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Spatial Analysis of Hospitalization for Heart Diseases in Vale do Paraíba

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Abstract

Background: Ischemic heart diseases (IHD) are important causes of death in the Vale do Paraíba paulista.

Objective: To identify patterns of spatial distribution of hospitalizations for acute myocardial infarction (AMI) and IHD in the Vale do Paraíba paulista.

Methods: This was an ecological study using exploratory spatial analysis of hospitalization data for acute myocardial infarction and ischemic heart disease in the Vale do Paraíba between 2004-2005. The statistical analysis used spatial georeferenced databases of 35 municipalities and spatial statistics routines. The admission data were obtained from the Portal Datasus of the Ministry of Health. The variables were the number of admissions for males and females aged over 30 years. To evaluate the spatial dependence we used the autocorrelation coefficients of Global Moran and Local Moran's index. We also analyzed the correlations between variables, using the Terraview program. The level of significance was 5%.

Results: Among 6,287 admissions, the rates were 161.66/100 thousand. Of the total of 35 municipalities, 31.4% had rates above average. The coefficient of Moran (global) showed a statistical significance. Local indexes showed clusters, indicating a cluster of 9 municipalities in which there was spatial dependence with their own dynamics.

Conclusion: In the mid Vale do Paraíba paulista, the spatial analysis identified spatial clusters of hospitalizations due to acute myocardial infarction and ischemic heart disease, allowing intervention to reduce rates. (Arq Bras Cardiol 2010;94(6) : 702-708)

Key words: Cardiovascular diseases/epidemiology; geographic information systems; myocardial infarction; myocardial ischemia; Vale do Paraíba (SP); Brazil.

Introduction

In recent decades, throughout the world, cardiovascular disease (CVD) has become the leading cause of mortality[1], according to the World Health Organization. By 2010, CVD will be the main cause of mortality in developing countries. Today, the accelerated growth in these countries is one of the most relevant public health issues.

In Brazil, the proportion rises to one in every three deaths from CVD, since, like everywhere else in the world, acute myocardial infarction (AMI) has an important impact in mortality and hospital admissions. Expenditure on hospital admissions for CVD are high in Brazil, exceeding the average for other diseases, and this has led the National Health System (SUS) to take steps to reduce them.

The understanding of how this context affects the population health stresses the importance of the incorporation of CVD in the public health agenda. In 2006, the total amount spent on hospital admissions for ischemic heart disease (IHD) and AMI in the Vale do Paraíba paulista was about 10% of the total amount spent on hospital admissions in the state of São Paulo.

For a long time the idea prevailed that these diseases were genetically determined and that little could be done to prevent them. However, the recognition of risk factors has changed this point of view.

The impact and influence of behavior and lifestyle on the development and progression of heart diseases are undeniable. Modern epidemiologists have come to see the environment and lifestyle of individuals as causes of diseases. The importance of including environmental factors; socio-economic development; the process of urbanization; and its impact on the lifestyle of the population, has begun to be taken into account[2,3]. The mapping of events becomes an important tool for the public health system, both for diagnosis and planning. Spatial analysis permits the implementation of health programs that include several municipalities or regions of the state, or even districts of a city. In our region, a recent study was designed to assess the neonatal mortality[4].

Original Article

The objective of this study was to identify the spatial pattern of hospitalizations for acute myocardial infarction and ischemic heart disease in the municipalities of Vale do Paraíba paulista between 2004 and 2005.

Methods

This was an ecological and exploratory study which used spatial analysis of area data. The area analysis unit was formed by the municipalities of the health region of Taubaté (SP). This region consists of 35 municipalities (Figure 1), with a population of two million inhabitants, and is located between the Mantiqueira and the Serra do Mar mountain ranges, and between the cities of São Paulo and Rio de Janeiro. The region is crossed by the Dutra highway, and its economy is based on the manufacturing industry, on dairy farming and agriculture.

For spatial statistical analysis, we created a georeferenced database of the municipalities that constitute the region (excluding the municipalities of the north coast, which are far from the vicinity of the Vale do Paraíba paulista and do not have direct contact with those municipalities), using the SPRING program, version 4.1[5], a public domain software, and spatial statistical routines, which were implemented in the SPRING program and in the TerraView program, version 3.2.0[6].

