1.22) was below the dmft found for the Brazil Oral Health Project[9], which was of 2.50 for the Southeast region and 2.80 in the whole country and the prevalence of children with dmft equal to zero was higher in this study (63.54%) (Figure 2) than in the previously mentioned analyses (Southeast region: 40.62% and Brazil: 40.62%), hence showing better oral health conditions in Araraquara. It is important to emphasize that this National Survey is considered a reference in the odontologic area for the diagnosis of the oral disease situation in the country.

These data may be due to the fact that Araraquara is considered an important referential in dentistry, with two Universities offering Dentistry courses and Class Associations, both with extension care. The city has an odontological assistance network with 74 surgeon-dentists and 38 dentists in dentistry clinics, which conduct basic and specialized attention activities. The city also offers oral health educational activities with preschool children and children from the public school system. Additionally, the use of fluoridated tap water and dentifrice, and the decentralization and expanded coverage of public health services are associated with the reformulation of the Brazilian health system.

Regarding the nutritional status, Table 2 shows the coexistence of malnutrition (9.37%) and overweight (31.17%) among pre-scholars, also seen in the national surveys carried out[10,30] emphasizing the high prevalence of overweight and obese children, a situation observed in several countries worldwide.

Considering the methodology used, it was observed that the interpretation of the maps, according to the statistical evidence, can provide important contributions to understanding the process that outlines the special patterns of diseases, as already mentioned by Szwarcwald et al.[31].

Mainly in the case of dental caries and the children's nutritional status, the results suggest that the understanding of its prevalence cannot be carried out only through the spatial dimension (Figures 2 and 3), because the pure nugget effect were observed in the experimental semivariograms, showing an absence of spatial correlation. In the case of the dental caries, this claim may have occurred due to the high prevalence of the individuals with dmft index equal to zero, making an interpolation data process harder.

Regarding the nutritional status, the geostatistic analysis was accomplished from the categorized data, which could have contributed to the occurrence of the pure nugget effect.

Although the variables studied, treated separately, did not show spatial dependence, the importance of GIS in the health context should be emphasized, reaching the different levels of service management in order to increase the analytical capacity of the health situation, improving the exchange of information in its various sectors, and providing and disseminating information to the population.

Conclusion

The geostatistical analysis of the dmft index and nutritional status showed that these variables are not regionalized and consequently, do not reflect spatial dependence. Thus, new studies are suggested starting from data modeling and the association with social-demographic variables.

Collaborators

JADB Campos worked in the design of the study accompanied the data collection, conducted the data analysis and wrote the text; EA Melander developed the geo-referenced database and performed the geo-statistical analysis; JS Antunes conducted the collectionthe geographical reference points; ALR Foschini performed the oral and anthropometric clinical examination of preschool students and built the database.

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