Geo-socio-economic factors as determinants of health: An analysis of small-area mortality rates in Germany

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Presented at GeoHealth 2002
Victoria University of Wellington
December 3-5th 2002

ABSTRACT

The study "Geo-socio-economic factors as determinants of health: An analysis of small-area mortality rates in Germany" shows a comparison of different conventional and spatial regression models for determining county-based differences in premature mortality. Socio-economic factors considered in these models are the unemployment rate, the education level and the population density. Geographical longitude and latitude and the federal state are used as geo-indicators. The residuals of the models are tested for spatial autocorrelation. The results show that integrating spatial components into the conventional model or calculating a spatial regression model leads to less clustering of the residuals. Nevertheless, in this study, the unemployment rate seems to be the best indicator for mortality rates. Great differences in mortality rates between eastern and western states are due to the historically based differences between former East and West Germany.

***Keywords and phrases*:** GIS, spatial autocorrelation, regression analysis, health inequalities, geo-socio-economic determinants of health

1.0 OBJECTIVES

One of the major aims of public health is the reduction of high mortality rates (Last, 1995). Therefore, the identification of potential determinants of premature death is essential.

Several studies discuss socio-economic factors as determinants of health (e.g. Heinrich et al., 2000; Jozan and Forster, 1999; Kawachi and Kennedy, 1997; Mielck et al., 2000; Mitchell et al., 2000; Sihvonen et al., 1998). In some studies also spatial indicators are taken into account to predict regional differences in mortality (Fehr, 1997; Lorant et al., 2001; Walter et al., 1999). For Germany, there are only a few approaches regarding spatial aspects as predictors for mortality rates (e.g. Fehr, 1997).

This study is based on a comparison between conventional regression models and spatial regression models to investigate the influence of spatial factors on regional differences in mortality in Germany. It is focused on the analysis of small-area mortality data on all-cause mortality in 1996 and 1998. This study includes an investigation of spatial patterns of the mortality rates and the search for determinants of high resp. low mortality. As determinants both socio-economic factors and spatial factors are considered.

The overall aim of this study is to identify regions where special public health programs should be established, and to identify factors that should be discussed to reduce inequalities in health.

2.0 MATERIAL AND METHODS

All-cause mortality rates in 1996 and 1998 in the 439 counties of Germany were used for this ecological study. The mortality data of the Federal Office of Statistics were age-standardised according to the European Standard Population in 1990 (Statistik regional, 2001). Socio-economic data like population density, unemployment rate and education level were taken from the same institution. As geo-data, the geographical longitude and latitude of the centroids of the counties and the affiliation of the county to a state were used.

Univariate and multiple regression analyses with mortality rates as dependent and geo-socio-economic data as independent variables were performed using SAS®. The GIS ArcView® was used to investigate spatial patterns of the mortality rates. Spatial analyses were performed with the S-Plus® module for SpatialStats integrated in ArcView.

We developed four different linear conventional non-spatial regression models and one spatial model to explain the variation of mortality rates in 1996. The conventional models were generated by using stepwise selection procedures with an inclusion level of p=0.15. These models include different sets of geo-socio-economic variables. A neighbourhood matrix was used to calculate the spatial linear model (Kaluzny et al. 1998). All variables and residuals of the models were tested for spatial autocorrelation according to Moran's I (Kaluzny et al., 1998; Lorant et al., 2001; Moore et al., 1999; Wakefield et al. 2000).

The models were fit for the year 1996 and validated with data for the year 1998. To compare the applicability of the models for the 1998 data, a technique was used which was developed by Bland and Altman (1999) to compare different measuring methods in medicine. A general reduction of mortality rates in Germany between 1996 and 1998 was taken into account by including a mean difference between the mortality rates of both years.

3.0 RESULTS

The investigation of the spatial patterns of mortality rates shows that the highest mortality rates are detectable in the eastern states of Germany and in the highly industrialized Rhine-Ruhr-area. The state Baden-Württemberg and the southern part of Bavaria showed the lowest mortality rates (see Figure 1).

