Age-Period-Cohort Effects on Mortality from Cerebrovascular Disease in Southern Spain

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Background: The aim of this article is to evaluate the age-period-cohort effects on mortality from cerebrovascular disease in Andalusia (southern Spain) as a whole and in each of its 8 provinces during the period 1981-2008. *Methods:* A population-based ecologic study was conducted. In all, 145,867 deaths were analyzed for individuals between the ages of 15 and 84 years who died in Andalusia in the period of study. A nonlinear regression model was estimated for each gender group and geographic area. The effects of age, year of death, and birth cohort were parameterized using spline smoothing functions. *Results:* There is an upward trend in mortality from the age of 25 years. The risk of death was downward for cohorts born after 1896, decreasing after 1970 with steep slope. The analysis of the period effect showed that death rate first declined from 1981 to 1995 and then increased between 1995 and 2000, only to decrease again until 2008. *Conclusions:* There is a similar age-period-cohort effect on male and female mortality from cerebrovascular disease in all the provinces of Andalusia and for Andalusia as a whole. A significant reduction of male and female mortality has been observed during the last decade. **Key Words:** Cerebrovascular disease—mortality—age-period-cohort models—Poisson regression—Andalusia—Spain.

Cerebrovascular disease is the second leading cause of death and one the top 6 causes of burden of disease worldwide.[1,2] Death rates of cerebrovascular disease have diminished severely over the last decades in Europe and other continents in response to improvements in health promotion policies, health care, and treatments.[3,4] Spain is currently 1 of the European Union countries with the lowest mortality from cerebrovascular disease. The crude death rate was 6.2 per 10,000 population in 2011 (5.3 for men and 7.1 for women).[5-7] However, as Spanish statistics tend to vary by region, proper health planning requires analysis of regional mortality patterns.[6]

Andalusia, one of the 17 autonomous communities in Spain, is located in the southern part of the Iberian peninsula. It accounts for 17% of the Spanish territory and 18% of the Spanish population.[5,8] Administratively it is divided into the 8 provinces of Almeria, Cadiz, Cordoba, Granada, Huelva, Jaen, Malaga, and Seville (Fig 1). According to the latest official figures, the crude death rate from cerebrovascular disease in Andalusia is 6.9 per 10,000 population (5.9 for male and 7.9 for female).[9]

The Interactive Mortality Atlas for Andalusia is a web-based dynamic Geographic Information System that stores mortality data dating back to 1981 by cause of death, age, sex, and year for all of Andalusia's municipalities.[10] Recent studies based on these data show that now, in over 95% of

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Figure 1. *Andalusia (southern Spain) and its administrative division into 8 provinces.*

the Andalusian municipalities, male and female mortality rates from cerebrovascular disease for age groups under 65 are similar to, or significantly lower than, the corresponding Spanish rates. Since 1981, however, male and female mortality rates for age groups more than 65 years have been significantly higher in the western Andalusia region. As is the case with other municipalities and other causes of death, the cerebrovascular disease mortality rate ratio in age groups more than 65 years has generally been falling in this region since the mid-1990s, and the death rate is tending to gradually reduce the significant difference with the Spanish figure.[11,12]

These results suggest a possible age-period-cohort effect on mortality from cerebrovascular disease, with a higher mortality observed over previous years, possibly because of certain features of past periods and generations that have gradually disappeared from the newer population cohorts.

Age-period-cohort analyses are typically performed using pooled period data and 5-year age groups. Because this approach to aggregation can result in significant bias in estimating trends, recent studies suggest that time-based analyses of mortality rates should minimize confusion between age, death period, and birth cohort by using data tabulated for periods as small as possible and by treating age, period, and cohort as continuous variables.[13] This would result in more accurate and less biased results, although the complexity of the mathematical models used is greater.

The aim of this study was to evaluate the effect of age, year of death, and birth cohort on male and female deaths from cerebrovascular disease in Andalusia as a whole and in each of its 8 provinces during the period 1981-2008, using continuous-time statistical models.

Methods

Design

An ecologic study was implemented with a Lexis diagram triangle comprising each annual age group, year of death, and year of birth as the unit of analysis.

Scope

The study was conducted in Andalusia as a whole and in each of its 8 provinces.

Population

In all, 145,867 deaths from cerebrovascular disease (International Classification of Diseases, 9th revision, 430-434, 436-438, and International Classification of Diseases, 10th revision, I60-I69), 68,563 male and 77,304 female, were analyzed for individuals between the ages of 15 and 84 years who died in Andalusia in the period 1981-2008. The deaths correspond, therefore, to cohorts born between 1896 and 1993.

Variables

Using information recorded for each death (the person's age, sex, year of birth, year of death, and province of residence), the number of male and female deaths in each