The digital database used was generated from the existing georeferenced data, which were compiled and processed by the GIS Laboratory (LAGEO), University of Taubaté (UNITAU). Morbidity data were obtained using the DATASUS portal and refer to the municipality of residence[7]. These data, presented on a consolidated basis, were for the years 2004 and 2005, and the morbidity list included only AMI and IHD, in the age group over 30 years, for both genders, analyzed separately and then together.

The statistical analysis was based on the techniques proposed by Cliff and Ord[8], which are suitable for studying mortality spatial distribution, by testing the hypothesis of spatial independence. As a measure of spatial dependence, we used the global Moran coefficient of autocorrelation to evaluate the degree of association in the data set, allowing for several possibilities of generalizing associations at local level. This index ranges from -1 to +1. A value close to 1 means that the municipalities are very similar. We also used the local Moran index (LISA), which determines the dependence of local data in relation to neighbors. This indicator helps to identify spatial association patterns that may characterize the occurrence of groups (clusters) among the polygons that constitute the database. The local Moran index (LISA) indicates the local autocorrelation, i.e. it detects the municipalities which influence the overall indicator, by assessing the covariance between a municipality and a certain neighborhood, in function of the distance.

Thus, it is possible to identify sub-regions which are responsible for spatial dependence. In parallel, we calculated the measure of spatial significance through random permutation of the other figures in the georeferenced database, and we evaluated the significance from the analysis of the normal distribution of these values. Therefore, this local analysis was characterized by a decomposition of the global index, to determine where there is non-stationarity. The total hospitalization rates and the hospitalization rates by gender were correlated with the per capita income and the São Paulo Social Responsibility Index (IPRS) (available at <http://www.al.sp.gov.br/web/forum/iprs06/Estado.html>). The IPRS ranges from 1 to 5, with the value 1 indicating the best evaluation. The statistical Student t-test compared the rates of the municipalities with IPRS 1 (better) with those of the municipalities with IPRS 5.
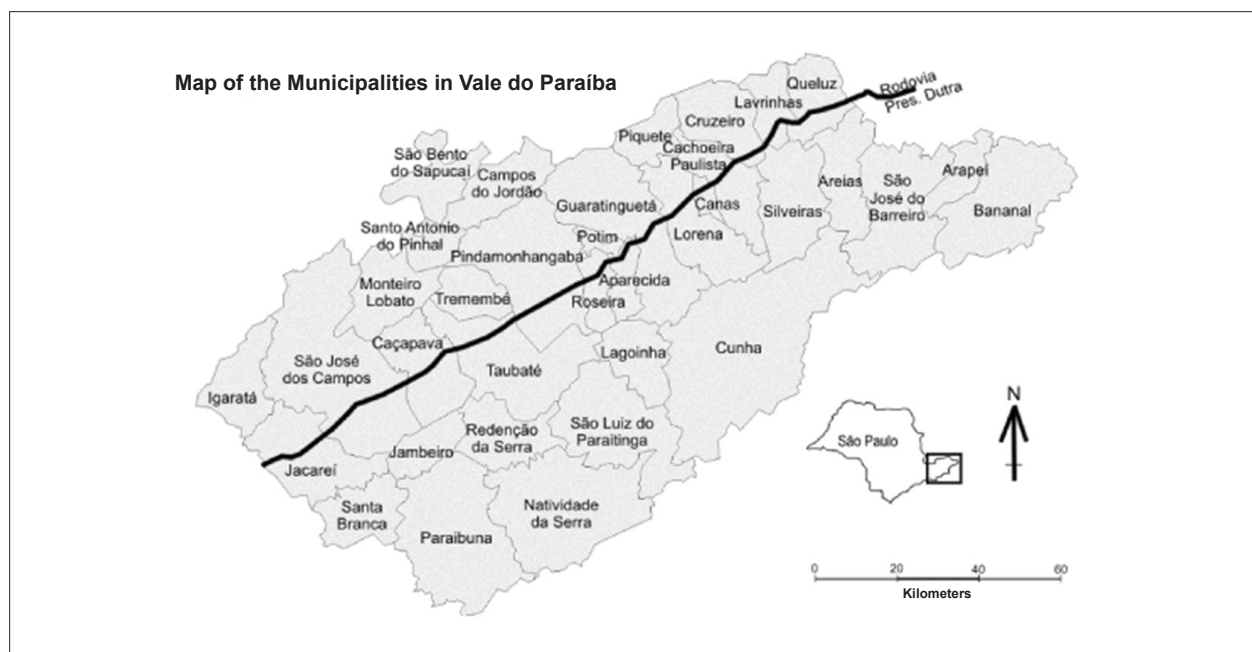

