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Spatial and Temporal Modelling of Hospital Admissions in the Northern Region of Portugal

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Abstract. *The main goal of this project was to analyse and to characterize the hospital admissions in the Northern Region of Portugal during the period 2000 to 2007. Hypothesis testing was performed to compare the Age-Standardized Rates of hospital admissions between Portugal, the Northern Region and the Primary Health Care groups that we call ACES. We proposed methods in temporal and spatial analysis in order to characterize the evolution of hospital admissions and their spatial distribution.*

Keywords. *Hospital admissions; Portugal's Northern Region; Hypothesis testing; Time series; Spatial analysis*

1 Introduction

Hospital admission rates, hospital admission causes and other hospital-based data are currently considered important indirect measures of the burden of certain diseases in the community. For example, there are studies that, using specific methods, seek to estimate the incidence of certain chronic diseases, based on hospital morbidity data.
This study is a joint project conducted by the Public Health Department of Portugal's Northern Region Health Administration and the University of Minho. The main goal of this project focused on the spatial and temporal analysis of hospital admissions in the Northern Region of Portugal. Information included episodes of hospital admissions of residents in Portugal, occurring between the years 2000 and 2007. This information relates only to admissions in public hospitals in the National Health Service (NHS) and was collected from the Central Administration Health System's Diagnosis Related Groups (DRG) data base.
In Portugal we are undergoing a reform of Primary Health Care (PHC) services, and as a consequence of this, now PHC services are organized in what we call ACES (a kind of PHC Groups). There are 26

ACES in Portugal's Northern Region. This study began with the geographical characterization of hospital admission distribution, comparing hospital admission Age-Standardized Rates. A comparison was made between Portugal, the Northern Region and the ACES.
Methodologies were developed in the areas of temporal and spatial statistics. A temporal analysis of hospital admissions in the Northern Region was made for some causes of hospital admission with the purpose of forecasting certain diseases, such as those of the respiratory system. A method to perform the same analysis to any set of data relating to any hospital admission cause was established. A spatial analysis at municipality level was also conducted in order to identify clusters that showed a higher risk of hospital admission, for specific causes, in the different municipalities.

2 Methods

2.1 Analysis of Age-Standardized Rates of Hospital Admissions

The hospital admissions Age-Standardized Rates was used to make comparisons between regions. Age-Standardized Rates (ASR) were provided by $ASR = \sum_{i=1}^{k} \frac{np_i}{n_i * np} * x_i$. Hypothesis testing was applied to compare Age-Standardized Rates in the Northern Region to the ones in the country (excluding Madeira and the Azores) and the Northern Region to the ACES (see Reference [4]). This comparison was made for all ages, for ages 0 to 64 years, for both sexes and for every cause of admission. Maps, such as the one presented in Figure 1, have been produced.

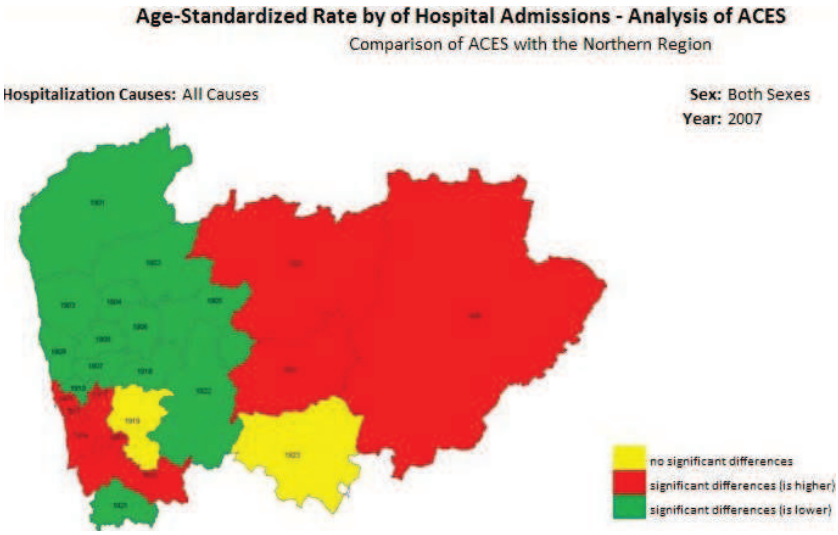

Figure 1: Age-Standardized Rates for all causes and both sexes.

2.2 Temporal Models

A temporal analysis of hospital admissions in the Northern Region from 2000 to 2007 (see Figure 2) was made with the aim of obtaining the behaviour and evolution of the series, forecasting and developing a method that allowed us to make the same type of analysis for every set of data, referring to any cause of admission. Here, in this paper, only the study of the Northern Region hospital admissions series is presented. This series, stationary in the mean, presents a growing linear trend, as well as a seasonal effect

(monthly seasonality). It was clear that a considerable amount of heteroscedasticity does exist in the data. We use Box and Cox transformation (log transformation). The series was modelled using a MA(1) process: $Z_t = 6.431 + 0.0021t + s_t + e_t - 0.217e_{(t-1)}, \quad t = 1,\ldots,84$. Model adequacy was checked by the analysis of residuals like Ehlers [3]. Figure 2 represents the forecasts for hospital admissions in the Northern Region and respective confidence intervals. A 5% growth in relation to 2007 is foreseen for 2009 (records from 2007 onwards are not available yet).

