

# HOSPITAL ADMISSIONS FROM MOTORCYCLE ACCIDENTS IN THE VALE DO PARAÍBA: A SPATIAL APPROACH

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## ABSTRACT

**OBJECTIVE.** To identify clusters of municipalities with high rates of hospital admissions because of motorcycle accidents in the “Vale do Paraíba”.

**METHODS.** This was an ecological study and exploratory data was obtained from DATASUS for the period 2001 to 2005 for 27 municipalities in the part of the “Vale do Paraíba” that falls within São Paulo state and covering a population of about one million inhabitants. Spatial analysis was with Terraview software and Moran Global coefficients were calculated for hospital admission rate and motorcycle fleet, while the Pearson correlation was used for admissions. Thematic maps of spatial distribution and a BoxMap were constructed. Hospitalization data were presented as rates per 100 thousand inhabitants.

**RESULTS.** During the study period 1268 people were admitted, ranging from one to 608 hospital admissions per municipality. The Moran Global Index (IM) = 0.34 ( $p = 0.02$ ) for hospital admission rate and IM = 0.42 ( $p = 0.012$ ) for admission rate by fleet. There was also strong correlation between motorcycle fleet and rate of hospital admission because of motorcycle accidents, ( $r = 0.94$ ).

**CONCLUSION.** A large cluster of nine municipalities was identified in the western region of the Paraíba Valley, thereby indicating where those hospitalized for motorcycle accidents lived and highlighting municipalities where preventive measures should be implemented.

**KEY WORDS:** External causes. Geography. Epidemiology, Descriptive. Public health.

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## INTRODUCTION

External causes of morbidity and mortality, and traffic accidents in particular, have attained extremely significant proportions, compromising the health of populations. They have reached levels similar to cardiovascular diseases, which are the principal cause of morbidity and mortality in Brazil. In general, accidents are complicated because they involve a series of events and environmental factors which are very often linked to the people and vehicles involved and also to the public highways. <sup>1</sup> Accidents and violence (external causes) have a significant impact on the health of populations in many different countries worldwide. Comparison with other countries shows that the figures in Brazil are extremely high: ranked third in terms of homicides and fifth in terms of traffic accidents. <sup>2</sup>

According to Brazil's federal traffic authority, an accident is any unintentional event involving at least one vehicle, whether motorized or not, circulating on a road intended for vehicles. <sup>3</sup>

The World Health Organization (WHO) estimates that around 1.2 million people lose their lives because of these causes worldwide and there is an even greater number of hospital

admissions, emergency service utilization and both physical and psychological sequelae. <sup>4</sup> Estimates based on figures from developed countries suggest that 80% of all costs related to vehicle collisions can be attributed to nonfatal events. <sup>5</sup>

In this context, accidents involving motorcyclists are of great importance.

Brazil has five administrative regions and the region with the highest rate of motorcycle accidents was the Southeast, followed by the Northeast, Midwest, South and North regions; spending by the Brazilian national health service, for hospital admission, was approximately R\$ 58 million (SE), R\$ 22 million (NE), R\$ 10 million (MW), R\$ 12 million (S) and R\$ 2 million (N). <sup>6</sup> In 2005 specifically, R\$ 31 million were spent in Brazil and more than R\$ 10 million were spent in the State of São Paulo on hospital admissions caused by motorcycle accidents. <sup>6</sup>

Spatial analysis is a geostatistical tool that is becoming widely used in research, whether in the field of health or in many others. One of its applications is the identification of spatial clusters. A spatial cluster is: any grouping of events that is not merely by chance and the identification of which is the focus of research in spatial statistics. <sup>7</sup> Constructing colored maps,

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called choropleths, is a common method for illustrating data grouped by area, and is a simple method for the translation of this information, due to visual perception of the problem. After construction, the maps are analyzed to determine whether the distribution of these events really does follow a pattern or is random. Furthermore, the data can prove useful in other areas, such as road safety education and traffic control, serving as the foundation for accident reduction.<sup>8</sup> Therefore, one application of spatial analysis is to identify the locations with the greatest intensity of accidents – critical areas – serving as a basis for the implementation of measures for prevention and control.