Figure 1 - *Municipalities of the Vale do Paraíba, with the Dutra Highway highlighted. (Nascimento et a., 2007).*

Original Article

In the case of statistical significance of this coefficient, the independent variables taken into account were studied for their association with spatial clusters matches. The statistical significance adopted was 5%.

Results

In a two-year analysis conducted in the Vale do Paraíba paulista, 6,287 cases of hospital admission of patients over 30 years (about 28% from AMI, and 72% from IHD) have been reported. Of the total admissions, 39.9% were female (35.3% from AMI, and 41.6% from IHD), and 60.1% were male (64.7% from AMI, and 58.4% from IHD).

Considering the separation by age, the majority of admissions lie in the age range of over 50 years. The summary data are presented in Table 1.

As for total hospitalization rates, 31.4% of the municipalities had above average values. Male rates (188.4/100 thousand) were higher than female rates (134.4/100 thousand), and 34.2% of municipalities had above average values for both genders.

The existence of spatial autocorrelation was tested on rates, and the values were statistically significant, indicating spatial dependence. The test confirmed the presence of spatial clusters obtained for total male and female rates for the number of admissions. The global Moran's coefficients were 0.37 ($p = 0.009$) for both genders, 0.31 ($p = 0.018$) for males, and 0.35 ($p = 0.015$) for females. These values indicate spatial dependence among the cities analyzed.

The spatial distribution of total rates shows the existence of a cluster in the northwest region toward the southeast, which indicates a positive correlation and $p < 0.05$ (Figure 2a). The existing polygons are composed of high and low rates, and they were higher in the municipalities near the capital. Toward the historic Valley, the rates are higher near the cluster center. Bananal, which is far from the cluster center, has a high rate compared to its neighbors. In LISAMAP, there are two municipalities with significant levels, with $p < 0.001$: Bananal, located at the eastern end of Vale paulista toward Rio de Janeiro and Campos do Jordão, in the Mantiqueira mountain range; São Bento do Sapucaí, with $p < 0.01$, and São José dos Campos, Taubaté, Redenção da Serra, and Lorena, with $p < 0.05$, totaling 20% with their own dynamics (Figure 3a).

The spatial distribution of the male rates indicates a pattern very similar to that observed in the distribution of total rates, but with an increase in the number of polygons with higher rates, especially toward the capital; Areias and Caçapava had higher rates (Figure 2b).

In LISAMAP, the setting indicates the existence of separate areas, with statistically significant index values: Bananal, São Bento do Sapucaí and Campos do Jordão had $p < 0.001$. In Santo Antonio do Pinhal and Taubaté, the indexes were $p < 0.05$, totaling 14% with dynamics of their own (Figure 3b).

The distribution of the female rates indicates a concentration of high rates in most municipalities, especially the existence of a central cluster, extending from northwest to southeast, however, it differs on the east and west axis, as there is a predominance of rate reduction in many municipalities (Figure 2c). The LISAMAP for females shows São Bento do Sapucaí and Redenção da Serra with $p < 0.001$; Queluz and Campos do Jordão with $p < 0.01$; and São José dos Campos, Taubaté, Caçapava with $p < 0.05$, totaling 20% with their own dynamics (Figure 3c).

The total hospitalization rates and the hospitalization rates by gender were not correlated with the per capita income and the values of IPRS. When comparing the mean hospitalization of the municipalities (5) with IPRS = 1 and of the municipalities (16) with IPRS = 5, we found that these were not statistically different (data not shown).