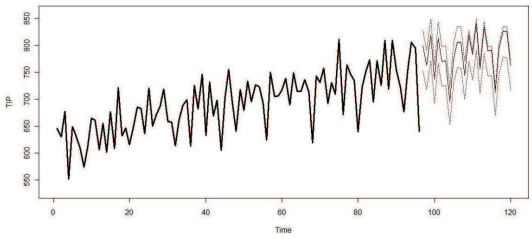

Figure 2: Observed values until 2007 and predictions from 2007 until 2009 with 95% point-wise prediction intervals.

2.3 Spatial Analysis

Taking into account the spatial component, it was our intention to put into evidence the locations in the Northern Region (groups of municipalities) where there was a high (or low) risk of hospital admission for each group of disease (five groups have been studied), using the annual average rate for each municipality occurred between 2000 and 2007.

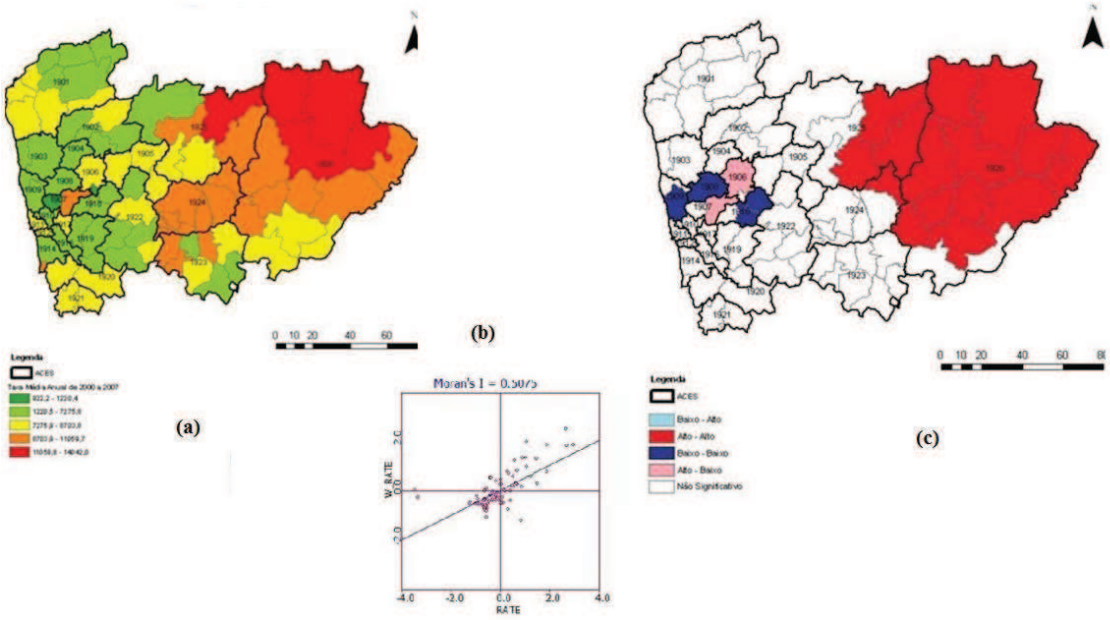

Figure 3: (a) Choropleth map with the average rates in each municipality. (b) Moran's Graphic. (c) Municipalities Clusters for all causes of hospital admissions.

The Northern Region is constituted by 86 municipalities that were designated as partitions B_i, $i = 1,\ldots,86$. The annual average rate for each municipality were also designated as $Y = (Y(B_1),\ldots,Y(B_{86}))$. Each block was represented by a centroid that was used to measure the proximity among municipalities.

It was used Moran's index (I) which is a global measurement of spatial autocorrelation, indicating the degree of spatial association present in any set of data. Moran's local index (I_i) was also used (defined in Cliff [2] and in Anselim [1]). Figure 3(a) shows a choropleth map with the average rates of hospital admissions for each municipality. It is evident that in the inner area of the Northern Region the rates of hospital admissions are higher. It should be noted in this analysis the effect of age has not been removed, and it is therefore to be expected that areas of elderly population (inner Northern Region) have higher rates of hospital admissions. The analysis of Moran's graphic (Figure 3(b)) indicates the existence of points with positive spatial association, in the sense of a location having neighbours with similar values. Through the analysis of the values of LISA indexes groups of neighbouring municipalities that constitute three spatial clusters have been highlighted, as shown in Figure 3(c).

3 Conclusions

In this case study, different statistical techniques were used to evaluate spatial and temporal behaviour of hospital admissions observed between 2000 and 2007. We have arrived to the conclusion that, in average, for each 100 inhabitants in continental Portugal, there were 8 hospital admissions in public hospitals in 2007; there was also 1 hospital admission for each 100 inhabitants due to diseases of the respiratory, circulatory and digestive system.
The number of hospital admissions has been increasing every year, and there is a forecast of a 5% growth for 2009 in relation to 2007.
For females aged 15 to 44 most hospital admissions are due to pregnancy or delivery, and as age increases so do hospital admissions due to diseases of the respiratory, circulatory and digestive system.
The malignant neoplasm of trachea, bronchus, and lung is the cause of hospital admission that presents the highest rate of intra-hospital lethality 30%. It is also this cause of hospital admission that requires, in average, more days in hospital, about 19 days. The causes that, in average, require less time in hospital are eye diseases, about 3 days.
There are causes of hospital admissions with a well defined seasonal behaviour, namely diseases of the respiratory system with a period with a high number of hospital admissions (Winter) and another period with a low number of hospital admissions.
In general, with the exception of hospital admissions due to pregnancy or delivery, there is a higher number of hospital admissions and a higher risk of hospital admissions in the interior of the Northern Region, namely in Bragança and Vila Real. On the other hand, there is a lower number of hospital admissions and a lower risk of hospital admissions in the coast of the Northern Region, namely in Braga and Porto.

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