The objective of this study was to identify spatial clusters of municipalities with high rates of hospital admission because of motorcycle accidents.

**METHODS**

This was a study with an ecological and exploratory design, analyzing hospital admission data from the Brazilian National Health Service (SUS, *Sistema Único de Saúde*) covering the period from January of 2001 to December of 2005. Population data were estimated mathematically, multiplying the number of residents in the municipalities in 2003 by five, in order to provide an estimate covering the 5 years of data. Rates were calculated per 100 thousand inhabitants and per 1000 motorcycles for analysis on the basis of one type of address: residence of victim. This study analyzed diagnoses V20 to V29 of the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10).<sup>9</sup>

Data were georeferenced by the accident victims' municipalities of residence.

Twenty-seven municipalities were analyzed for this study, corresponding to the old XXIV Regional Health Directorate of Taubaté. This area has a population of a little less than one million inhabitants, is located in the part of the Vale do Paraíba that falls within the State of São Paulo, in the East of the state, and links the states of São Paulo, Minas Gerais and Rio de Janeiro. It occupies a strategic position between the Serra do Mar and the Serra da Mantiqueira and the Presidente Dutra highway runs through it (Figure 1 ).

**Figure 1 - Map of the municipalities in the Vale do Paraíba, state of São Paulo**



The spatial statistical treatment was performed with the aid of Terraview software, provided by INPE, and employed a georeferenced database of the municipalities and the analysis by area technique to obtain the Moran Global indices, (I), first order autocorrelation and Pearson's correlation coefficient, (r), which are expressed, respectively, by:

In the first equation, for the Moran Global Index, we have n which corresponds to the number of areas (municipalities),

$$I = \frac{n \sum_i \sum_j w_{(i,j)} (x_{(i)} - \bar{x})(x_{(j)} - \bar{x})}{\sum_i \sum_j w_{(i,j)} \sum_i (x_{(i)} - \bar{x})^2}$$

$W_{(i,j)}$  is equal to the weight of neighbors,  $X_{(i)}$  represents the square root of the mean incidence rate for the municipality  $i$  during the periods studied and  $\bar{X}$  is the mean of all  $X_{(i)}$  for the whole region studied. In the second equation, for Pearson's correlation,  $X_{(i)}$  and  $Y_{(i)}$  represent the values of the variables  $X$  and  $Y$ , respectively, and are the means of the values  $X_{(i)}$  and  $Y_{(i)}$ . Here, the variables  $X_{(i)}$  and  $Y_{(i)}$  represent the motorcycle fleet and the number of admissions in each municipality  $i$ .

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(\sum (x_i - \bar{x})^2)(\sum (y_i - \bar{y})^2)}}$$

The Moran Index is a global measure of spatial autocorrelation, which indicates the degree of spatial association in a dataset on the basis of the relationship between the product and the mean. Possible values are in the range [-1; 1]. Once calculated, it is important to establish the statistical validity, by estimating significance. If the result corresponds to an extreme of a distribution simulation, then the result is statistically significant. Pearson's coefficient also varies between -1 and 1. The closer it is to 1 or -1, the stronger the linear correlation between the two variables. The correlation between fleet and admission rate was estimated using this coefficient.

Another method of analyzing spatial dependency is by using LISA local autocorrelation and producing a Moran scatter plot – which is another way of visualizing spatial dependency. In this case, one takes the value of the indicator for a subarea comprising neighbors. This technique makes it possible to visualize the degree of similarity between neighbors, identifying points at which certain characteristics predominate. Quadrants can be interpreted as: Q1 - High-High (positive values, positive means) or Q2 - Low-Low (negative values, negative means), which have a positive spatial association, having neighbors with similar values; or as Q3 - High-Low (positive values, negative means) or Q4 - "Low-High" (negative values, positive means) which have a negative spatial association, having neighbors with differing values.

Choropleths were constructed for the rate of admissions per 100 thousand inhabitants and for the rate of admissions

per 1000 motorcycles and also for the *BoxMap*, which is an alternative to the Moran scatter plot that makes it possible to visually identify those municipalities in which possible intervention measures are indicated.