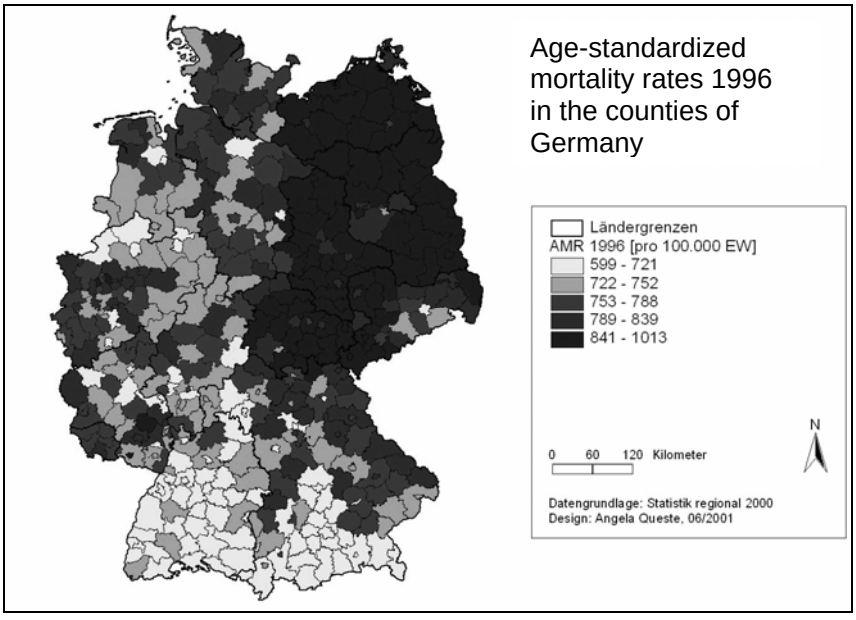

Figure 1: Age-standardized mortality rates in the counties of Germany in 1996

The univariate regression analyses indicate that the unemployment rate and the state explain 57% resp. 59% ($p<0.0001$) of the variance of the mortality rates. The multiple regression analyses result in R-square values of about 71% ($p<0.15$) when unemployment rate, state, education level and geographical longitude were included into the model. Unfortunately, there were no R-square values available for the spatial linear regression model.

The Moran's coefficients of the residuals of the mortality rates were all significant ($p<0.01$) and range between 0.15 for the spatial regression model and 0.41 for a model just using socio-economic variables. Generally, the models fit best and the residuals showed least clustering when spatial components were included into the data sets.

The validation of the 5 models in 1998 showed that the lowest relative bias was reached when a spatial linear model was calculated. The second best explanations were obtained by including the state as geo-variable into the conventional model.

4.0 DISCUSSION

There are great regional differences in the small-area mortality rates in Germany. Most of the differences between the eastern and western states can be explained by historical reasons. The identified regions with highest mortality rates can be classified as focal points, where suitable public health programs should be established to reduce mortality rates.

The results of the univariate regression analysis indicate that unemployment plays a major role as a determinant of premature mortality in Germany. This strong relationship is in accordance with results of previous ecological studies (Brenner, 1987; Sundquist et al., 1996), but was also found in studies using individual data (Bartley et al., 1999; Bethune, 1997; Wilkinson, 1999).

The comparison of the 5 models showed that the integration of a spatial component into the data set gave better results for predicting mortality rates in 1996 than just using socio-economic variables. The calculation of a spatial linear regression model resulted even in the least clustered residuals of the mortality rates (cf. Lorant et al., 2001; deviant from Walter et al., 1999). The result found in this study indicates that space has a noticeable influence on the regional distribution of mortality and should be taken into account each time an analysis of this kind is performed. It can be recommended either to calculate spatial regression models or at least to include spatial components into these models.

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