Discussion

Although cardiovascular diseases are considered the main cause of death in Brazil, studies addressing this topic are few. The same is true in relation to the spatial distribution and their interactions with socioeconomic and environmental factors. This is the first study in the Vale do Paraíba paulista in the State of São Paulo using the technique of spatial analysis to identify spatial clusters and investigate the spatial pattern of the number of hospitalizations for ischemic heart disease (IHD) and acute myocardial infarction (AMI) during 2004 and 2005.

Currently, spatial analysis is an important tool for the study of certain diseases, from their emergence, their spread and possible ways to combat them, up to the influence of individual and contextual factors in population groups.

The proportion of admissions for AMI in age groups over

Table 1 - Number of admissions for IHD and AMI by age group and gender, Vale do Paraíba, 2004-2005

Age range	Total				AMI*				IHD**			
30 to 50 years (19.3%)	1,209 (100.0%)				334 (27.6%)				875 (72.4%)			
	Female		Male		Female		Male		Female		Male	
	423	35.0%	786	65.0%	92	27.5%	242	72.5%	331	37.8%	544	62.2%
> 50 years (80.7%)	5,078 (100.0%)				1,430 (28.2%)				3,648 (71.8%)			
	2,082	41%	2,996	59%	532	37.2%	898	62.8%	1,550	42.4%	2,098	57.6%
> 30 years	6,287 (100.0%)				1,764 (28.0%)				4,523 (72.0%)			
	2,505	39.9%	3,782	60.1%	624	35.3%	1,140	64.7%	1,881	41.6%	2,642	58.4%

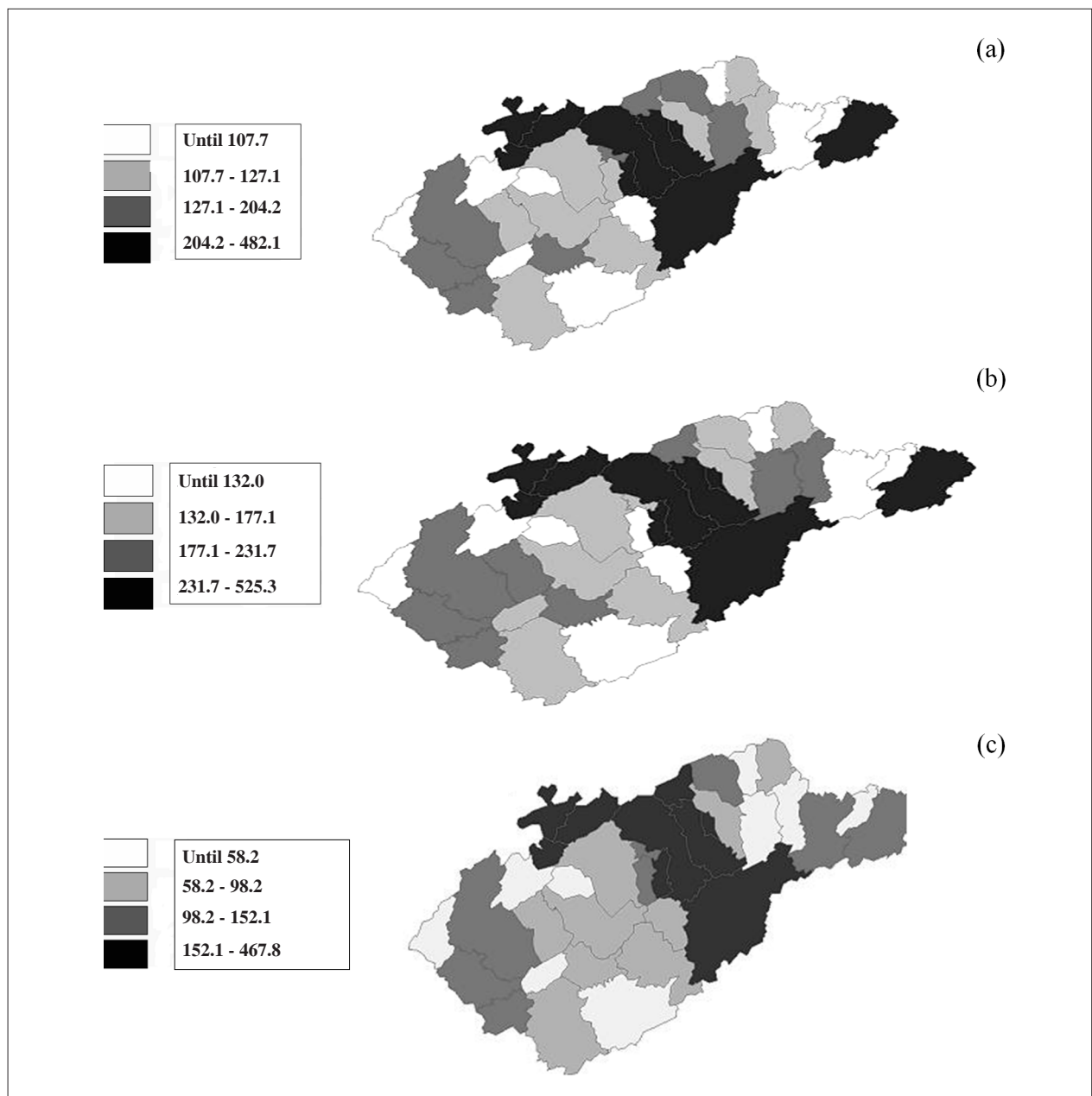*Acute myocardial infarction; ** Ischemic heart disease.*