Since this was an ecological study based on unidentifiable data available on the internet, the requirement for a Research Ethics Committee hearing was waived.

## RESULTS

A total of 1,268 people were hospitalized during the study period, ranging from one to 608 admissions. The mean per municipality was 46.9 admissions (SD=117.5). The mean cost of admissions was approximately R\$ 40 thousand per municipality, ranging from R\$ 40 (Arapeí) to R\$ 600,000 (Taubaté). The Moran global index ( $I_M$ ) and its respective p-value ( $p$ ) were  $I_M = 0.34$  ( $p=0.02$ ) for the rate of admissions/100 thousand inhabitants. Figure 2A illustrates the distribution of hospital admissions because of motorcycle accidents per 100 thousand inhabitants, by place of residence of those admitted. There is an obvious cluster of municipalities in the West of the Vale do Paraíba, where the greatest rates of admission per 100 thousand inhabitants are concentrated.

There was a strong correlation between motorcycle fleet and admissions ( $r = 0.94$ ). The Moran Index and p-value for this variable were  $I_M = 0.42$  and  $p = 0,012$ . A cluster with high rates of admission by fleet was identified in the West of the Vale do Paraíba, encompassing the following municipalities: São Bento do Sapucaí, Santo Antônio do Pinhal, Tremembé, Redenção da Serra, Natividade da Serra, São Luiz do Paraitinga and Areias, (Figure 2B).

As can be observed on the Moran scatter diagram (*BoxMap*), in the West there is a cluster of eight municipalities, all in Q1, exhibiting high rates of admission, which directly indicates the regions where those who suffer most motorcycle accidents live (Figure 2C). The municipalities in this Q1 cluster were: São Bento do Sapucaí, Santo Antônio do Pinhal, Campos do Jordão, Pindamonhangaba, Tremembé, Taubaté, Natividade da Serra and Redenção da Serra.

## DISCUSSION

This spatial analysis study of motorcycle accidents is the first to be conducted in the Vale do Paraíba. Its importance lies in the identification of clusters of municipalities with high rates of motorcycle accidents.

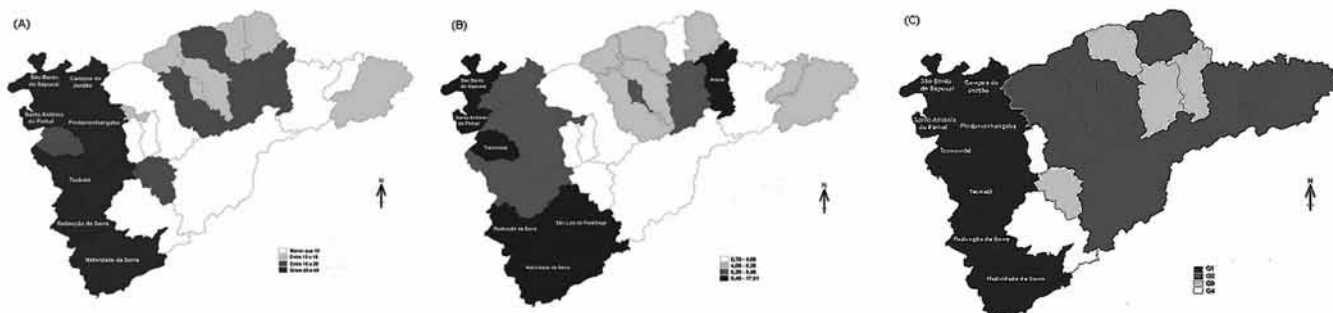
A similar strategy was employed by Bastos et al,<sup>10</sup> in Vitória, ES, in a study that analyzed the spatial distribution of mortality due to accidents, identifying accident victims' residential addresses and relating the results to the socioeconomic context. That study showed that traffic accidents are responsible for 21.8% of violent deaths, to the extent that they can be defined as a public health problem.

