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Which geo-socio-economic factors predict mortality best? An analysis of small-area mortality rates in Germany

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Determinants of health

One of the major aims of public health is the reduction of high mortality rates. Therefore, the identification of determinants of premature mortality is needed. In most studies socio-economic factors are investigated as determining variables. Spatial factors are only randomly taken into account.

This study is focused on the analysis of small-area mortality data in Germany. As determinants of mortality here both socio-economic factors and spatial factors are considered. The regions with the highest mortality rates and important determining factors should be identified to develop suitable public health strategies to reduce premature mortality.

Methodological Approach and Data Material

This ecological study uses German county-based mortality data as health indicators and geo-socio-economic data as determinants of health. The data were collected in 1996 and 1998. A GIS was used to visualise the spatial distribution of all these data.

Dependent Variable	Independent Variables
all-cause mortality rates, age-standardized according to the European Standard Population [deaths/100.000 inhabitants]	socio-economic data unemployment rate [%] pupils leaving school with high school graduation [%] population density [inhabitants/km²] geo-data geographical longitude and latitude [UTM] federal state [categorical variable]

Univariate and multiple linear regression analyses were performed. We developed three multiple regression models and one spatial regression model using different geo-socio-economic variable sets to explain the variation of mortality rates in 1996. The models were fit by using stepwise selection procedures in SAS (inclusion level of p=0.15). They were validated with data for 1998.

Results

The spatial distribution of the dependent variable and the independent socio-economic factors are shown in Figures 1 to 4. Mortality rates and unemployment rate as well as population density and level of school education show similar distribution patterns. Both the highest mortality rates and the highest unemployment rates occur in the eastern part of Germany and in the highly industrialized Rhine-Ruhr area. In contrary, the level of education and the population density show a more urban-rural gradient than regional patterns.

Dependent variable (1996)	Independent variables (1996)	R^2	p-value
mortality rates	state	0,5983	<0,0001
	unemployment rate	0,5705	<0,0001
	latitude	0,1396	<0,0001
	longitude	0,2621	<0,0001
	population density	0,0108	0,0296
	high school graduation	0,0001	0,8715

Table 1: Results of the univariate regression analyses

The results of the univariate regression analyses are shown in Table 1. The state and the unemployment rate predict mortality rates best.

The developed multiple regression models are shown in Table 2. The regression analyses gave R-Square values of about 71% (p=0,15), when unemployment rate, state, education level and y-coordinates were included into the model. The unemployment rate was identified as the best socio-economic predictor. In general, models fitted best when spatial components were included.

Table 2: Multiple linear regression models

Model	Data set	Development	R^2
1	unemployment rate high school graduation longitude state	all variables in the model; selection stepwise → latitude and population density not significant (p<0.15) and excluded	0,71
2	unemployment rate high school graduation population density longitude latitude	model without state; selection stepwise → all variables significant (p<0.15)	0,64
3	unemployment rate high school graduation population density	no geo variables in the model; selection stepwise → all variables significant (p<0,15)	0,62
4	unemployment rate high school graduation population density	no geo variables in the model, but spatial linear model	

The expected mortality rates in 1996 are shown in Figure 5. Figure 6 gives the residuals of observed and expected mortality rates in 1996. In figure 7 and 8 the observed mortality rates in 1998, and predicted mortality rates in 1998 by using the models developed for 1996 are visualised.