Figure 2 - *Hospitalization rates for acute myocardial infarction and ischemic heart disease by age range over 30 years for (a) both genders, (b) male, and (c) female patients. Municipalities of Vale do Paraíba paulista, 2004 and 2005.*

50 years was higher for males, corroborating a study that revealed that the increase in mortality and frequency of acute myocardial infarction in the elderly is higher in women than in men[9].

The spatial pattern of admissions for females was significant in several municipalities, increasing in less developed municipalities.

The global Moran index (I), applied to total hospitalization rates and hospitalization rates by gender, showed positive values which indicate positive spatial autocorrelation. This is an indication that the rates in the Vale do Paraíba paulista are connected, and that there is a strong relationship among the municipalities, which is even stronger among nearer neighbors.

The spatial distribution highlights the existence of a spatial cluster located almost in the central region of Vale do Paraíba paulista, around 60 km from the Dutra Highway, extending from the Serra do Mar to the Mantiqueira mountain range (southeast - northwest axis), an area with a concentration of high rate municipalities. Aparecida, Potim, Guaratinguetá, Cunha, Lorena, Campos do Jordão, Santo Antonio do Pinhal and São Bento do Sapucaí have positive and significant spatial correlation. The existence of spatial dependence is also
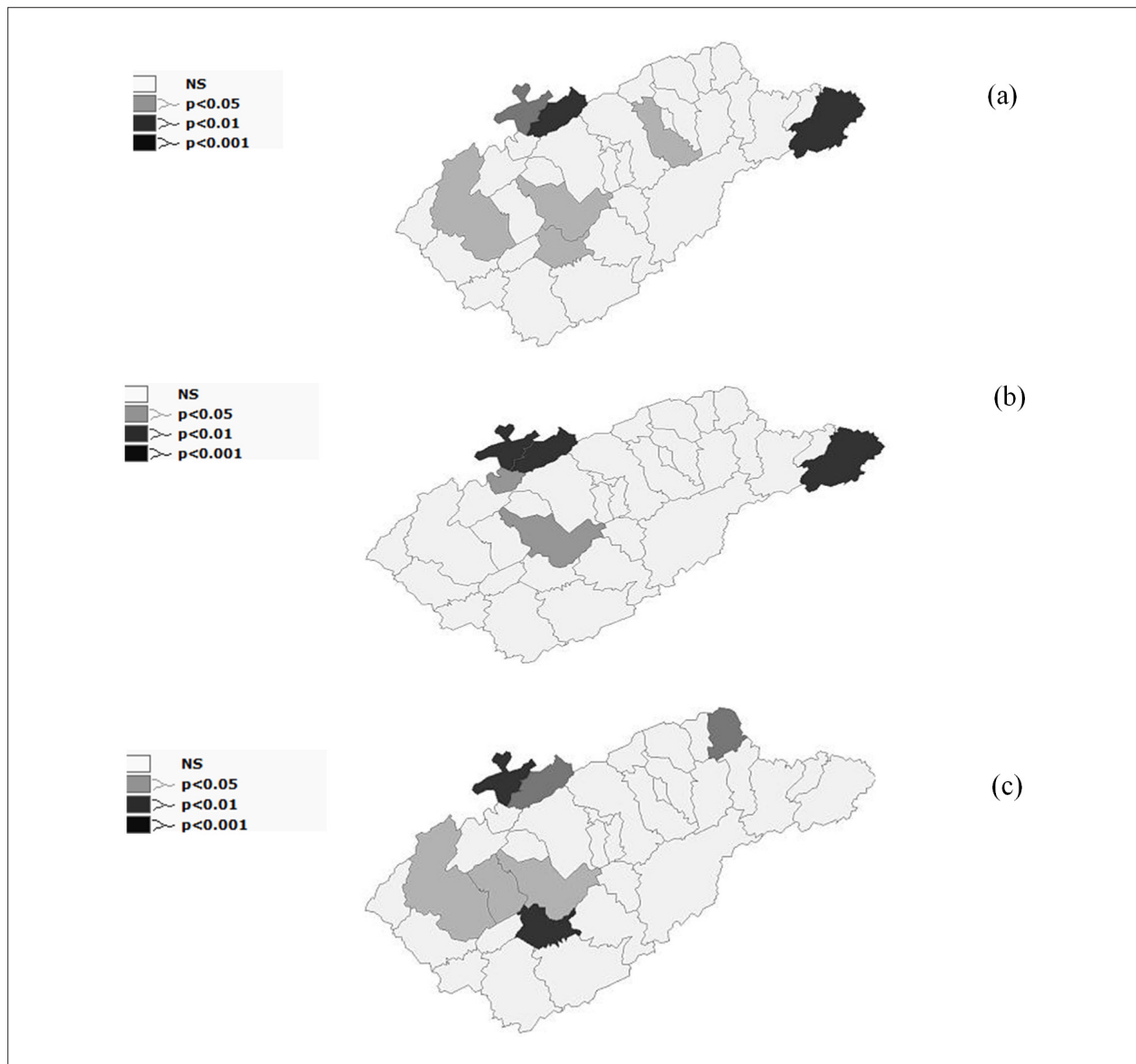
Original Article

Figure 3 - *LISAMAP rates of hospitalization for acute myocardial infarction and ischemic heart disease by age group over 30 years for (a) both genders, (b) male, and (c) female patients. Municipalities of Vale do Paraíba paulista, 2004 and 2005.*

observed from west to east, in places where rates fluctuate.

