On the use of Statistical Process Control in Monitoring Mortality. An Application to European Countries

Speed Talk Session 4

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Introduction

Motivation

• Notable progress in health in recent decades.
• Different causes of mortality between developed and developing countries.
• EUROPE: Great variability between mortality rates of the countries that compose it

Main objective

In this work, we address the study of the trend of the European mortality by means of Standard Mortality Ratio (SMR).

SMR: the ratio of the actual number of deaths in studied population A to the number of deaths that would be expected to in population A if it experienced the age-specific death rates of the standard population.
Methodology

**Statistical tools**
- Time series
- Control Charts

The joint use of time series and statistical process control (SPC) techniques to model and monitor the behavior of the SMR is explored (Knoth and Schmid, 2004).

**Specific objectives**
- Analysis of the SMR time series for each European Country.
- The use of control chart to detect trend changes in mortality.
Application to European countries

Data

- Time period: from 1990 to 2009
- 26 European Countries: Austria, Belarus, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom and Ukraine.
- Database: Human Mortality Database (Human Mortality Database, 2015).

Software

Free statistical software R, R-packages such as tseries (Trapletti and Hornik, 2015) for time series, and qcc (Scrucca, 2004) for control charts.
Fitting assessment of the model

**Hold out**
- Train dataset: 15 first observations
- Validation dataset: 5 last observations

**Procedure**
- Fitting ARIMA model to the train dataset
- Assessment of the model by means of the residuals
- Contrast of the prediction with the validation dataset
- EWMA control chart for the residuals
- Stationary time series
- Normality
- Independence
- FAP and FAS functions
- Independence
Results for each country

- Countries with SMR lower than 1: Germany, Austria, Belgium, Denmark, Spain, Finland, France, Netherlands, Ireland, Italy, Luxembourg, Norway, Portugal, United Kingdom, Sweden and Switzerland.
- Countries with SMR greater than 1: Belarus, Slovenia, Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Czech Republic and Ukraine.
Results for cluster

**Different behaviour between Eastern Europa and Western Europa**

- Different traditions and culture.
- Disparate Economic and social development (Herta Gongola, 2004).
- Example: Contrast for levels of SMR.

**Clusters**

- **Western Europa**: Portugal, Spain, France, Switzerland, Italy, Austria, Luxembourg, Belgium, Germany, Netherlands, Denmark, Sweden, United Kingdom, Ireland, Norway and Finland.

- **Eastern Europa**: Estonia, Latvia, Lituania, Polonia, Belarus, Ukraine, Czech Republic, Slovakia, Hungary, Slovenia.
Application to Eastern Europe

Control chart for residuals range: Large differences of SMR in 2009 between countries of the Eastern Europe region.
Application to Western Europe

Control chart for residuals range: Large differences of SMR in 2009 between countries of the Western Europe region; in addition, a sequence of 7 observations with same sign (1997-2003).
Conclusions

• Combined use of time series and control charts EWMA to monitor mortality on residuals of the time series adjusted to SMR. The methodology used to detect possible situations in which the behavior of mortality of countries, is changing with respect to the predictable.

• 11 out of the countries considered show the expected behavior outside limits: Estonia, France, Netherlands, Hungary, Ireland, Italy, Latvia, Lithuania, United Kingdom, Czech Republic and Ukraine.

• Two types of countries: one with SMR greater than 1 (usually Eastern Europe) and SMR lower than one (generally Western Europe).

• Western Europe has an average range of residues lower than Eastern Europe, which means that mortality is much more homogeneous and stable in Western Europe.

2. Human Mortality Database (2015). University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany), Available at www.mortality.org or www.humanmortality.de, (data downloaded on 01/06/2015).