In another study conducted in Recife, PE, traffic accidents were more prevalent in areas with better socioeconomic conditions. This possible connection was linked to a probable increase in the number of people and vehicles in circulation in areas with higher social status. The study described here did not analyze the populations' socioeconomic status.<sup>11</sup>

In our study, the West of the part of the Vale Paraíba that falls within the state of São Paulo contained a cluster of eight municipalities that exhibited elevated rates of admission because of motorcycle accidents. One of these was Taubaté, which had the greatest expenditure on these events.

Spending on these types of admissions has also increased in Brazil as a whole, from R\$ 13 million in 2001 to R\$ 31 million in 2005.<sup>6</sup> According to the Municipal Health Department of São José dos Campos, both in Brazil and in the State of São Paulo, external causes demand greater mean expenditure per patient-day than conditions with natural causes, despite causing fewer admissions of shorter mean duration. The picture painted here is undoubtedly having an immense impact on public healthcare resources. However, as has been stated by the State Health Department of São Paulo,<sup>2</sup> despite the magnitude of the costs involved in caring for the victims of violence and despite the economic cost of the loss of productivity due to death, incapacity or prison, few studies have been conducted in Brazil that attempt to assess the economic impact of external causes. When all admissions in the State were analyzed according to ICD-10

**Figure 2 – Map of place of residence with rate of admissions because of motorcycle accidents: per 100 thousand inhabitants (A), and by thousand motorcycles (B), Moran scatter plot map (C), Vale do Paraíba, 2001-2005**



chapters, it was observed that accidents and violence have a strong impact on hospital costs since they were in sixth place in terms of number of admissions, but were in third place in terms of the amount paid out by the SUS.

A similar situation was observed in São José dos Campos, SP,<sup>13</sup> where traffic accidents were not only the principal cause of hospital admissions (32.8%), but were also the number one cause of expenditure (41.2%). This municipality was not covered by our study since it is not part of the Taubaté administrative region, but it is another important pole within the Vale do Paraíba.<sup>12</sup>

After investigating age as a possible aggravating factor in motorcycle accidents, Bastos et al.<sup>10</sup> concluded that the majority of victims were predominantly young people of productive age (median of 25 years old). We did not analyze age as a variable in our study.

With relation to the location of the accident and the location of the residential addresses of the victims, it can be concluded that both are important, but that they are different. One study of neighborhoods in the city of Rio de Janeiro identified impressive differences between location of victims' residences, location of occurrence of accident and location of death.<sup>13</sup> In order to implement preventative measures, it is important to determine the types of traffic accident and where each type occurs. Therefore, when choosing to work with traffic accident data, the location in which they are most frequent is analyzed. This, in turn, provides information to enable the competent authorities to identify the causes for large numbers of accidents in a given place and implement preventative measures such as better policing, speed cameras and other techniques. When choosing to work with the residential addresses of the victims, the objective is to identify the regions in which the people affected live and, on the basis of this information, implement preventative and educational interventions with the local population. The data for this study on admissions because of motorcycle accidents by residence were collected from the DATASUS web portal. This was an intramunicipal rather than an intermunicipal analysis.

This study may suffer from certain limitations: one possible cause is that the analysis did not consider the age or sex of those admitted. Is it possible that younger or male accident victims were more common? This is a question that will be answered by a study design covering all 35 municipalities in the Vale do Paraíba. Another possible limitation is related to the location of the accidents, i.e. did a given motorcyclist who lives in a given municipality suffer the accident in that municipality or in a different one? Did the accident take place on local streets or on the highways that cut through the region's municipalities? This limitation was caused by the fact that the DATASUS database does not contain this information.

Notwithstanding, analysis of the data on admissions because of motorcycle accidents by municipal populations and motorcycle fleets identified eight municipalities that require interventions to reduce the scale of the problem. These are: São Bento do Sapucaí, Santo Antônio do Pinhal, Campos do Jordão, Pindamonhangaba,

Tremembé, Taubaté, Natividade da Serra and Redenção da Serra, as shown on the *BoxMap*, which is an alternative to the Moran scatter plot.

## CONCLUSIONS

Spatial analysis of accidents involving motorcycles was capable of identifying clusters of municipalities with high rates and of identifying municipalities where interventions are needed in order to reduce these rates.

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