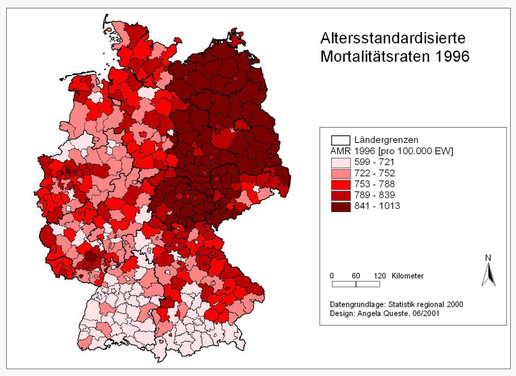

Figure 1: Mortality rates 1996

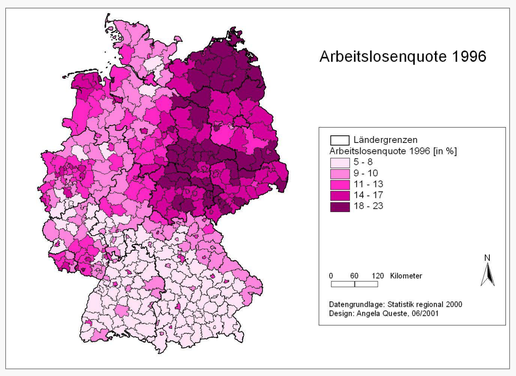

Figure 2: Unemployment rates 1996

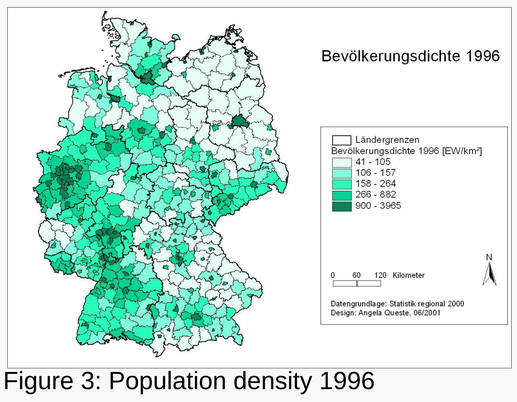

Figure 3: Population density 1996

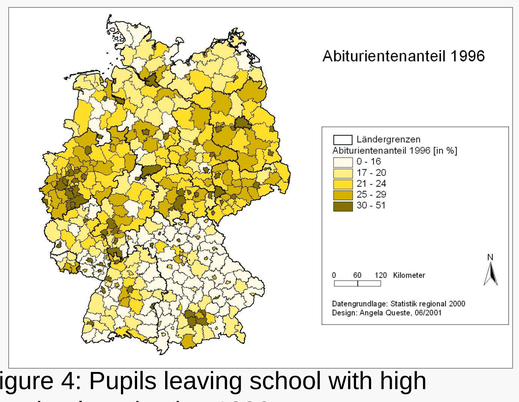

Figure 4: Pupils leaving school with high school graduation 1996

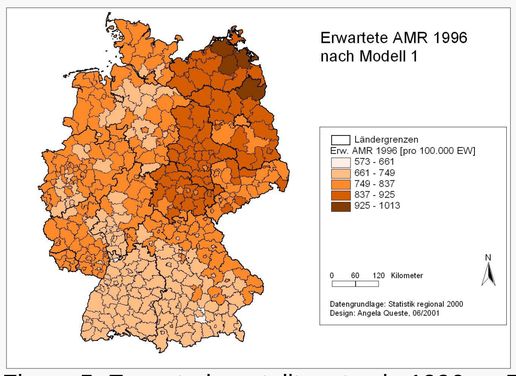

Figure 5: Expected mortality rates in 1996, model 1 as example

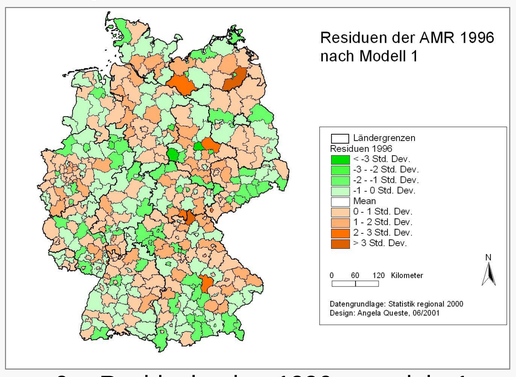

Figure 6: Residuals in 1996, model 1 as example

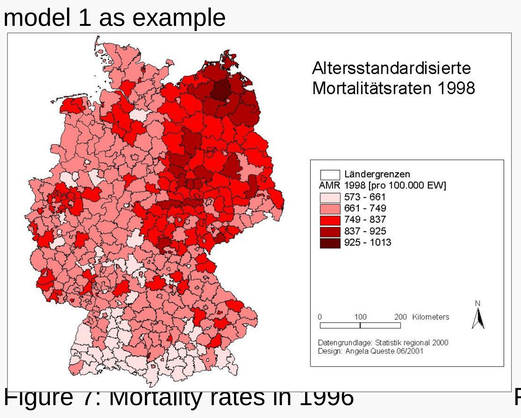

Figure 7: Mortality rates in 1998

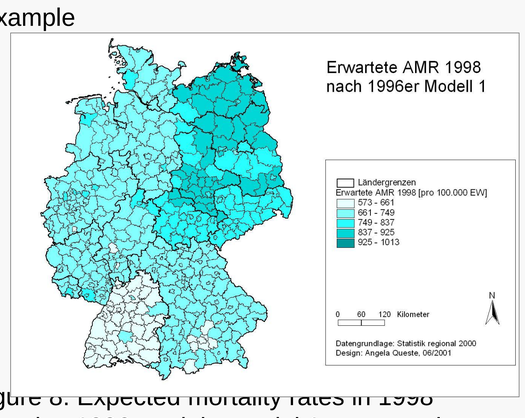

Figure 8: Expected mortality rates in 1998 using 1996 models, model 1 as example

Discussion

The highest mortality rates were found in the eastern part of Germany and in the Rhine-Ruhr-Area, the lowest mortality rates were detected in the southern part of Germany in the federal states of Baden-Württemberg and in parts of Bavaria. Priority should be given to the further clarification and then reduction of the increased levels of mortality, particularly in the above mentioned regions. Suitable public health programs should be established in these regions to reduce mortality rates.

There were strong associations found between the unemployment rate, state and mortality rates, but there were no relationship between population density or the educational level and mortality rates. It is assumed, that strong relationships between population density and educational level and mortality rates as found in several other studies, are superimposed in this study by structural differences between the former East and West Germany. The unemployment rate can be seen as an important factor for mortality, which is also found on the individual based data level.

Spatial components included into the data set gave better results for predicting the variation of the mortality data in 1996 than solely using socio-economic variables. Therefore, spatial aspects should always be included when investigating regional patterns of health, diseases or mortality.

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