The rates are lower towards São Paulo, and higher towards the historic Valley. There is a consequent increase in spatial dependence in this area due to an increase in total rates, male and female; the same happens less conspicuously in some municipalities towards São José dos Campos.

Pindamonhangaba, Taubaté, Redenção da Serra and Natividade da Serra are neighboring municipalities and lie in the vicinity of the cluster center. This group is less conspicuous, i.e., their rates are lower, as these municipalities have positive spatial correlation and statistical significance. Guaratinguetá, Campos do Jordão, Santo Antonio do Pinhal and São Bento do Sapucaí are municipalities that, in the two-year period of the analysis, had high rates and dynamics of

their own - they are "pockets" that concentrate the highest rates. Campos do Jordão and São Bento do Sapucaí also had high rates and statistical significance. Santo Antônio do Pinhal and Guaratinguetá showed statistical significance with respect to male and female rates, whereas the rate for both genders the value was at the limit, p = 0.07 (data not shown). We observed in LISAMAP that there is clearly a bias in admissions in the Guaratinguetá region that extends from northwest to southeast.

Taubaté and Redenção da Serra, followed by the Natividade da Serra, Pindamonhangaba, Caçapava and Santa Branca, located in the southwest of the Valley, can also be seen as "pockets" because they are areas with their own spatial dynamics.

The variations among the values of hospitalization rates in the Valley indicate the existence of a heterogeneous spatial pattern associated with a strong social gradient. "Noble" and poor, rural and industrial populations coexist side by side. This composition brings to the Valley an organization marked by contrasts, with patterns that are compatible with the social contrasts observed in other studies of CVD[10].

