Spatial analysis of mortality by cardiovascular disease in the adult population: a study for Brazilian micro-regions between 1996 and 2015

Abstract
The number of deaths by cardiovascular diseases (CVD) is one of most serious health issues, being the leading cause of death worldwide, including Brazil. However, CVD mortality rates are not uniformly distributed across the country. Brazil is marked by important regional differences resulting from socioeconomic inequality and access to health services. Since there is a spatial distribution of causes and spatial heterogeneity of deaths from cardiovascular disease in Brazil, the goal of this paper is to evaluate the spatial patterns of deaths from CVD in the adult population (over 30 years of age), by sex, in Brazilian micro-regions from 1996 to 2015. This paper contributes to the literature by focusing on small areas of a very diverse country and taking into consideration space as an important variable to understand changes in the CVD mortality. We will use a combination of demographic techniques and spatial autocorrelation methods to study this problem.
BACKGROUND

The number of deaths by cardiovascular diseases (CVD) is one of the most serious health issues, being the leading cause of death worldwide, including Brazil (around 30% in recent years). However, CVD mortality rates are not uniformly distributed across the country. Brazil is marked by important regional differences resulting from socioeconomic inequality and access to health services. Since there is a spatial distribution of causes and spatial heterogeneity of deaths from cardiovascular disease in Brazil, both at the macro and micro level, the goal of this paper is to evaluate the spatial patterns of deaths from cardiovascular disease in the adult population (over 30 years of age), by sex, in Brazilian micro-regions from 1996 to 2015. Understanding the heterogeneity in the distribution of causes of deaths across regions and time in Brazil is important to developing better public health interventions and also to explaining the variation and differentials in life expectancy at birth in the country. Furthermore, this paper contributes to the literature by focusing on small areas of a very diverse country and taking into consideration space as an important variable to understand changes in the CVD mortality. We will use a combination of demographic techniques and spatial autocorrelation methods to study this problem.

In Brazil, recent studies show that mortality from cardiovascular disease in the population has been decreasing since 1985 (MANSUR et al., 2002; MANSUR & FAVARATO, 2016a; MANSUR & FAVARATO, 2016b; BRANT et al., 2017). Curioni et al. (2009) and Sala (2011) show that mortality from cardiovascular diseases in the country declined steadily since the 1980s. This trend was also observed in each of the regions of Brazil, but the rates of decline have not been uniform. In more recent years, the trend has shifted and mortality by CVD has begun to rise again (MINISTÉRIO DA SAÚDE, 2014). One of the main explanations is the aging of the Brazilian population in recent decades. According to IBGE data (2013), in 2010 the elderly population represented 10% of the population and projections indicate that by 2050 the population above age 65 will constitute 29% of the total population. This process of population aging verified in the country brings reflexes on the life expectancy of people. From 1990 to 2015, life expectancy at birth in Brazil increased from 67.9 to 74.4 years. If deaths from cardiovascular disease were eliminated, there would be an additional gain of 2 years, the highest recorded among all causes of death in the period. In parallel, in 2015 the mortality by CVD represented 14.83% of all DALYs (Disability-Adjusted Life Years) registered in Brazil (IHME, 2015). We also note that improvement of basic
health conditions is another important aspect of this process because it depends on population access to basic health services whether good or bad.

**DATA & METHODS**

**Study population, level of analysis and information source**

The data used in this study on mortality from cardiovascular disease comes from the Tenth Revision of the International Classification of Diseases (ICD-FR-10), Chapter IX, and is available in the Sistema de Informações sobre Mortalidade (SIM), DATASUS, which was created by the Brazilian Ministry of Health in 1975. The data are organized by sex (males and females), age (population over 30 years and in 5-year groups up to 80 years or more) and cause of death as well as by the geographical micro-region where deceased resided. For purposes of analysis, it is suggested to use four 5-year periods 1996-2000, 2001-2005, 2006-2010 and 2011-2015. Population data by age and sex were obtained from the 2000 and 2010 Censuses and intercensal estimates from the Brazilian Institute of Geography and Statistics (IBGE). The units of analysis are the 558 Brazilian micro-regions, as proposed by the Brazilian Institute of Geography and Statistics (IBGE). The micro-regions are statistical constructions aggregated using regional and socioeconomic similarities, i.e., geographic micro-regions do not constitute political or administrative entities. One of the advantages of using this type of unit is that their boundaries are constant throughout the research period. Thus, it was possible to monitor and study the 558 areas between 1996 and 2015. Furthermore, it is assumed there is internal homogeneity within the micro, that is, important changes occur on the borders.

**Spatial Autocorrelation**

The spatial autocorrelation can be calculated by global and/or local index of spatial association. These indexes characterize the relative distribution of events observed in space with the objective of finding patterns of spatial clusters or to verify if the data are randomly distributed. These two statistics are differentiated by the unit of analysis, being that the global ones consider the general spatial tendency of the events and the locals specify where the agglomerations or extreme cases occur. In this paper, specifically, local spatial autocorrelation will be used (ANSELIN, 1995, 2005).

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1 IBGE. http://www.ibge.gov.br
The local spatial autocorrelation index allows comparing the values of a variable in each area with the values found in its neighbors. That is, this type of "local analysis" or "local modeling" disaggregates global statistics according to its local constituents, focusing more on local specificities than on the search for global regularities. The local indicators of spatial autocorrelation produce a specific value for each object, thus allowing the identification of clusters of objects with values of similar attributes, outliers and more than one spatial regime. For Anselin (1995), the LISA (Local Indicators of Spatial Association) must satisfy two criteria: 1) have the ability, for each observation, to indicate statistically significant spatial clusters; and 2) the property that the sum of local indicators for all regions should be proportional to the corresponding global spatial autocorrelation indicator. As an example of local index of spatial autocorrelation, we have the Cluster Map. The Cluster Map presents sites with local statistical significance of Moran “with the significant locations color coded by type of spatial autocorrelation” (ANSELIN, 2005).

To implement this methodology, GeoDa software has been used. This generated the Lisa indicators (local indicator of spatial association) that were mapped. In the software, a neighborhood structure between the micro-regions called Queen was also defined. This criterion correlates the microregions with their neighbor independent of their direction.

PRELIMINARY SPATIAL RESULTS

The methodology used in this paper shows us how an analysis based on the verification of the existence of spatial autocorrelation can clarify about the relative distribution of the observed events in space. The preliminary results presented below allow us to better understand the correlation between cardiovascular disease deaths in each micro-region and explain the clusters with high or low mortality due to cardiovascular diseases found in Brazil during the study period.
FIGURE 1 – *LISA cluster map* for deaths from cardiovascular diseases in the adult population with direct standardization data, men, microregions, Brazil – 5-year periods 1996-2000(a), 2001-2005(b), 2006-2010(c) and 2011-2015(d)
FIGURE 2 – *LISA cluster map* for deaths from cardiovascular diseases in the adult population with direct standardization data, women, microregions, Brazil – 5-year periods 1996-2000(a), 2001-2005(b), 2006-2010(c) and 2011-2015(d)
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