Some municipalities have so called noble and poor populations living side by side (Campos do Jordão, Santo Antonio do Pinhal and São Bento do Sapucaí), especially Campos do Jordão, which receives tourists with high purchasing power, unlike the resident population, which has low income and poor living conditions.

Guaratinguetá has a modest industrial park, a significant agricultural economy and an especially intense commercial activity, as well as education centers and two SUS hospitals, which prioritize the health care needs of the residents of the municipality. Probably residents of other municipalities go to Guaratinguetá seeking medical care and use its health services as if they were in their city of residence, although they truly reside in other cities. Guaratinguetá became the municipality of reference, particularly for the population living in the bottom of the valley, and there is intense affluence of neighbors and positive spatial correlation, especially towards the historic Valley.

Municipalities with better equipped hospitals attract the surrounding population, especially for the treatment of IHD, because, as there is no immediate life risk, the patients can choose the best time to request a leave of absence from their activities and undergo the needed treatment for a few days.

Taubaté and São José dos Campos possibly exert the same influence as Guaratinguetá, although they have dynamics of their own. Besides all individual and contextual factors, it is likely that other factors may be taken into account to justify their high rates of hospitalization, especially when compared to cities that have greater demand for admissions and better quality of medical and hospital resources. Situated in the most prosperous part of the Valley, with a large industrial park, educational centers and hospital network - and in the case of Taubaté, a regional hospital - and a high human development index (HDI)[11] compared to the rest of the region, these cities have become a reference to neighboring municipalities. Many individuals who reside in other cities go there in order to enjoy a high quality health service. Perhaps the easy access to health networks is responsible for their high rates of hospitalization for IHD and MI, and also the easy access to hospitalization, which is done few hours after the onset of symptoms, as well as the availability of specialists and services with reasonable spatial distribution.

Bananal lies 150 km from Guaratinguetá, and is a municipality with a predominantly rural economy, located in the east corner of the region. It presented significant values of spatial independence, with some relevant factors that have been taken into account to justify its high rates of hospitalization, such as the distance from the municipalities

that are considered as references - Guaratinguetá and Taubaté. Due to the distance and the need for emergency care for AMI, the treatment is provided in the municipality.

Possible attempts to explain the results obtained in this study consider that CVD reflect a summation of individual and/or contextual factors that affect individuals at different stages of life, especially in a society whose factors are inflicted on the individual, mantaining a clear relationship with the socio-economic, educational, cultural and environmental conditions of the region[12]. The possibility of the existence of a positive association between the results and the influence of individual and contextual factors indicate the need for further studies involving recognized risk factors for IHD and AMI.

Unlike the case-control study of Silva et al[13], which analyzed the primary data of hospitalized subjects in 20 medical centers, identifying, among other factors, hypercholesterolemia, high blood pressure and smoking habit, we were unable to identify these factors in this study because such information was not included in the DATASUS portal. But then, a study with secondary data allowed us to estimate an increase in expenditure on treatment of cardiovascular disease as the population ages[14].

This study considered safe and effective the population strategy for disease prevention, since the emphasis is on the diseases of the population as opposed to the diseases of the individual, although they should not be mutually exclusive. There may be limitations, because the data used in this study are secondary, obtained from the DATASUS Portal and provided by the health departments of the municipalities, and errors may occur in diagnosis, and the rates may be overestimated. However, at the time of hospital release, the SUS ratifies or amends the diagnosis, and minimize errors.

In this study, admissions made by operators of health care facilities or organizations, which may underestimate the values, were not taken into account. Information on the socioeconomic status of each hospitalized individual is not provided by DATASUS. However, the IPRS shows, in this study, a correlation or association between different socioeconomic conditions and the rates of hospitalization. We are aware that, in an ecological study, the target of scrutiny is the population and not the individual, which may lead to possible ecological fallacies.

Thus, the approach met the proposed objectives, identifying possible spatial patterns in the number of hospitalizations for acute myocardial infarction and ischemic heart disease in the municipalities located at the Vale do Paraíba paulista, in the period of 2004-2005. Epidemiological cross-sectional or case-control studies that include personal information should be performed to clarify the differences in hospitalization rates found in this study.

Acknowledgements

Original Article

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